13

Space under Construction: Language-Specific Spatial Categorization in First Language Acquisition

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13.1 Introduction

Does language influence nonlinguistic cognition, and do different languages influence it in different ways? Testing these classical Whorfian questions presupposes speakers who are old enough to have mastered the relevant aspects of their language. For toddlers in the very early stages of linking meanings to language forms, we need to ask another question: do the concepts initially associated with language arise solely through nonlinguistic cognitive development, or are they formulated, at least in part, under linguistic guidance?

Establishing where children's early meanings come from—the relative contributions of nonlinguistic cognition and exposure to language—is important to the debate about the Whorfian hypothesis because it provides clues to how flexible—hence how potentially malleable—children's cognitive structuring of their physical and social world is. If the concepts children bring to the language acquisition task are so salient and prepotent that language is simply molded around them, linguistic influences on nonlinguistic cognition seem less likely. Put differently, the more robustly children organize their world according to certain categories of meaning and not others, independently of language, the more resistance language would have to overcome to bring about any restructuring of mental life. On the other hand, if children readily take on the structuring of meaning displayed in the input language, this suggests a receptivity to patterns of conceptual organization introduced from outside that makes Whorfian effects more plausible.

Until recently, opinion among developmentalists came down almost unanimously on the side of nonlinguistic cognition as the driving force behind children's early word meanings. The dominance of this position is due in part to its compatibility with the universalist/cognitivist climate that has reigned more generally in psychology and linguistics over the last 30 years (see Bowerman 1989, 2000, for an overview). During the prelinguistic period, children have been portrayed as busy establishing a repertoire of basic notions of objects, actions, causality, and spatial relations. As they begin to want to communicate, they are seen as searching for the linguistic forms that allow them to express their ideas (e.g., Nelson 1974; Slobin 1973). Alternatively (a more recent trend), they are depicted as trying to discover which concept, from among those already available to them, is the one an adult intends by her use of a word (e.g., Gleitman 1990). Within this universalist/cognitivist perspective, there is little room for Whorf.

In the last decade, however, new ways of thinking about the relationship between language and cognition have emerged. Most basically, long-standing arguments for semantic universals—which had been a cornerstone of the universalist/cognitivist approach—have been challenged by a renewed interest in language diversity. Languages are undoubtedly constrained in their expression of meaning, but they are by no means uniform: in every conceptual domain, there are significant differences in the categories of meaning to which words, bound morphemes, and grammatical patterns are linked. Where languages differ, human cognition must be correspondingly flexible, and there is no reason to suppose that just one mode of construal is easiest or most obvious for children (Brown 1965, 317). Indeed, as we will discuss, recent comparisons of children learning different languages show that children adopt language-specific principles of categorization by as early as the one-word stage. Evidence for early mastery of language-specific categories does not, of course, show that the linguistic categories, once acquired, exert an influence on nonlinguistic cognition, but it does set the stage for this possibility. Consistent with this, studies over the last few years have offered new evidence for a variety of Whorfian effects, as discussed in some of the chapters of this volume.

In this chapter, we explore developmental perspectives on the Whorfian hypothesis in the domain of spatial cognition and language. Space may seem like an unpromising domain in which to investigate crosslinguistic semantic variation and its effects on children: spatial words have in fact often been used as prime evidence for the claim that early words map directly to prelinguistic concepts (e.g., Slobin 1973), and the human ability to perceive and mentally represent spatial relationships is undeniably supported and constrained by a host of universal influences, both biological and environmental (e.g., vision, posture, front-back body asymmetry, and gravity—Clark 1973). Recent research shows, however, that languages diverge strikingly in the way they organize spatial meanings—for example, in the spatial frames of reference they use (Levinson 1996, this volume; Pederson et al. 1998) and in how many and what kinds of spatial relationships they recognize (Ameka 1995; Bowerman 1989, 1996a,b; Bowerman and Choi 2001; Bowerman and Pederson, in preparation; Brown 1994; Choi and Bowerman 1991; Wilkins and Hill 1995).

This variation raises challenging questions for developmentalists. By the time toddlers learn their first words, they already have a practical grasp of many aspects of space, including when objects will fall, what objects can contain other objects, and the path objects can follow in moving from one place to another (Baillargeon 1995; Needham and Baillargeon 1993; Spelke et al. 1992). They are also sensitive to certain categories of spatial relationships, such as left-right, above-below, and between (Antell and Caron 1985; Behl-Chadha and Eimas 1995; Quinn 1994, in press; Quinn et al. 1999). What happens, then, when they are confronted with a language-specific organization of space? Do powerful prelinguistic concepts of space initially hold sway, causing children to use the spatial words of their language in accordance with universal "child basic" spatial meanings (Slobin 1985)? Or do children take on the imprint of the local language from the beginning?

As with most starkly drawn conflicts between nature and nurture, the answer is not simple: both nonlinguistic cognition and language seem to influence early spatial semantic development, often in interaction. In the following sections, we first briefly summarize evidence for the contribution of nonlinguistic cognition. We then review recent crosslinguistic findings suggesting a role for the linguistic input as well: children use and understand spatial words according to language-specific categories from a very young age. Early sensitivity to linguistic organization might mean that children can construct semantic categories on the basis of the input, but in itself it is not decisive: perhaps it means only that children are good at choosing among alternative concepts made available by nonlinguistic cognition. Further evidence for the existence of a construction process, however, comes from error data: patterns of correct and incorrect usage of spatial words differ across languages, and they do so systematically, in ways that suggest that children try to make sense of the distribution of the words in the speech they hear. Category construction of course requires a learning mechanism, and some raw perceptual or conceptual building materials for the mechanism to work on. Our discussion of these elements brings us back to the Whorfian question, and we present evidence from a new study showing that learning a language can affect nonlinguistic spatial cognition by selectively maintaining or discouraging sensitivity to spatial distinctions that are, or are not, relevant to that language. We conclude with a brief sketch of a plausible learning process that could lead to these effects.

13.2 Universality and Language Specificity in Early Spatial Semantic Development

13.2.1 Evidence for the Role of Cognition

All around the world, children's first spatial words are applied to the same kinds of events: putting things into containers and taking them out, separating things and trying to put them back together, piling things up and knocking them down, donning and doffing clothing, opening and closing objects, climbing on and off laps and furniture, being picked up and put down, and posture changes like standing up and sitting down. Consistent with these preferred topics, early-acquired spatial words revolve around relationships of containment (e.g., for English, *in*, *out*), accessibility (*open*, *close*, *under*), contiguity and support (*on*, *off*), verticality (*up*, *down*), and posture (*sit*, *stand*). Only later come words for proximity (*next to*, *between*, *beside*), and still later words for projective relationships (*in front of*, *behind*) (Bowerman and Choi 2001; Bowerman, de León, and Choi 1995; Choi and Bowerman 1991; Johnston and Slobin 1979; Sinha et al. 1994). This sequence of development is consistent with the order of emergence of spatial concepts established through nonlinguistic testing by Piaget and Inhelder (1956), and this correspondence led to the hypothesis that cognitive development sets the pace in spatial semantic development. The idea was that as new spatial concepts mature, children look for linguistic forms to express them with (Johnston and Slobin 1979; Parisi and Antinucci 1970; Slobin 1973).

Further evidence for the role of nonlinguistic spatial cognition has come from children's under- and overextensions of spatial forms. Words that in adult speech can be used for both motion and static relationships (e.g., *up*, *down*, *in*, *out*) tend at first to be restricted to motion (Smiley and Huttenlocher 1995). Words for the relationships "in front of" and "behind" are initially applied only to things in front of or behind the child's own body; later they are extended to a wider range of reference objects with inherent fronts and backs (e.g., *behind the car*); and still later they are extended to nonfeatured objects (*behind the bottle*) (Johnston 1984). Words applied to actions involving separation are often broadly overextended (e.g., *open* for pulling two Frisbees apart) (Bowerman 1978; Bowerman, de León, and Choi 1995; Clark 1993). Researchers have assumed that systematic deviations from adult usage patterns indicate that children are relying on their *own* concepts, since—to the extent that they are guided by concepts introduced through *adult* speech—their usage should be more or less correct (see Clark 2001 on the reasoning). Later on (section 13.3) we will argue that comparisons of error patterns across languages in fact provide strong evidence for the construction of categories under linguistic guidance. But when children do make errors, their generalizations often proceed along shared cognitive "fault lines"; for example, overextended words for separation in different languages converge on rather similar classes of events.

13.2.2 Evidence for the Role of Language

Although on first impression children learning different languages seem to approach spatial encoding in a similar way, closer inspection reveals significant differences. Much of the evidence for crosslinguistic variation in early semantic categorization comes from our work comparing children learning English and Korean (Bowerman and Choi 2001; Choi and Bowerman 1991; Choi et al. 1999). Before showing examples, we must sketch some important differences in how English and Korean classify space. We focus first on "topological" path words applied to motions "in," "out," "on," "off," and so on, and, within this domain, we restrict ourselves to caused rather than spontaneous motion. Later we will look also at the expression of paths "up" and "down." Following Talmy (1985), we refer to the moving or moved object as the *figure* and the object with respect to which it moves as the *ground*.

13.2.2.1 Spatial Categorization in Adult English and Korean In talking about placement of one object with respect to another, English speakers make a fundamental distinction between putting a figure into an enclosure, container, or volume of some kind (*put [throw, stuff, etc.]* IN) and putting it into contact with an exterior (i.e., flat or convex) surface of the ground object (*put [set, smear, etc.]* ON). This classification is illustrated in figure 13.1. The same semantic space is partitioned differently in Korean (figure 13.2).[1] Notice in particular that *kkita* (see middle of figure 13.2), a very early-learned verb, picks out a path category having to do with bringing three-dimensional objects with complementary shapes into an interlocking, tight-fit relationship (a comparison of figure 13.2 with figure 13.1 shows that *kkita* crosscuts the categories of *put in* and *put on*, and extends to some situations that are considered neither "putting in" nor "putting on"). This everyday verb has no English counterpart.[2]

The crosscutting of the domain of *put in* by *kkita* means that what English treats as a unified category of "containment" events is, for speakers of Korean, subdivided (see bottom of figure 13.2): tight-fit containment events like putting a book into an exactly matching box-cover, described with *kkita*, are treated as a different class of actions from loose-fit containment events like putting an apple into a bowl or a book into a bag, described with *nehta*.[3] The category of *nehta* encompasses not only loose containment events but also loose encirclement events, such as putting a loose ring on a pole (not shown). Just as Korean breaks down the category of English *put in*, it also subdivides the domain of *put*

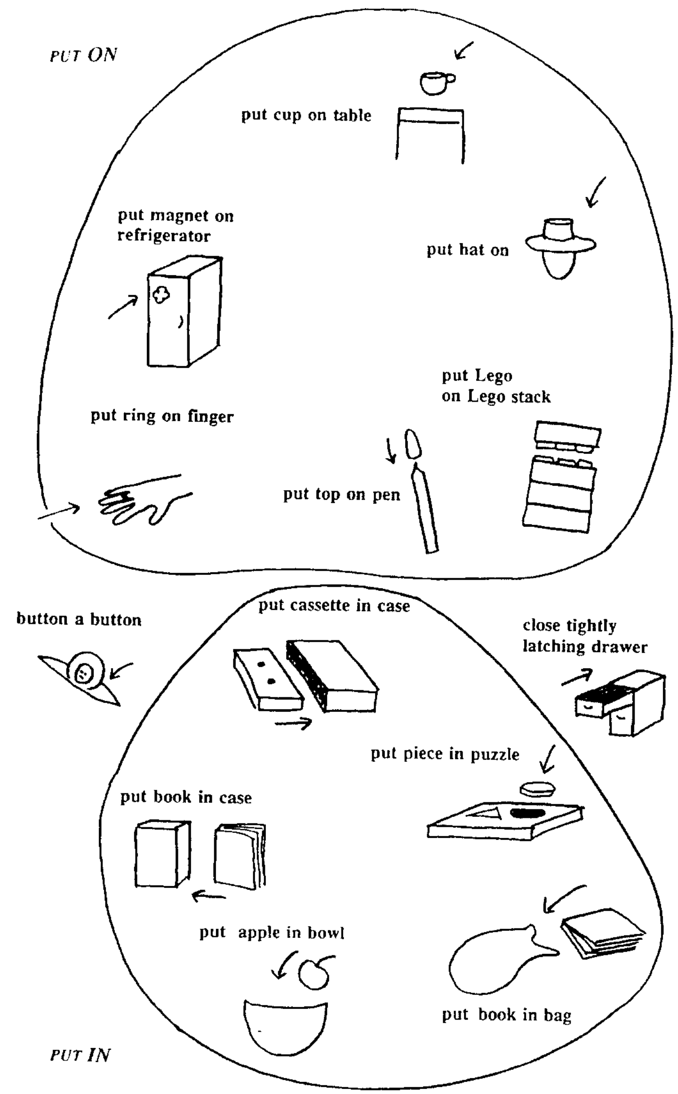

Figure 13.1
Categorization of some spatial events in English

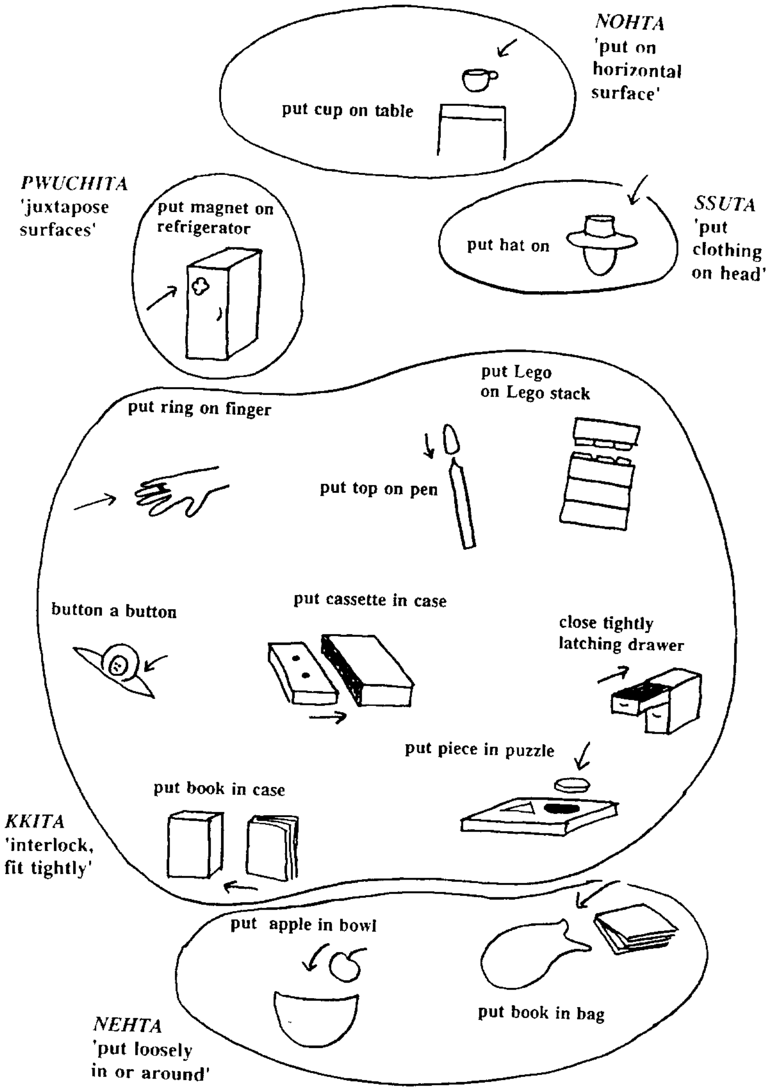

Figure 13.2
Categorization of some spatial events in Korean

on (top of figure 13.2). Here, the partitioning is more extensive: attaching a figure to the exterior surface of a ground object with a complementary three-dimensional shape (e.g., putting a top on a pen or a Lego block on a stack of Legos) falls into the "tight-fit" category of *kkita*, while juxtaposing objects with flat surfaces (e.g., magnet on refrigerator) is *pwuchita*, depositing a figure on a roughly horizontal surface (e.g., cup on table) is *nohta*, and putting a clothing item on the head is *ssuta* (distinguished from putting clothing on the trunk—*ipta*, and feet—*sinta*).

Notice that all the words shown in figures 13.1 and 13.2 are applied to *topological* relationships—situations of the sort encoded in English by words like *in*, *on*, *together*, and *around* or their opposites—but they focus on topological properties of different kinds. For instance, *put IN* requires the figure to end up in an interior space or volume of the ground, but is indifferent to whether the fit between figure and ground is tight or loose. *Kkita*, in contrast, cares centrally about the fit between a figure and a ground with complementary shapes, but is indifferent to whether this fit is obtained by insertion, covering, surface attachment, or encirclement.

13.2.2.2 Spatial Categorization in the Spontaneous Speech of Learners of English and Korean If children initially associate spatial words with a universal set of basic concepts of space, these differences between English and Korean should not matter: learners of the two languages should interpret and categorize the spatial events of their world in a similar way. But in a study of the spontaneous speech of children age 1–3 years, we found that language-related differences such as those shown in figures 13.1 and 13.2 were in place by as early as 17–20 months (Choi and Bowerman 1991). As soon as the children used the words productively for both familiar and novel situations,[4] learners of English distinguished systematically between actions involving containment (*in*) and those involving surface contact/support (*on*), regardless of fit, while learners of Korean ignored this distinction in favor of a discrimination between tight fit and various loose-fit and loose contact events along the lines shown in figure 13.2. The Korean-speaking children also distinguished, like adults, between putting clothing on the head, the trunk, and the feet—all *(put)* ON for the learners of English. Although figures 13.1 and 13.2 show only acts of "joining" objects (putting in, on, etc.), acts of separation are also treated differently in adult English and Korean, and the children showed sensitivity to these distinctions as well: for example, learners of English discriminated between *out* of a container and *off* a surface, while learners of Korean used *ppayta* 'remove from tight fit' (the opposite of *kkita*), *kkenayta* 'remove from loose containment' (the opposite of *nehta*), and *pesta* 'remove clothing item' (from any body part). In short, when the children talked about spatial events, they classified them in language-specific ways. (Of course, this does not mean that they never made errors from the adult point of view. Errors will be discussed in section 13.3.)

13.2.2.3 Elicited Production Spontaneous speech data offer valuable clues to children's early semantic categories, but comparisons across children and across languages are often indirect, since children do not talk about exactly the same events. To allow for more exact crosslinguistic comparisons and quantitative analysis, we designed an elicited production study to examine how speakers of English, Korean, and an additional language, Dutch, encode actions of joining and separating objects (Bowerman 1996a; Choi 1997). In a playlike setting, we elicited descriptions of a wide range of actions from 10 adult speakers of each language and 10 children in each of three age groups ranging from 2 to 3½ years. The actions included putting objects into tight and loose containers and taking them out, attaching and detaching things in various ways, putting objects down on surfaces, opening and closing, hanging and "unhanging," buttoning and unbuttoning, and putting on various clothing items and taking them off.

To compare the linguistic classification systems of speakers from different language and age groups, we examined which actions they used the same expressions for and which ones they distinguished. The logic is like that used in analyzing sorting task data: actions described in the same way are like stimuli sorted into the same pile; actions described in different ways are like stimuli sorted into different piles. The data can be represented in similarity matrices (for all actions taken pairwise: does the person use the same expression? different expressions?), and these can be analyzed with techniques suitable for similarity data, such as multidimensional scaling or cluster analysis (see Bowerman 1996a). If language learners initially map spatial words onto a universal set of basic spatial notions, children at least in the youngest age group ($2–2\frac{1}{2}$ years) could be expected to classify events more like same-age children learning other languages than like adult speakers of their own language. If they classify more like same-language adults, this means that their word use is guided by categories that are already language specific, even though perhaps not yet entirely adultlike.

The outcome of the analyses was clear: from the youngest age group on up, the children grouped and distinguished the actions significantly more like adult speakers of their own language than like same-age children learning the other two languages. As in their spontaneous speech, the children learning English, like the adults in this study, distinguished systematically between events of containment (e.g., putting toys into a suitcase, small cars into a box, and a piece into a puzzle, all described as *(put)* IN) and events of contact/support/surface attachment (e.g., putting a suitcase on a table, a Lego on a Lego stack, a ring on a pole, and clothing onto various body parts, all called *(put)* ON). In contrast, the children learning Korean—also as in their spontaneous speech and like the adults in this study—subdivided events of containment depending on whether they were loose (e.g., toys into suitcase, cars into box: *nehta* 'put loosely in/around') or tight (e.g., piece into puzzle: *kkita* 'interlock, fit tightly'), and they grouped tight containment events with tight surface attachment or encirclement events (e.g., joining Legos, putting a cap on a pen or a close-fitting ring on a pole) (all *kkita*). They also used different verbs, as is appropriate, for putting clothing on the head, trunk, and feet. This study shows that by at least 2 to $2\frac{1}{2}$ years of age, children learning different languages classify space in strikingly different ways for purposes of talking about it.

13.2.2.4 Early Comprehension The studies just discussed establish that learners achieve language specificity very early. But how early? Do they discover the spatial semantic categories of their language only in the early phases of actually *producing* spatial words, or do they begin to work on them even earlier, in pre-production language *comprehension*?

To explore this question, we designed a crosslinguistic preferential looking study to compare very young children's comprehension of two early-learned words with overlapping denotations: *put in* for learners of English and *kkita* 'interlock, fit tightly' for learners of Korean (Choi et al. 1999). This study showed that children understand these categories language-specifically at least by 18 to 23 months (the only age group tested): hearing *put in* (embedded in various carrier phrases) directed our English-learning subjects' attention toward events involving containment, regardless of tightness of fit, whereas hearing *kkita* pulled our Korean-learning subjects' attention toward events involving tight fit, regardless of containment. This looking pattern is illustrated in figure 13.3 for two of the four event pairs used.

Most of the children were not yet producing the target word for their language, according to parental report, which suggests that sensitivity to language-specific spatial categories begins to develop in comprehension even before production sets in. This finding allows us to reconcile two observations that have previously seemed to conflict. On the one hand, children often generalize spatial words rapidly to a wide range of referents in their production—a finding that has been taken as evidence that the words express meanings that originate in nonlinguistic cognition (e.g., McCune-Nicolich 1981; Nelson 1974). On the other hand, as soon as children use spatial words productively, they use them to pick out language-specific categories of meaning—a finding that suggests guidance from the input language. How can both things be true? The results of our comprehension study suggest that generalization in early production can be both rapid and language specific because children start to work out the categories in comprehension before production begins.

13.2.2.5 Additional Evidence for Language Specificity in Early Spatial Language Containment and support are not the only spatial domains that are treated differently by children learning different languages. Another important area of diversity is the expression of *vertical motion*. In English, the commonality among diverse events involving motion "up" and "down" is captured with the path particles *up* and *down*, which can be combined with many different verbs (e.g., *go/climb/slide* UP/DOWN, *pick* UP, *put* DOWN, *sit/stand* UP, *sit/lie* DOWN, *look* UP/DOWN). English-

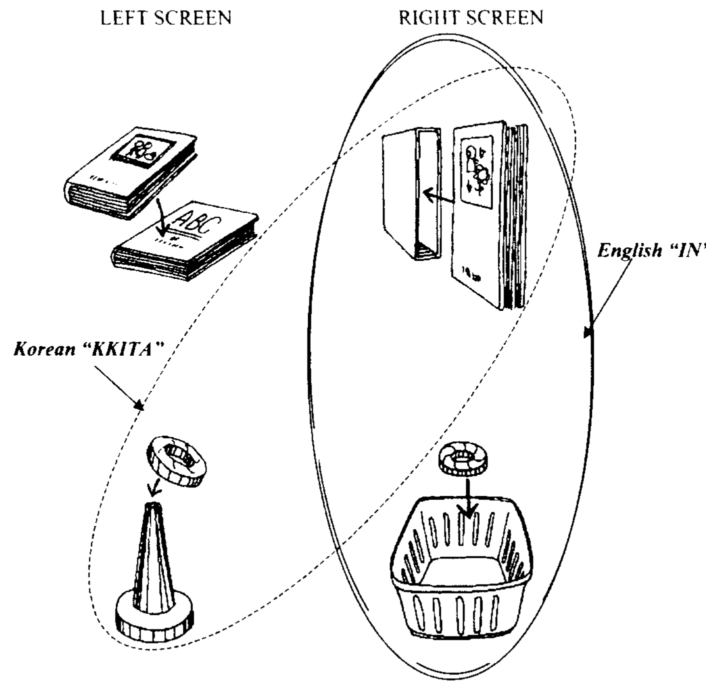

Figure 13.3
Two pairs of scenes used to test comprehension of English *put in* and Korean *kkita* in Choi et al. 1999, showing the language-specific looking patterns obtained

speaking children grasp the abstract spatial meaning of these morphemes very early. *Up* and *down* figure among their first relational words, emerging sometimes by as early as 12 to 14 months and typically by 16 to 17 months (Bloom 1973; Choi and Bowerman 1991; Gopnik 1980; Greenfield and Smith 1976; Nelson 1974; Smiley and Huttenlocher 1995). Some children restrict them initially to spontaneous and caused movements of their own body, while others generalize them immediately across a wide range of referents (see Choi and Bowerman 1991, 100ff., for discussion); by the end of the second year of life, however, children typically use them freely for a variety of "vertical motion" events, both familiar and novel. A few examples from a little girl between 13 and 16 months: *down* as she tried to climb down from a counter and as a request to be taken down from it, while she sat at the top of a slide preparing to slide down, when dumping yarn into a wagon, when setting books on the floor, and when trying to take a small chair down from on top of a low table (Choi and Bowerman 1991).

Korean lacks all-purpose "up" and "down" morphemes, and the encoding of events involving vertical motion develops very differently in learners of this language (Choi and Bowerman 1991). Children learning Korean talk about events involving vertical motion using a large variety of verbs, which enter their speech piecemeal between the ages of about 17 and 24 months and are used appropriately for relatively specific categories of action, either spontaneous (intransitive verbs) or caused (transitive verbs): for example, first *anta* 'hold/carry in arms' and *epta* 'hold/carry on back' as requests to be picked up, and *ancta* 'assume a sitting posture' (either 'up' or 'down'), *nwupta* 'lie down', and *ileseta* 'stand up' for posture changes; later *ollita* 'cause to ascend' and *naylita* 'cause to descend' for putting objects on a raised surface or taking them down; still later *olla kata* 'ascend go' (=go up) and *naylye kata* 'descend go' (=go down) for spontaneous vertical movements like negotiating stairs or climbing on and off furniture. If learners of Korean recognize a common element of vertical motion "up" or "down" across these events, this is not apparent in their word use; for example, they do not overextend *ollita* 'cause to ascend' to requests to be picked up or helped to stand up.

Like children learning Korean, children learning Tzeltal and Tzotzil, sister Mayan languages spoken in the Chiapas highland of Mexico, use no all-purpose words for vertical motion "up" or "down," but distinguish a variety of posture changes, ways of being picked up and carried, and falling. They are also quick to get the hang of a number of verbs that distinguish language-specific categories of positioning: for example, *nuj* 'be located face down/upside down', *kot* 'be located standing on all fours', *pak'* 'be located on the ground', and *kaj* 'be located on a high surface' (Tzotzil), and *pach* 'be located, of an upright bowl-shaped object' (Tzeltal) (Brown 2001; de León 1999, 2001). A favorite early verb for children learning Tzotzil is *xoj*, which specifies actions in which an elongated object ends up encircled by a ring- or tube-shaped object. This

verb—which picks out a topological category different again from those of English *put in* and *put on* and Korean *kkita*—is used appropriately at a very young age for actions that result in a "ring-and-pole" configuration regardless of whether it is the "ring" or the "pole" that is moved: for example, putting a ring on a pole or a pole through a ring, an arm in a sleeve, a leg in a trouser-leg, a head through an opening in a shawl, a chick in a blouse pocket, and a coil of rope over a peg (Bowerman, de León, and Choi 1995).

13.2.3 Summary: Universality and Language Specificity

Previous work has suggested that early spatial concepts are universal, with children mapping the spatial morphemes of their language directly to such presumably basic notions as containment, contact and support, and vertical motion "up" and "down," after these become available in the course of nonlinguistic cognitive development. It is true that children initially concentrate on words for various kinds of topological relationships and for events involving vertical motion, and this focus is presumably conditioned by cognitive factors. But within these bounds, the meanings of children's early spatial words are by no means universal, and the ways they differ are consistent with differences in the target languages' partitioning of these semantic domains.

13.3 Do Children Construct Semantic Categories of Space? Evidence from Error Patterns

Does early language-specific variation in children's semantic categorization of space mean that learners are capable of using linguistic input to actively construct spatial categories that they might otherwise not have had? This is one possible explanation for the findings, but it is not the only one. An alternative is that children's early nonlinguistic repertoire of spatial concepts is more extensive than has been assumed, including not only the notions of containment and support corresponding to English *in* and *on*, but also a notion of tight fit or interlocking corresponding to Korean *kkita*, and presumably further concepts corresponding to the categories of early-learned spatial words in other languages (Mandler 1992, 1996; see Bloom 2000, 250–254, for discussion).

Under this scenario, children's task would not be to construct a concept to account for a word's pattern of use in the input, but to select, from among the concepts already available to them, the one that adult speakers intend when they use the word (see Gleitman 1990 for similar assumptions about the early acquisition of verb meanings).

As Bloom notes, "this alternative is plausible only to the extent that one doesn't have to posit a new set of nonlinguistic spatial notions for every language we look at; the variation that exists should be highly constrained"; ideally, there should also be "evidence for these putatively nonlinguistic spatial categories in babies" (2000, 252). At present, spatial semantic development has been investigated in too few languages to establish just how constrained the list of notions would be (although it is worth noting that so far, each new language examined has turned up new candidates, such as Tzotzil *xoj* 'put into a "ring-and-pole" configuration', and Tzeltal *pach* 'be located, of an upright bowl-shaped object'). Evidence on babies' spatial categorization will be discussed in section 13.5.

Interesting additional clues to whether language learners simply choose from among preexisting concepts, or can actively construct semantic categories from early on, come from errors in children's use of spatial words (Bowerman 1996a; Bowerman and Choi 2001; Choi 1997). Recall, for example, that children often overextend words for "separating" objects. These errors have typically been interpreted as evidence for a direct reliance on nonlinguistic concepts of space—that is, on children's sense that events of certain kinds are so similar that they should be described with the same word even though adults may describe them using different words (Bowerman 1978; Griffiths and Atkinson 1978; McCune and Vihman 1997). If this view were correct, we could expect a very strong convergence across children learning different languages on the makeup of the categories picked out by their early uses of "translation equivalent" words. But this is not the case: whether or not children overextend a particular word, and the exact shape of their extension patterns, turn out to differ across languages in ways that are closely related to semantic and statistical properties of the target language.

Errors with *open* and its translation equivalents provide a good illustration. These errors have been reported in children's spontaneous speech in English and several other European languages (Bowerman 1978; Clark 1993). Typical are examples from a child who used *open* between about 16 and 21 months not only for canonical actions on doors, windows, boxes, and the like, but also for separating two Frisbees, unscrewing a plastic stake from a block, spreading the handles of nail scissors apart, taking the stem off an apple, a piece out of a jigsaw puzzle, a handle off a riding toy, and a shoe off a foot, and also for turning on an electric typewriter, a light, and a water faucet (Bowerman 1978). Similar errors occurred in our crosslinguistic elicited production study (section 13.2.2.3): children from 2 to $3\frac{1}{2}$ years learning English or Dutch often overextended *open* (Dutch *open[-maken]* 'open[-make]') to actions like pulling Pop-beads and Lego blocks apart, undoing a Velcro fastening, and taking the top off a pen or a shoe off a foot.

Children learning Korean, in contrast, scarcely make this error. In our elicited production study, there was only one such overextension (*yelta* 'open' for unhooking two train cars); and in the spontaneous speech data examined in Choi and Bowerman (1991), there were none. How to explain this difference? A plausible answer points to differences in the breadth and makeup of the categories in the "opening" domain in Korean versus English (and Dutch) (Dutch *open* 'open' has an extension similar to that of English *open*). As shown in figure 13.4, actions that fall uncontroversially into the *open* category in English are split up in Korean into a number of more specific categories, many of which include events that would not be described as "opening" in English: opening doors, boxes, bags, and the like (*yelta*, the verb most similar to *open*); opening objects with two parts that separate symmetrically (a clamshell, a mouth, a pair of shutters or sliding doors) (*pellita*); opening things that spread out flat (a book, hand, or fan) (*phyelchita*); and so on.

The possible effect of these differences on learners is suggested by a simple experiment by Landau and Shipley (1996), which tested how children generalize names for novel objects. Two different novel objects —the "standards"—were placed in front of 2- and 3-year-old children. Children in the same label condition heard the same name applied to

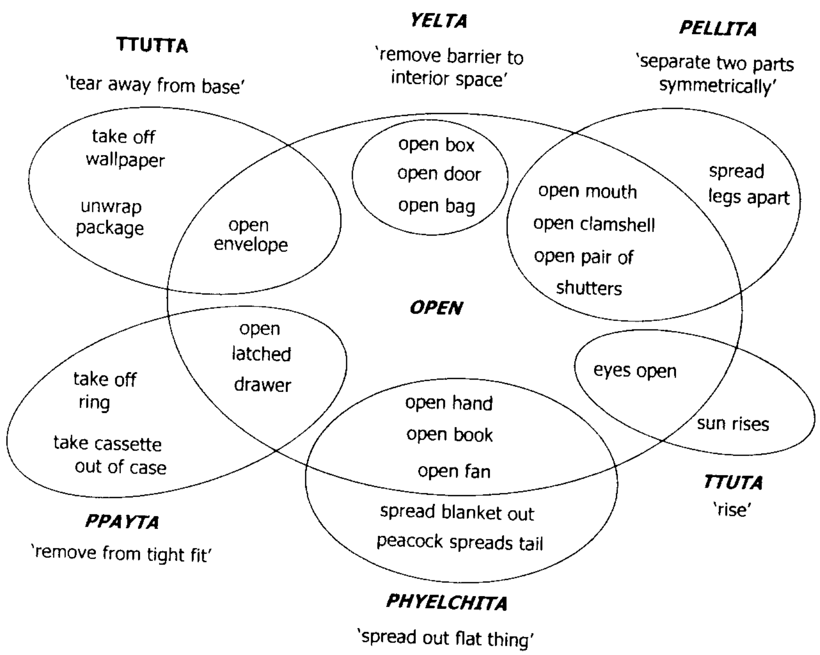

Figure 13.4
Categorization of "opening" in English and Korean

both standards ("This is a blicket ... and this is a blicket"). Children in the different label condition heard different names ("This is a blicket ... and this is a steb"). Now the children were shown, one by one, four test objects, which had been "morphed" so that they were intermediate in shape along a continuum between the two standards. When asked, for each test object, "Is this a blicket?," children in the same label condition accepted *blicket* at ceiling for all test objects, but children in the different label condition accepted it decreasingly as the test objects grew less like the first standard and more like the second. Landau and Shipley conclude that hearing identical labels can induce children to "'fill in' the gap between even very different exemplars, probably guided by the assumption that members lying on the hypothetical similarity line between standards

are also members of the category" (p. 446). Hearing different labels, in contrast, leads children to set up a boundary somewhere on the gradient between the two exemplars.

To apply the logic of this experiment to the treatment of candidate "opening" actions, children learning English and Dutch are in the same label condition: they are invited, on hearing *open* applied to so many different kinds of actions, to generalize very broadly;[5] object details like having symmetrically moving parts or being able to spread out flat are taken to be irrelevant to the meaning of the word. Children learning Korean, on the other hand, are in the different label condition: hearing a different word at every juncture dampens the inclination to generalize *yelta*, the word for the most prototypical "open" events.

But Korean learners do have another word, also shown in figure 13.4, that they overgeneralize to many events of "separation": *ppayta* 'uninterlock; remove from tight fit' (this is the opposite of *kkita* 'interlock, fit tightly', although it is more tolerant in what it counts as a "tight fit"). Is this then simply another word for the same concept to which learners of English and Dutch (over)extend *open*? It is not. Critically, although the extensions of Korean *ppayta* and English or Dutch *open* overlap in children's speech, they show clear language-related differences (Bowerman and Choi 2001); this is especially obvious in the distribution of responses in our elicited production task.

Learners of Korean who participated in this task, like the adults, used *ppayta* most frequently and consistently for *separating fitted, meshed, or interlocked objects with a bit of force* (e.g., pulling Pop-beads or Lego blocks apart, taking the top off a pen, prying an audiocassette out of its case). From this core meaning, they sometimes overextended it to separations involving other objects or object parts that were somehow "engaged" with each other, even if not tightly fitted (e.g., opening a box or suitcase, taking Legos out of a bag, "unsticking" adhering and magnetized objects, and taking off clothing); in these uses, however, *ppayta* competed with other, more appropriate words in the children's speech.

In contrast, uses of *open* by learners of English and Dutch in this task—as in the speech of the adult participants—centered on *separation as a means of making something accessible* (e.g., opening a box, suitcase, or cassette case to get at something inside; cf. also the predominant uses in children's spontaneous speech for opening doors, windows, etc.—Bowerman 1978). From this core, *open* was extended relatively rarely to separating objects such as Pop-beads or Legos and to taking off clothing (these actions were much more often called *[take]* OFF by the learners of English), or to taking things out of containers (much more often called *[take]* OUT). Spontaneous speech data (Bowerman 1978; Clark 1993) show that English learners also overextend *open* to events where something is made accessible with little or no separation of "engaged" elements, such as turning on an electrical appliance or water faucet, pulling a chair away from a table, bending a knee to reveal a toy hidden behind it, and sliding a T-shirt up to peek at the belly beneath. Korean learners do not use *ppayta* for these events, presumably because its primary use in adult speech has to do with the physical disconnection of engaged elements, and not (in contrast to adult English *open*) with making something accessible.

Examples like these suggest that even very young children are closely attuned to the way words are distributed across events in the speech they hear, and that their word meanings can be influenced by factors such as the number and semantic makeup of competing forms, the frequency and consistency with which a form is used for events of various types, and (not illustrated here, but see Bowerman 1996a) the presence or absence of polysemy in a word's meaning. These are the kinds of factors that have been singled out in "usage-based" approaches to language, which stress the dynamic properties of linguistic knowledge and posit that speakers of all ages can induce schemas and continually restructure them in response to (possibly shifting) patterns in the linguistic input (e.g., Bybee 1985, 1991; MacWhinney 1987). This view of category construction lends itself well to computational modeling of schema induction, and indeed, Regier (1997) has successfully modeled some of the differences between young learners of English and Dutch in the elicited production study discussed here and in section 13.2.2.3.

Category construction of course requires both a learning mechanism and raw materials (perceptual or conceptual sensitivities) that can be structured into new configurations. Let us consider these requirements in turn.

13.4 Mechanisms of Category Construction

In an earlier era, when it was more usual to suppose that different languages make use of different concepts and that language input has something to do with the formation of new concepts, Roger Brown described the process of lexical development as "the Original Word Game." In this game,

> the tutor names things in accordance with the semantic custom of his community. The player forms hypotheses about the categorial nature of the things named. He tests his hypotheses by trying to name new things correctly. The tutor compares the player's utterances with his own anticipations of such utterances, and, in this way, checks the accuracy of fit between his own categories and those of the player. He improves the fit by correction. (1958, 194)

In this formulation of the learning process, one of the critical problems that Brown was trying to solve was the fact that "everything in the world is susceptible of multiple categorizations" (1958, 225). This means that even if children know what a word refers to in a particular context (i.e., have solved "Quine's problem" of identifying the referent), they cannot be certain how to identify additional instances of the same category. The ambiguity is reduced when the word is encountered again in other contexts: "a speech invariance is a signal to form some hypothesis about the corresponding invariance of referent" (1958, 228). In today's intellectual climate, we would resist the implication that children formulate and test their hypotheses consciously, or that improving the fit between hypothesis and target category requires explicit correction. Still, Brown's characterization of how children could form categories under linguistic guidance retains a strong intuitive appeal. What is lacking, however, is an explicit specification of the learning procedure.

A modern approach to learning with the potential to capture Brown's insights more precisely is *structure-mapping* (Gentner 1983, this volume; Gentner and Loewenstein 2002; Gentner and Markman 1997; Gentner and Namy 1999; Gentner and Rattermann 1991). Structure-mapping theory, which focuses on the acquisition of relational concepts by learners of any age, posits that relational abstractions can emerge in the course of *comparing* exemplars. In the process of comparing, the learner tries to align structured conceptual representations with each other and to identify the ways in which they are similar and different. Alignments are typically shallow at first, suggests Gentner, based primarily on similarities in the objects that play a role in the situations being compared (we come back to this shortly). But with successive opportunities to compare situations in which the objects vary, alignments based on more abstract similarities in the *relationships* among the objects are discovered. Studies have suggested that the process of comparing can call attention to abstract relational similarities that otherwise go unnoticed (Kotovsky and Gentner 1996; Loewenstein and Gentner 2001).

In experiments, comparisons leading to relational abstractions have been stimulated in a variety of ways—for example, by presenting subjects with successive exemplars of a candidate relationship or explicitly asking them to compare instances (Gentner and Loewenstein 2002; Gentner and Namy 1999). Gentner hypothesizes that one stimulant to comparison with tremendous importance for children's development is *hearing the same word applied to different situations* (cf. Brown 1958, 210: repetitions of a word across contexts "will orient the player toward contemporaneous stimuli and will tell him when the important nonlinguistic stimuli recur"). Note that specific instantiations of the concepts encoded by words typically occur at different times, often embedded in very different contexts, and are in no other way flagged as being somehow "the same." Being prompted to compare situations that are called by the same word—for example, events labeled *open* or *take off*, or behaviors described as *cruel* or *generous*—could lead learners to search for and extract cross-situational commonalities that are considered important in their society. The word that promotes the comparison of instances, suggests Gentner, also provides a convenient label for the relationship that the flagged situations share, and this makes the relationship more accessible the next time it is relevant.

Notice that in our earlier discussion (section 13.3) of why children learning English and Dutch overextend their word for prototypical "opening" events, while children learning Korean do not, we already made an implicit appeal to a process of comparison. There, we suggested that in using the word *open*, English-speaking adults in essence invite children to generalize broadly: by flagging a set of events as diverse as opening a door, opening the eyes, and opening a book, they implicitly prompt children to *compare* them in search of some commonality. Depending on the semantic categories of the language, the set of events singled out for comparison will differ, so the scope of the learner's final categories will differ. For example, to arrive at a concept that accounts for the distribution of *open* in English, learners must ignore the identity and many of the properties of the objects involved in the events labeled *open*, and bring into focus an abstract relationship that has to do with making something accessible. In contrast, to grasp the meanings of the "opening" verbs in Korean, children must recognize that certain object information is critical—for example, that uses of *pellita* all involve objects with two parts that are separated symmetrically (mouth, clamshell, sliding doors that meet in the middle, pair of legs) and that uses of *phyelchita* all involve objects that can be spread out flat (book, hand, fan, picnic cloth) (see figure 13.4).

Many of Gentner's experiments in domains other than language acquisition have suggested that it is difficult for learners to disregard object information in favor of a relational commonality—that abstraction proceeds stepwise, first to situations that are closely similar to the original exemplars and only later to situations involving very different kinds of objects. Counter to this, we have often been impressed, in our work on the acquisition of relational words, at how quickly children make conceptual leaps to contexts quite different from those in which a word has been modeled (see, e.g., the broad overextensions of *off*, *open*, and other relational words discussed in Bowerman 1978, 1980). In our view, the learning of relational words can proceed in either direction: either by stepwise extension from known exemplars (abstraction; expanding the domain of an initially underextended word) or by adding critical information that was initially overlooked (differentiation; narrowing the domain of an initially overextended word).[6] Regardless of directionality, what is crucial is the process of comparison, and it seems plausible that language—here, the way spatial words are distributed across referent events in the speech children hear—guides learners in discovering what needs to be compared, and so can influence the final makeup of learners' semantic categories.

13.5 Raw Ingredients for Category Construction: What Are Infants' Spatial Sensitivities?

Obviously, a serious theory of learning cannot conjure up concepts out of nothing. Even a theory like structure-mapping, which posits that deep relational structures that are not known a priori can be disembedded over time from a morass of surface detail, must presuppose that learners have the wherewithal to set up initial representations of situations and that they are sensitive to certain properties and dimensions along which situations can be compared. Establishing exactly what these building materials consist of (e.g., domain-general sensitivities to perceptual properties? domain-specific sensitivities, such as "semantic primitives" for space? more abstract inborn conceptual knowledge?) is one of the most challenging and controversial questions facing developmentalists today (see, e.g., Fodor 1975; Landau and Jackendoff 1983; Mandler 1992, 1996; Spelke et al. 1992, for some different views on the problem). In the domain of space, one critical source of evidence for investigating these issues is information about what kinds of spatial distinctions and similarities are salient to infants *before* they acquire spatial words.[7]

13.5.1 Containment, Support, and Tight Fit

Casasola and Cohen (2002) have recently examined the prelinguistic status of three categories of central interest to us: CONTAINMENT (English *in*), SUPPORT (English *on*, encompassing both support from beneath, as in *Put the cup on the table*, and surface attachment, as in *Put this Lego block on that one*), and the INTERLOCKING/TIGHT-FIT category associated with Korean *kkita*, which crosscuts "in" and "on" relations. Two groups of infants from an English-speaking environment, 9–11 months (prelinguistic stage) and 17–19 months old (early linguistic stage), were habituated to four videotaped actions showing events of putting varied objects into either a containment, a support, or a tight-fit relation.[8] Four test trials followed: (1) familiarized objects being put into the familiar relation (one of the habituation events again), (2) familiarized objects put into a novel relation, (3) novel objects put into the familiarized relation, and (4) novel objects put into a novel relation.

At both ages, infants who had been habituated to the containment relation discriminated reliably (as determined by assessing which events caused their attention to revive) between this relation and another (a support event) regardless of whether the objects depicting the relation were familiar or novel. But at neither age did the babies who had been habituated to the support or tight-fit relation discriminate between the familiar relation and the novel relation (a tight containment event for the support condition and a loose containment event for the tight-fit condition). The younger babies in the support and tight-fit conditions reacted only to the novel objects, not to the relationships. The older babies discriminated between familiar objects in the novel versus familiar relation, but they did not look longer at novel objects in the novel relation than at novel objects in the familiar relation; apparently they had not picked up on the support or tight-fit property shared by all the habituation events they had witnessed.

In sum, this study provides evidence that prelinguistic infants are sensitive to a category of "containment" events, but not to the categories of "support" and "tight-fit" events, at least as operationalized here. Of course, further studies using other techniques may still reveal such sensitivities. But for the moment—as also noted by Casasola and Cohen—this outcome leaves open the possibility that these two categories are constructed in the course of learning the meaning of English *on* or Korean *kkita*.[9]

13.5.2 Tight versus Loose Containment

Discovering a shared property of "tight fit" that transcends containment events requires being able to distinguish, *within* the containment category, between putting things into containers that fit tightly (e.g., a book into a fitted box-cover: Korean *kkita*) versus into containers that fit loosely (e.g., an apple into a bowl: Korean *nehta*; see figure 13.2). To explore whether prelinguistic infants are sensitive to these subcategories of containment, McDonough, Choi, and Mandler (in press) tested infants 9, 11, and 14 months of age from both English- and Korean-speaking environments.

The study employed a modified version of the familiarization-novelty preference procedure used by Behl-Chadha and Eimas (1995) and Quinn

(1994) to study the categorization of left-right and above-below in young infants. Babies were first shown six pairs of videotaped scenes of putting one object into another. Half were familiarized with *tight-fit* containment events (the tight-IN condition), and the other half with *loose-fit* containment events (loose-IN); in both conditions, a wide range of figure and ground objects were used. After familiarization, two test trial pairs were shown, identical for children in the two conditions: one member of each test pair showed putting yet another novel object into yet another tight-fitting container (a novel relation for children in the loose-IN condition); the other member showed putting this same novel object into a loose-fitting container (a novel relation for children in the tight-IN condition).[10]

Infants from both language environments and in all three age groups (9, 11, and 14 months) looked longer at the test scenes showing an additional instance of the *familiar* relation than at the test scenes showing an instance of the *novel* relation, regardless of which relation—tight-IN or loose-IN—they had been familiarized on.[11] These results show that babies in this age range can discriminate between tight and loose containment events. Thus, sensitivity to the tightness of a containment event—handy if you happen to be growing up in a Korean-speaking environment—is accessible to preverbal children.[12]

13.5.3 Summary on Infant Spatial Sensitivities, and a Caveat

To summarize, studies of infant cognition using the habituation/familiarization paradigms show that already in the first year of life, babies are sensitive to three categories of spatial events that are relevant to the spatial words we have been considering: "containment" (Casasola and Cohen 2002; section 13.5.1) and two subcategories of containment, "tight" versus "loose" (McDonough, Choi, and Mandler, in press; section 13.5.2). There is as yet no evidence for sensitivity to a *kkita*-style category of "tight three-dimensional fit" that encompasses both tight-fit containment and events of surface attachment/covering/encircling, nor for an *on*-style category of support that encompasses both placing things loosely on surfaces and juxtaposing surfaces by attachment, covering, or encirclement.

It is important to recognize that although these studies show a prelinguistic sensitivity to certain categories, they do not establish just when or how the categories emerged. The infants' grasp of the categories might already have been firmly in place before the experiments began—available when needed. Also possible, however, is that the infants became sensitized to the categories *in the course of the experiment*.

Recall that, according to structure-mapping theory (Gentner, this volume; Gentner and Namy 1999), an appreciation for an abstract relational similarity often emerges through the process of *comparing* situations and trying to align them with one another. Language is, by hypothesis, one good way to prompt comparison, but it is not the only one. Assuming that infants have attained a certain minimal level of cognitive "readiness" (also of course necessary before the language-guided learning of a new category could take place), being shown successive actions all instantiating the same candidate event category (e.g., "containment" or "tight containment") during the familiarization phase of an experiment might prompt babies to discover an abstract relational similarity they had not previously recognized.

Results from the domain of early speech perception (Maye, Werker, and Gerken 2002) show that babies are in fact astonishingly sensitive to the statistical distribution of the stimuli they encounter in the familiarization/habituation phase of a study. Babies 6 and 8 months old were exposed for only 2.3 minutes to one of two frequency distributions of the same set of speech sounds ranging along a continuum from /ta/ to /da/: a *bimodal* distribution (the most frequently presented sounds were clustered at the /ta/ and /da/ ends of the continuum, with fewer from in between) and a *unimodal* distribution (the most frequently presented sounds were the ones intermediate on the continuum, with fewer from either pole). On the test phase of the study, only the infants in the bimodal condition discriminated tokens from the endpoints of this same continuum; babies in the unimodal condition did not.

Applying the reasoning to the "containment" studies, we can imagine that familiarization/habituation to a set of containment events that are all "tight" or all "loose," as in McDonough, Choi, and Mandler's study, may—analogously to the bimodal condition used by Maye, Werker, and

Gerken—cause the child to (temporarily?) set up a relatively narrow category (either tight or loose containment), thereby promoting discrimination of these events from events of the opposing degree of fit. In contrast, familiarization/habituation to a range of containment events that encompasses *both* tight and loose instances, as in Casasola and Cohen's study, may—analogously to the unimodal distribution—lead to formation of a single, more abstract category, which can be discriminated as a whole from events belonging to still another category, such as support.

Clearly, more research is needed to determine how much the categories to which preverbal infants show sensitivity can be manipulated by changing the exact makeup of the familiarization stimuli: high malleability would suggest a strong potential for rapid online learning, while low malleability would suggest that children rely in this experimental paradigm on category distinctions that are already available to them.

13.6 Does Learning Language-Specific Spatial Semantic Categories Affect Nonlinguistic Cognition?

Let us now return to the Whorfian question: does learning the spatial semantic categories of our native language influence how we think about space? If the requirement to learn the meanings of the words in their language causes children to form concepts of space that they would not otherwise have had, then in this minimal sense language can be said to affect cognition. But inquiries into the Whorfian hypothesis usually rightly hold out for more: for evidence that even when people are *not* talking or listening to speech, the structure of their language influences their cognition—for example, their perceptual sensitivities, their nonlinguistic similarity judgments, their recall accuracy, or their problem-solving strategies.

It is by no means necessary that the semantic spatial categories of a language affect the way its speakers deal with space nonlinguistically. In a domain other than space, Malt et al. (1999) showed that when speakers of English, Spanish, and Chinese were asked to label a set of containers (bottles, jars, etc.), the three language groups classified very differently from one another, but when they were asked to compare objects and judge how similar they were to one another, their classifications were

much more alike. Whorfian effects have, however, been documented in tasks having to do with space (see the frame-of-reference studies discussed in Levinson 1996, this volume; Pederson et al. 1998) and for nonlinguistic categorization in domains other than space (Lucy 1992; Lucy and Gaskins 2001, this volume). So the potential for Whorfian effects on nonlinguistic spatial categorization remains open.

To explore whether the spatial semantic categories of English versus Korean affect speakers' nonlinguistic sensitivities, McDonough, Choi, and Mandler (in press) extended the familiarization-novelty preferential looking task described in section 13.5.2, which tested tight and loose containment, to *adult* speakers of these languages. The adults were simply asked to watch the video scenes. Their gaze behavior, like that of the babies, was videotaped, and the amount of time they spent watching the familiar versus novel events on the test trials was compared. Recall that 9- to 14-month-old babies in both language communities looked significantly longer at the test scenes showing the relation they had been familiarized on, regardless of whether it was tight or loose containment, thereby showing that they are sensitive to this distinction. Adult speakers of Korean behaved in exactly the same way. Adult speakers of English, in contrast, looked equally long at the two members of each test pair; they showed no sensitivity to the distinction between tight and loose containment. These data suggest that the distinction between tight and loose containment events, if English speakers recognize it at all, is far less salient to them than it is to Korean speakers. This is a real Whorfian effect.[13]

Even if English-speaking adults do not notice the distinction between tight and loose containment events in the course of casual viewing, could they do so if prompted to compare and contrast the events more explicitly? Immediately after participating in the preferential looking task just described, the adult subjects in McDonough, Choi, and Mandler's study took part in an oddity task. Four of the actions they had just seen on the looking task were acted out for them with real objects: three came from the familiarization trials and one was a test pair action depicting the novel relation. For example, participants who had just been in the tight containment familiarization condition were now presented with three instances of tight containment events (putting a Lego person in a Lego car, a book in a matching box-cover, and a cork in a bottle) and one instance of a loose containment event (putting sponge letters in a large bowl). The experimenter performed the four actions one by one, just as in the video scenes, and then asked the participant, "Which is the odd one?" After making their selection, participants were asked to explain it.

Across the two conditions, significantly more Korean- than English-speaking adults based their choice on degree of fit (80% vs. 37%). Almost two-thirds (63%) of the English speakers selected on the basis of object properties (e.g., texture, size, or function of the object)—for example, "This one is made of glass," "This is a tall object." Thus, even when they were explicitly asked to compare a set of events all involving containment, the English speakers were relatively insensitive to the tight- versus loose-fit distinction; their attention was drawn much more to the properties of the objects.

These differences in sensitivity to tight versus loose containment of course mirror the differences in the semantic categories of the two languages. When talking about putting one thing into another, Korean speakers must assess how tight the containment relationship is so that they can choose appropriately between *kkita* 'interlock, fit tightly' and *nehta* 'put loosely in/around'. English speakers *can*, of course, also talk about this distinction if it is really important to do so (as we have been doing throughout this chapter, with the aid of imprecise translations plus examples to illustrate what we mean), but they rarely need to worry about it: for everyday purposes, an all-encompassing *(put)* IN is sufficient.

13.7 Conclusions

Taken together, the studies discussed in sections 13.4–13.6 suggest a developmental sequence in the acquisition of language-specific categories of space that goes something like this. (Of course, there is no reason to suppose that space is the only conceptual domain in which this process is at work.)

Before embarking on the language acquisition task, infants notice many different properties of specific spatial situations. Some of these properties may already take a relatively abstract form and so immediately be recognized as applying to a number of different situations ("containment" might be a case in point). Other properties may be more embedded in the contexts in which they occur (e.g., "attachment in the Lego fashion" might be seen as distinct from "attachment in the cap-on-pen fashion," so that infants are slow to recognize potential cross-contextual similarities among these situations unless they are prompted in some way to compare them.

In cases like this, an important stimulant to comparison can be hearing the same word. As the child encounters successive uses of the word, she "tries" (although this process is presumably rarely if ever conscious) to align the referent situations and work out what they have in common. Sometimes she may already have a suitable concept in her cognitive tool kit, but may simply not have noticed that it is applicable to some of the situations. Other times there is no existing concept that does the job, and the child has to construct a new one to account for the distribution of the word. (The qualifications mentioned in note 5 of course apply here too.)

As semantic categories are formed, the speaker becomes increasingly skilled at making the rapid automatic judgments they require; for example, Korean speakers implicitly monitor how tight the fit is in contexts of putting one object into contact with another, since the choices they have to make when talking about such events depend on it. These linguistically relevant sensitivities achieve and maintain a high degree of standing readiness (see also Slobin, this volume). Sensitivities that are not needed for the local language may diminish over time (although presumably they do not always do so). Loss of sensitivity seems especially likely in the case of distinctions that not only are irrelevant to the lexical and grammatical distinctions of the local language, but also crosscut the distinctions that *are* relevant, since attending to linguistically irrelevant distinctions might interfere with developing the automaticity that is needed for the linguistically relevant ones.

This sketch of semantic development, based on the research reviewed in this chapter, has some striking parallels to the view of early speech sound perception that has been built up over the last couple of decades. In the first months of life, infants have been shown to be sensitive to a large variety of phonetic distinctions, both those that play a role in their language and those that do not. By the end of their first year, infants have reorganized their pattern of speech sound discrimination around the phonetic structure of their native language, and they have lost sensitivity to some of the contrasts their language does not use (Best, McRoberts, and Sithole 1988; Kuhl et al. 1992; Polka and Werker 1994; Streeter 1976; Werker and Tees 1984, 1999). Though loss of sensitivity to phonetic contrasts has been the phenomenon most thoroughly documented and discussed, there is also evidence that linguistic experience can *increase* sensitivity to certain distinctions (Aslin et al. 1981; Polka, Colantonio, and Sundara 2001).

Just how deep the parallels go between early speech perception and the early development of semantic categories is not yet clear. For instance, does the decline in English speakers' sensitivity to the distinction between tight and loose containment demonstrated by McDonough, Choi, and Mandler (in press) come about quickly, as soon as language-specific principles of categorizing containment in English are learned, or does this happen only later? Are declines in sensitivity to semantic distinctions as persistent, even in the face of new experience, as declines in phonetic sensitivity, or are they easily reversed? There is clearly much work to be done here. One thing, however, is becoming clear: just as infants are geared from the beginning to discover underlying phonological regularities in the speech stream, so too are they born to zero in on language-specific patterns in the organization of meaning.

Notes

We thank Jürgen Bohnemeyer and Dan Slobin for helpful comments on earlier drafts of this chapter, and Jürgen Bohnemeyer for suggesting the title "Space under Construction."

1. In Talmy's (1985, 1991) typological classification of the characteristic ways languages express path meanings, English is a "satellite-framed" language—a language that expresses path meanings primarily through particles, prepositions, or affixes (cf. *go* IN/OUT/UP/DOWN/ACROSS and *put* IN/ON/TOGETHER, *take* OUT/OFF/APART). In contrast, Korean is a "verb-framed" language—a language that expresses path primarily through verbs with meanings suggested by English verbs such as *enter*, *exit*, *ascend*, *descend*, *insert*, *extract* (these verbs are not "native" to English, but are borrowed from Romance, where they represent the dominant pattern).

2. Sometimes *fit* is suggested to us as the English counterpart of *kkita*, but *fit* does not fit: in one way it is too general and in another too specific. Too general because for *kkita*, but not *fit*, figure and ground must have complementary shapes *before* the action is carried out, and the fit requires at least a slight degree of three-dimensional engagement (thus, *kkita* cannot be used in contexts like "Does this belt fit?" or "This bandage is too small to fit over the wound"). Too specific because *fit* is typically used only when the degree of fit is the point at issue, and not for actions like putting a cassette into its cassette case or the cap on a pen. Relatively low frequency English words like *interlock*, *mesh*, *couple*, or *engage* come a bit closer, but the first two suggest the involvement of more than one projecting part from each object, and the second two evoke the notion of a connecting link between two entities, such as train cars, so it is absurd to use them for putting a book into a tight box-cover or a cap on a pen—perfectly normal uses for *kkita*. The meaning of *kkita* can, of course, be approximated in English by combining words into phrases such as *tight fit*, as we have done in this chapter, but such phrases are inexact and cumbersome, and, as ad hoc compositions, they are not part of the permanent stock of semantic categories of English.

3. Conversely, of course, from the Korean point of view, the English insistence on honoring containment relations wherever applicable means that a commonality is missed between diverse events involving snug fit, regardless of whether the figure ends up "in," "on," or in some other relation to the ground.

4. It is important to look for evidence of productivity (e.g., uses of a word for novel referents, including referents for which adults would not use it). This is to rule out an interpretation for early language-specific word use that does not require crediting children with knowledge of language-specific categories: that children simply repeat what they have often heard adults say in particular contexts. (See Choi and Bowerman 1991, 110, for discussion.)

5. The range of exemplars across which generalization can take place is presumably constrained by both the child's level of cognitive development and the conceptual "stretch" required to bridge the gap. For instance, the meaning associated with *in front of* and *behind* will not at first include projective relationships based on speaker perspective (as in *The glass is in front of the plate*), even though uses for such relations occur in the input, because the child cannot yet understand them (Johnston 1984). And the meaning of *on* for young English speakers is unlikely to encompass both spatial applications and manipulations with lights and other electric appliances; more probably, these uses of *on* are acquired independently.

6. See Regier 1997 for relevant discussion of how a semantic category can initially be formulated too broadly but later narrowed. In a computational model of the learning of some of the spatial words used by learners of English and Dutch in the elicited production study discussed in sections 13.2.2.3 and 13.3, Regier shows that words that are initially overextended will gradually retreat to their conventional adult boundaries if the learning model is equipped with a weak sensitivity to the Principle of Mutual Exclusivity (Markman 1989): the idea that a referent object or event should have only one name.

7. A number of important studies have explored infants' ability to *reason* about spatial situations of the kind we are interested in—for example, whether they show surprise when confronted with impossible events of containment or support (e.g., Baillargeon 1995; Caron, Caron, and Antell 1988; Hespos and Baillargeon 2001; Needham and Baillargeon 1993). But this research does not fundamentally address how infants *categorize* these events—for example, which events they perceive as "the same" even when they are instantiated with different objects. In the following discussion, we will focus on studies of spatial categorization.

8. For example, children in the *containment* condition repeatedly saw four containment events, two "loose" (putting an animal into a basket, putting a car into a container) and two "tight" (candle into same-shaped cookie-cutter, green peg into yellow block), until they reached the habituation criterion. Children in the *support* condition similarly saw two "loose" and two "tight" habituation events. For children in the *tight fit* condition, the four habituation events comprised the two "tight" containment events used in the containment condition and the two "tight" support events used in the support condition; these events would all be described in Korean with the verb *kkita*. The study thus tested sensitivity to crosscutting event categories.

9. One reason why the tight-fit category of *kkita* might be difficult to form is suggested by the results of a study by Baillargeon and Wang (2002). These authors compared infants' ability to reason about "containment" versus "covering" events, both of which involved the same objects: a short, snug container and a cylindrical object taller than the container. In the containment event, the infant watched as the cylinder was lowered into the container until it could no longer be seen; in the covering event, the container, shown in an inverted position, was lowered over the cylinder until the cylinder could no longer be seen. Both events are impossible, and for the same reason: the container is shorter than the cylinder. But children do not apply the same reasoning when faced with the two scenarios: they show surprise at the impossible containment event already by $7\frac{1}{2}$ months, but they are not surprised by the impossible covering event until 12 months. What babies know about containment events, then, does not initially transfer to covering events, and this means, conclude Baillargeon and Wang, that "containment" and "covering" are, for them, distinct event categories. Intriguingly, *both* Baillargeon and Wang's containment and covering events would be described with the Korean verb *kkita*, as long as the cylinder and container fit each other precisely. If babies indeed see events of the two types as strictly different, it may be hard for them to spontaneously spot a property they can share, such as snug three-dimensional fit in the case of the cylinder and container. Perhaps here is a place where linguistic input—hearing the same word applied to seemingly disparate events—can prompt toddlers to discover a commonality that might otherwise go unnoticed. That is: children would try to align events whose initial representations are disparate, revolving around "containment" versus "covering," to discover what they have in common, and in so doing they would discover "three-dimensional tight fit."

10. The children in the tight-IN condition saw actions of putting (1) nesting cups into nesting cups, (2) shapes into matching holes in a shape box, (3) Lego people into fitted niches in cars, (4) toy keys into locks, (5) books into fitted box-covers, (6) corks into bottles. The children in the loose-IN condition saw actions of putting (1) Lego people into the bed of a truck, (2) shapes into jewelry boxes, (3) pom-poms into candy molds, (4) pencils into a pencil cup, (5) shapes into a long basket, (6) Bristle-blocks into a cloth bag. The test pairs were (a) putting sponge letters into matching holes in foam mats versus into loose bowls, and (b) putting pegs into tight niches in variously shaped blocks versus into loose containers. The figure was held constant across the two scenes of each test pair to minimize the possibility that children would look longer at one of the scenes than the other because they preferred its figure, rather than because they preferred the relationship depicted; the color, size, and shape of the ground objects were also held as constant as possible.

11. Given the typical preference pattern found in studies with similar designs (e.g., Behl-Chadha and Eimas 1995; Quinn 1994), it may seem surprising that the infants looked longer at the familiarized relation than at the novel one. Hunter and Ames (1988) have shown that preference for familiarity over novelty is related to both task complexity and familiarization time: the more complex the task and/or the shorter the familiarization time, the greater the preference for familiarity; conversely, the easier the task and/or the longer the familiarization time, the greater the preference for novelty. The progression through a familiarity-to-novelty preference sequence is independent of age, although older participants may shift from familiar to novel with relatively more complex stimuli or relatively shorter familiarization times than younger participants. The experiment comparing tight and loose containment differed from those mentioned above in both task complexity and duration of familiarization time. The stimuli were far more complex (dynamic events rather than static pictures, with objects that changed from scene to scene in color, size, shape, and texture), and babies were familiarized to these stimuli for a preset number of trials, rather than habituated (i.e., shown instances of the same relation until they lose interest). Discovering what the familiarization scenes had in common may thus have been difficult, and babies may still have been intrigued to detect yet another new event that fit the category they were busy with.

12. Hespos and Spelke (2000) demonstrate sensitivity to a distinction between tight and loose containment even earlier (5 months). However, the containment scenes used in their study all involved simple containers and contained objects that—aside from the difference in tightness—were identical, so it is unclear whether babies of this age can yet generalize the distinction across objects as diverse as those used in McDonough, Choi, and Mandler's stimuli. (See Casasola and Cohen 2002 and Quinn, in press, for evidence that, in habituation/familiarization studies of infant spatial categorization, babies at first distinguish a novel spatial relation from a familiarized one only when the objects in the novel-relation test trials are the *same objects* they saw in the familiarization phase; only later can they discriminate between the two relations even when the objects change. Only the latter behavior is evidence for sensitivity to a spatial *category*.)

13. Studies purporting to show Whorfian effects are often criticized because, even though the task is ostensibly nonlinguistic, subjects might covertly be using language: for example, when asked to make judgments about the similarities and differences among stimuli, they might decide to group things together that they call by the same name. This explanation is not cogent for this experiment, however. Subjects were simply asked to watch the videos, and they were not expecting any memory tests or judgments about what they had seen; it is unlikely that they were covertly labeling the events they were shown and deciding to look longer at events with one label than at events with another.

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