CHAPTER ELEVEN

Making an Ontology
Cross-linguistic Evidence

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And every language is a vast pattern-system, different from others, in which are culturally ordained the forms and categories, by which the personality not only communicates, but also analyzes, notices, or neglects types of relationship and phenomena.

Benjamin L. Whorf, Language, Thought, and Reality

For the vocabulary of the language, in and of its self, to be a molder of thought, lexical dissections and categorizations of nature would have to be almost accidently formed, rather as though some Johnny Appleseed had scattered named categories capriciously over the earth.

E. Rosch, "Linguistic Relativity"

HUMAN CULTURES AND LANGUAGES are diverse. To some, these differences imply incommensurate ways of being human. To others, these differences only serve to underscore our profound sameness. Most cross-linguistic studies of categorization offer up their evidence on one side or the other of this philosophical divide. In this chapter, we summarize recent results from our cross-linguistic studies of early noun learning by English-speaking and Japanese-speaking children. The findings are clearly relevant to issues of linguistic and conceptual diversity. However, these issues were not the proximal impetus for our studies. Instead, our questions were pitched at a different level, to a mechanistic understanding of the development of categories and early noun learning. Still, by pursuing mechanisms of developmental change, we arrive at a deeper understanding of the processes that create both universal and linguistically specific ways of knowing.

Universal Ontological Distinctions?

The things we encounter in our everyday lives seem to fall naturally into different kinds. There are animate things that react and intentionally move; there are discrete things with stable forms that we move; and there are substances, masses with less regular forms, that also do not move on their own. This partition of things into animals, objects, and substances is sometimes considered an ontological partition in two senses: in the Aristotelian sense, that these are three different kinds of existence, and in the psychological sense, that these are distinct psychological kinds that provide a foundation for human category learning. There is empirical support for the second idea from children's judgments in novel noun generalization tasks.

Kind-Specific Generalizations of Newly Learned Nouns

The novel noun generalization task measures children's expectations about the category organization of different kinds. In this task, the experimenter presents the child with a novel entity and names it with a novel name, saying, for example, "this is the mel." The experimenter then presents choice items and asks the child which of these can be called by the same name, saying, for example, "show me the mel." This is an interesting task because the naming event itself provides the child with few constraints on the class to which the name applies. Thus, children's generalizations from this minimal task input provide insights into children's expectations about how nouns map to categories. And the evidence indicates that children's generalizations honor an organization of kinds into animates, inanimate objects, and substances.

In particular, when 2½- to 3-year-old children are presented with novel solid and rigidly shaped things, they consistently generalize the name only to new instances that match the exemplar in shape but not to instances that match in other ways (Imai, Gentner, & Uchida, 1994; Landau, Smith, & Jones, 1988, 1992, 1998; Soja, Carey, & Spelke, 1991). However, when the named entity is a nonsolid substance such as hair gel or lotion molded into a shape, same-aged children are more likely to generalize the name by its material and color (Soja et al., 1991; Soja, 1992). Finally, when the named entity has properties typical of animate things—eyes or feet or limbs—children generalize the name narrowly to objects that match the named example in both shape and texture (Jones, Smith & Landau, 1991; Jones & Smith, 1998; Yoshida & Smith, in press; see also Gelman & Coley, 1991; Keil, 1994; Markman, 1989). Further, increasing evidence suggests that children learning a variety of languages such as Korean, Japanese, English, and Spanish make similar distinctions, naming rigidly shaped things by shape, nonsolid substances by material, and depictions of animate things by shape and texture (e.g., Gathercole & Min, 1997; Imai & Gentner, 1997; Lucy, 1996; Yoshida & Smith, in press).

Where Does This Knowledge Come From?

Evidence That Language Learning Plays a Role

Four facts suggest that language learning contributes to children's developing understanding of different kinds, as follows:

- Categorization taking place in naming and non-naming tasks
- Emergence of kind-specific name generalizations with vocabulary growth
- Modulation of kind-specific name generalizations
- Cross-linguistic differences

First, children's attention to the different properties of different kinds is evident most robustly in naming tasks. Many of the experiments showing that children systematically extend novel names in different ways for different kinds have included non-naming control tasks (e.g., Imai, et al., 1994; Jones et al., 1991, 1998; Landau et al., 1988, 1992, 1998; Soja et al., 1991). These control tasks are identical to the novel noun generalization task, except the object is not named. Instead, children are shown the exemplar and then are asked what other objects are "like" or "go with" the exemplar. In these non-naming tasks, children do not systematically attend to the different properties of different kinds. This fact suggests a mechanistic link between naming and knowledge about the category organizations of different kinds.

Second, kind-specific name generalizations emerge with vocabulary growth (Jones & Smith, 1997; Jones et al., 1991; Landau et al., 1988; Samuelson & Smith, 1999, 2000; Smith, 1999; Soja et al., 1991). The evidence indicates that the tendency to attend to shape in the context of naming emerges only after children already know some nouns. Moreover, this so-called shape bias in naming becomes stronger with development and more specific to solid and rigidly shaped objects. A bias to extend names for animates by similarity in shape and texture and a bias to extend names for substances by similarity in material emerge later (see, especially, Jones et al., 1991; Samuelson & Smith, 2000). Thus, biases to attend to different properties when extending names for different kinds codevelop with increasing vocabulary, a fact consistent with the idea that children's word learning helps create their category knowledge.

Third, kind-specific name generalizations are modulated by syntactic cues. One area of relevant research concerns the influence of count and mass syntactic frames on English-speaking children's interpretations of novel object and substance names. Count nouns are nouns that take the plural and can be preceded by words such as *a, another, several,* and *few,* as well as numerals. Count nouns thus label things we think of as discrete—chairs, trucks, shirts, studies, and hopes. Mass nouns, in contrast, cannot be pluralized but instead are preceded by words such as *some, much,* and *little.* Mass nouns thus label things that are conceptualized as unbounded continuous masses—water, sand, applesauce, research, and justice. Past research shows that count syntactic frames (e.g., *a mel, another mel*) push children's attention to the shape of the named thing, whereas mass syntactic frames (e.g., *some mel, more mel*) push attention to material (e.g., Gathercole, Cramer, Somerville, & Jansen, 1995; McPherson, 1991, Soja, 1992). In brief, language exerts an on-line influence on children's category formation.

Fourth, although there are clear universals in the name generalizations of children learning different languages—solid rigid things tend to be named by shape, nonsolid things by material, and things with features suggesting animacy by joint similarity in shape and texture—there are differences as well, differences that we

believe provide a potentially rich window on the role of language in creating knowledge about kinds. In the next section we present background evidence on differences between English and Japanese.

Language Differences

Individuation

Lucy (1992) proposed an animacy continuum that is intimately related to how languages individuate kinds. As illustrated in figure 11.1, this continuum orders kinds by the degree to which instances are marked as individuals by devices such as the plural and indefinite articles. On one extreme of Lucy's proposed continuum are animate entities, the kinds most likely to be treated as discrete entities by a language. On the other extreme are substances, the kinds least likely to be individualized by languages. In the middle are objects, entities that are treated as individuals by some languages but not by others. The key point is this: different languages emphasize different boundary points along a continuum of kinds from animate to substance.

English, with its count/mass distinction, is said to partition the continuum between objects and substances. Both common animal and object names—*cow* and *cup*—are count nouns. Both are thus kinds that English treats as discrete entities. Common substance names such as *milk*, *sand*, and *wood*, in contrast, are mass nouns in English. These are treated by the language as unbounded continuous entities. Thus, through devices such as the indefinite article, pluralization, and quantification,

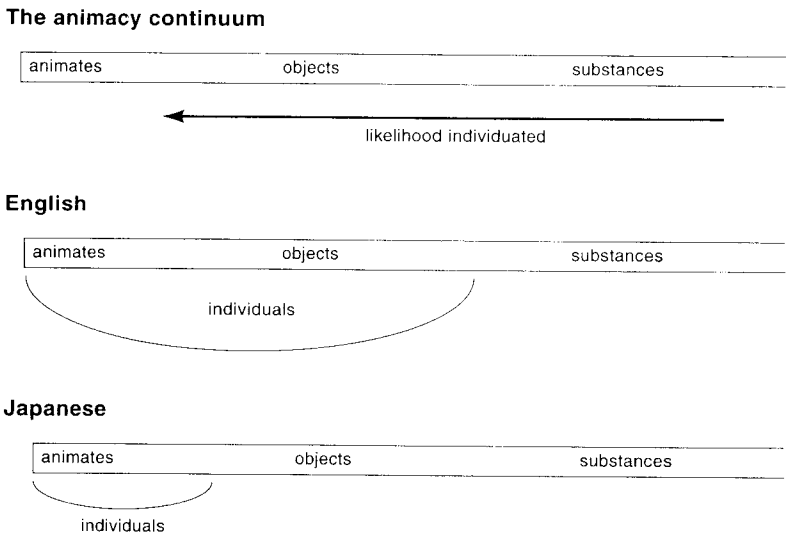

Figure 11.1. The animacy continuum and individuation in English and Japanese.

English treats animate and object names in the same way and differently from substance names.

The Japanese language, in contrast to English, appears to partition the continuum between animates and inanimates, treating only animates as discrete individuals. First, Japanese nouns that refer to multiple entities are not obligatorily pluralized. Thus *inu ga ita* could mean either "there was a dog" or "there were dogs." However, nouns referring to multiple humans or young animals are optionally pluralized with the suffix *tachi*. Thus, *koinu tachi ga ita* is "there were some puppies." The plural suffix appears not to be used on inanimate nouns. Second, when Japanese speakers do need to count discrete entities, they use a system of classifiers that often depend on the kind of thing being counted, much as English speakers count *loaves* of bread or *panes* of glass. The Japanese classifiers used for animates tend not to overlap with those used for inanimates. Finally, a distinction between animates and inanimates is also supported by other aspects of Japanese than plurals and quantification. Although not traditionally viewed as markers of individuation, there are additional aspects of Japanese that are closely linked to individuation and animacy (see Yoshida & Smith [in press], for further discussion). One of these is the distinction between *aru* and *iru*. For the very fundamental notion of existence ("there is") and spatial location ("be located"), Japanese has separate verbs for animates and inanimates: *aru* is "inanimate object exists/is located" and *iru* is "animate object exists/is located." Thus Japanese, through pluralization, its classifier system, and the *iru/aru* distinction in locative constructions, imposes a boundary between people and animals on the one hand and objects and substances on the other.

These are systematic language differences of the kind likely to matter in children's developing conceptualizations of kinds (Gumperz & Levinson, 1996; Lucy, 1996): noun categories in English are systematically partitioned into object names versus substance names, whereas noun categories in Japanese are systematically partitioned into names for animates versus names for inanimates. Both Quine (1969) and Lucy (1992) suggested that the partitions made by a language's system for marking individuals determines the ontological partitions made by speakers of that language.

Complete linguistic determination, however, seems unlikely, as there is relevant perceptual information about category structures that is available to speakers of all languages. Indeed, prelinguistic infants distinguish animate categories from objects that hold their shape and form, and also distinguish rigid forms from nonrigid ones (e.g., Spelke, Vishton, & Van-Hofsten, 1995).

Imai and Gentner's Results

Imai and Gentner's (1997) cross-linguistic study of the object–substance boundary provides clear evidence that both linguistic and perceptual information contribute to an object–substance distinction. In their study, they compared Japanese-speaking and English-speaking children's generalizations of names for novel solid and nonsolid forms. They used three kinds of stimulus sets: solid and complexly shaped things, solid but simply shaped things, and nonsolid and thus simply shaped substances. They did this because solids and nonsolids differ in the kinds of shapes they usually take. Solid things can be quite complex—with many angles and multiple parts.

Nonsolid substances, however, cannot take angular multipart shapes and over time relax toward rounded and accidental-appearing forms like splatters and drops.

In the experiment, Imai and Gentner presented children with an exemplar and named it with a novel noun. They used a syntactic frame in English that was neutral, consistent with either a count or mass noun. In this way, any language effects would be off-line effects, effects of a history of making distinctions between count and mass nouns in English and not making such a distinction in Japanese. After the exemplar was named, the child was shown two choice objects, one that matched the exemplar in shape and one that matched the exemplar in material. The child was asked to indicate the one called by the same name as the exemplar.

Imai and Gentner found that Japanese speakers and English speakers formed similar categories for solid complexly shaped things, generalizing a newly learned object name to new instances by shape. And speakers of both languages increased attention to material when the named entity was nonsolid. Imai and Gentner concluded from these similarities that the partition of objects from substances does not depend on linguistic individuation, since both English-speaking and Japanese-speaking participants treated solids and nonsolids differently, even though Japanese does not mark objects and substances differently.

However, Imai and Gentner also found differences between the novel noun generalizations of English and Japanese speakers. Most notably, English and Japanese speakers differed in their generalizations of names for simply shaped solids. Simply shaped solid things are like objects in the rigidity of their shapes but are like substances in the simplicity of their shapes. English speakers treated the simply shaped solid things as objects and generalized their names by shape, whereas Japanese speakers were more likely to generalize the name by material. The results suggest that as a consequence of different systems of individuation, Japanese and English speakers place the boundary between objects and substances in slightly different places. For speakers of English, solid things—both complexly and simply shaped—are categorized as objects, that is, by shape. For speakers of Japanese, simply shaped things—both solid and nonsolid—are more likely to be categorized as substances, that is, by material.

Ontologies as Statistical Regularities

Imai and Gentner's results show both universal and language-specific influences on children's "ontological" distinctions. We propose that both the universals and the differences are the product of the same statistical learning mechanism, arising from correlations among the perceptual properties of different kinds, lexical category structures, and linguistic devices concerned with individuation. This proposal is based on the following five core ideas.

1. *There are regularities that distinguish kinds of things in the world and our perceptual systems are sensitive to these regularities.* Solids, nonsolids, and animates present correlated bundles of perceptual properties.
2. *The nominal categories of languages honor these correlational bundles.* Languages evolved to fit the perceptual system and the world. Thus it makes sense that lexical categories across-languages respect and make use of the same correlated perceptual properties that distinguish animates from solid objects and from nonsolid substances.
3. *Word learning enables higher-order generalizations.* Word learning may be mechanistically crucial to going beyond specific knowledge about specific kinds to developing the higher-order correlations that constitute kind-specific noun generalizations and ultimately abstract knowledge, knowledge we might rightly call an "ontology."
4. *The mechanism is associative learning.* The statistical regularities characteristic of early noun categories may be sufficient in and of themselves to create a partition of things into animals, objects, and substances. Ontologies in their psychological sense could be the generalizations that arise naturally from the statistical regularities across lexical categories.
5. *Linguistic regularities are part of the associative mix and thus bend knowledge in language-specific ways.* Linguistic forms that are regularly associated with correlated bundles of perceptual cues may reinforce the connections between those perceptual cues. In this way, systematic linguistic contrasts, such as those that compose a language's system of quantifying individuals, may differentially bolster and weaken perceptual correlations, changing how things are perceived and conceived.

We present preliminary support for these ideas in the remainder of this chapter. We do so by first concentrating on Imai and Gentner's finding of differences in the object-substance boundary for children learning English and Japanese. We then turn to a parallel phenomenon at the animal-object boundary. Finally, we propose how abstract ideas about even abstract kinds might emerge from these correlations across categories of concrete things.

Creating an Object-Substance Boundary

Early noun categories are highly structured. They present the kinds of regularities that could yield a partition of kinds into objects and substances. Specifically, early learned categories of solid things are well organized by shape, and early learned categories of nonsolids are typically well organized by material. This is so in both English and Japanese.

Regularities in the Early English Lexicon

Samuelson and Smith (1999) asked: What kinds of nouns do young children learning English know? Do they learn names for solid things in shape-based categories and names for nonsolid things in material-based categories? To answer these questions, Samuelson and Smith examined the structure of a set of nouns that are typically known by children at 30 months. More specifically, they examined the list of nouns that compose the MacArthur Communicative Developmental Inventory (MCDI). The MCDI is a parent checklist that is used by many researchers to mea-

sure the vocabulary of children from 16 to 30 months. The list of words on the MCDI was developed from extensive studies of parental diaries, in-laboratory testing of early vocabularies, and large normative studies (Fenson et al., 1993). The nouns contained on the MCDI are known by 50 percent of children at 30 months. Samuelson and Smith specifically examined the category structures of 312 nouns—all the nouns in the animals, vehicles, toys, food and drink, clothing, body parts, small household items, and furniture and rooms sections of the MCDI.

The method used to examine the category structure of these 312 early learned nouns was borrowed from the pioneering work of Rosch (1973). Adults were presented with each noun on the list of 312 and asked to think of the instances named by each noun. For example, they might be told: "Think of apples that you commonly experience." Then, while thinking about these instances, the adults were then asked a series of yes/no questions: "Are these similar in shape? Are these similar in color? Are these similar in material? Are these solid? Are these nonsolid?" A separate group of adults was presented with the criteria for distinguishing count and mass nouns and asked to judge whether each noun on the MCDI was a count or a mass noun or could be used both syntactic frames (e.g., *cake*). To classify a nominal category as possessing any of these properties, Samuelson and Smith required that 85 percent of the adults agreed with that characteristic. This conservative criterion was used to ensure that the regularities attributed to the early lexicon were likely to be ones that are manifest in the experiences of most young learners. In this way, each noun was categorized as shape-based, material-based, color-based, based on a combination (or all) of these properties, or based on none of these properties. Each noun was also classified as referring to solid or nonsolid things or ambiguous insolidity, and each noun was classified as a count noun, a mass noun, or as ambiguous in its syntactic category.

Figure 11.2 summarizes the key regularities in terms of Venn diagrams. In these diagrams, the relative size of each circle represents the relative numbers of nouns of that kind, and the size of the overlap between intersecting circles represents the relative number of nouns of both kinds. The circles on the left depict the relative number of count nouns, names for solid things, and names for categories organized by shape. The circles on the right represent the relative numbers of mass nouns, names for nonsolid substances, and names for things in categories organized by material. (Color is not shown because so few categories were judged to be similar in color independently of similarity in material.) What the figure shows is that many early nouns are count nouns, many refer to solid objects, and many name objects in shape-based categories. Moreover, count nouns, solid things, and shape similarity go together. The right side of figure 11.2 shows that there are many fewer nouns in this corpus that are mass nouns, name nonsolid things, and name categories organized by material. However, nonsolidity, mass-noun syntax, and material-based categories are correlated. Thus, the early English lexicon presents correlations among category structures, the perceptible properties of solid and nonsolid things, and count-mass syntactic cues. The regularities are clearly lopsided—much stronger on the solid, shape, count side than on the nonsolid, material, mass side.

One might ask: Why does the early noun corpus have the structure it does? Sandhofer, Smith, and Luo (2000) examined transcripts of parent speech to young

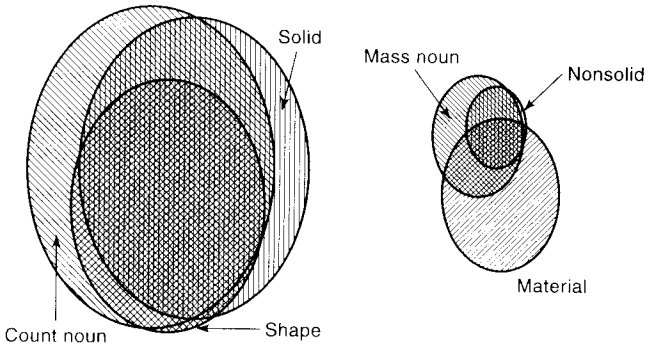

Figure 11.2. Venn diagrams illustrating the overlap among shape-based categories, solidity, and count syntax and material-based categories, nonsolidity, and mass syntax among the 312 early-learned English nouns.

children. They selected the most common 100 nouns and asked adults to judge the category structure, using the same method used by Samuelson and Smith. They found evidence for the same correlational structure as had Samuelson and Smith and the same emphasis on naming solid things in shape-based categories. We suspect that the structure of the common nouns children hear and use reflects deep truths about the perceptual regularities in the world and their functionality from a human perspective.

Children, however, must individually learn these deep truths. The evidence indicates that learning names for things is a crucial part of this. Children's kind-specific name generalizations become organized *as* they learn more and more names for different kinds (for review, see Smith, 1999). In line with previous results, Samuelson and Smith (1999) found that when children knew few nouns, they did not honor a distinction between solid and nonsolid things. Instead, they generalized novel names for solid things by shape only after they had already learned a substantial number of names for solid things, a fact that fits the idea that children's novel noun generalizations are themselves generalizations over the structure of already learned nouns. Further, children generalized names for solid things by shape long before they generalized names for nonsolid things by material—a fact that also aligns with the statistical regularities across early English noun categories.

Regularities in the Early Japanese Lexicon

What are early learned nouns in other languages like? Do they name the same kinds of categories as do the early English nouns? Colunga and Smith (2000) addressed this question by examining the nouns on the Japanese MCDI. The Japanese MCDI, like the English one, is a parent checklist of early-learned words and phrases. The Japanese MCDI was independently constructed and normalized across large samples of children learning Japanese as their first language (Ogura & Watamaki, 1997; Ogura,