CHAPTER 26

Language and Thought

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Possessing a language is one of the central features that distinguishes humans from other species. Many people share the intuition that they think in language and the absence of language therefore would be the absence of thought. One compelling version of this self-reflection is Helen Keller's (1955) report that her recognition of the signed symbol for 'water' triggered thought processes that had theretofore – and consequently – been utterly absent. Statements to the same or related effect come from the most diverse intellectual sources: "The limits of my language are the limits of my world" (Wittgenstein, 1922); and "The fact of the matter is that the 'real world' is to a large extent unconsciously built upon the language habits of the group" (Sapir, 1941, as cited in Whorf, 1956, p. 75).

The same intuition arises with regard to particular languages and dialects. Speaking the language of one's childhood seems to conjure up a host of social and cultural attitudes, beliefs, memories, and emotions, as though returning to the Casbah or to Avenue L and East 19th Street and conversing with the natives opens a window back into some prior state of one's nature. But do such states of mind arise because one is literally thinking in some new representational format by speaking in a different language? After all, many people experience the same or related changes in sociocultural orientation and sense of self when they are, say, wearing their battered old jeans versus some required business suit or military uniform; or even more poignantly when they reexperience a smell or color or sound associated with dimly recalled events. Many such experiences evoke other times, other places.

But according to many anthropological linguists, sociologists, and cognitive psychologists, speaking a particular language exerts vastly stronger and more pervasive influences than an old shoe or the smell of boiling cabbage. The idea of "linguistic relativity" is that having language, or having a particular language, crucially shapes mental life. Indeed, it may not be only that a specific language exerts its idiosyncratic effects as we speak or listen to it – that language might come to "be" our thought; we may have no way to think many thoughts, conceptualize many of our ideas, without this language, or outside of and independent of this language. From such a perspective, different communities of humans, speaking different languages, would think differently to the extent that languages differ from one another. But is this so? Could it be so? That depends on how we unpack the notions alluded to so informally thus far.

In one sense, it is obvious that language use has powerful and specific effects on thought. That's what it is for, or at least that is one of the things it is for – to transfer ideas from one mind to another mind. Imagine Eve telling Adam "Apples taste great." This fragment of linguistic information, as we know, caused Adam to entertain a new thought with profound effects on his world knowledge, inferencing, and subsequent behavior. Much of human communication is an intentional attempt to modify others' thoughts and attitudes in just this way. This information transmission function is crucial for the structure and survival of cultures and societies in all their known forms.

But the language-and-thought debate is not framed to query whether the content of conversation can influence one's attitudes and beliefs, for the answer to that question is too obvious for words. At issue, rather, is the degree to which natural languages provide the format in which thought is necessarily (or at least habitually) couched. Do formal aspects of a particular linguistic system (e.g., features of the grammar or the lexicon) organize the thought processes of its users? One famous "Aye" to this question appears in the writings of B. L. Whorf in the first half of the twentieth century. According to Whorf (1956, p. 214), the grammatical and lexical resources of individual languages heavily constrain the conceptual representations available to their speakers. To quote:

> *We are thus introduced to a new principle of relativity, which holds that all observers are not led by the same physical evidence to the same picture of the universe, unless their linguistic backgrounds are similar, or can in some way be calibrated.*

This relativistic view, in its strictest form, entails that linguistic categories will be the "program and guide for an individual's mental activity" (Ref. 143, p. 212), including categorization, memory, reasoning, and decision making. If this is right, then the study of different linguistic systems may throw light onto the diverse modes of thinking encouraged or imposed by such systems. Here is a recent formulation of this view (Pederson et al., 1998, p. 586):

> *We surmise that language structure . . . provides the individual with a system of representation, some isomorphic version of which becomes highly available for incorporation as a default conceptual representation. Far more than developing simple habituation, use of the linguistic system, we suggest, actually forces the speaker to make computations he or she might otherwise not make.*

Even more dramatically, according to stronger versions of this general position, we can newly understand much about the development of concepts in the child mind: One acquires concepts as a consequence of their being systematically instantiated in the exposure language (Bowerman & Levinson, 2001, p. 13):

> *Instead of language merely reflecting the cognitive development which permits and constrains its acquisition, language is thought of as potentially catalytic and transformative of cognition.*

The importance of this position cannot be underestimated: Language here becomes a vehicle for the growth of *new* concepts – those that were not theretofore in the mind, and perhaps could not have been there without the intercession of linguistic experience. It therefore poses a challenge to the venerable view that one could not acquire a concept that one could not antecedently entertain (Plato, 5th–4th B.C.E.; Descartes, 1662; Fodor, 1975, *inter alia*].

Quite a different position is that language, although being the central human conduit for thought in communication, memory, and planning, neither creates nor materially distorts conceptual life: Thought is first; language is its expression. This contrasting view of cause and effect leaves the link between language and mind as strong as ever and just as relevant for understanding mental life. From Noam Chomsky's universalist perspective (1975, p. 4), for example, the forms and contents of all particular languages derive, in large part, from an antecedently specified cognitive substance and architecture and therefore provide a rich diagnostic of human conceptual commonalities:

> *Language is a mirror of mind in a deep and significant sense. It is a product of human intelligence . . . By studying the properties of natural languages, their structure, organization, and use, we may hope to learn something about human nature; something significant, if it is true that human cognitive capacity is the truly distinctive and most remarkable characteristic of the species.*

This view of concepts as prior to and progenitive of language is not proprietary to the rationalist position for which Chomsky is speaking here. This commonsensical position is maintained – rather, presupposed – by students of the mind who differ among themselves in almost all other regards. The early empiricists, for example, took it for granted that our concepts derive from experience with properties, things, and events in the world and not, originally, from language (Hume, 1739; Book I):

> *To give a child an idea of scarlet or orange, of sweet or bitter, I present the objects, or in other words, convey to him these impressions; but proceed not so absurdly, as to endeavor to produce the impressions by exciting the ideas.*

And as a part of such experience of objects, language learning will come along for the ride (Locke, 1690, Book 3.IX.9; emphasis ours):

> *If we will observe how children learn languages, we shall find that, to make them understand what the names of simple ideas or substances for, people ordinarily* show them the thing whereof they would have them have the idea*; and then repeat to them the name that stands for it . . .*

Thus linguistic relativity, in the sense of Whorf and many recent commentators, is quite novel and, in its strongest interpretations, revolutionary. At the limit, it is a proposal for how new thoughts can arise in the mind as a result of experience with language rather than as a result of experience with the world of objects and events.

Before turning to the recent literature on language and thought, we want to emphasize that there are no ideologues ready to man the barricades at the absolute extremes of the debate just sketched. To our knowledge, none – well, very few – of those who are currently advancing linguistic–relativistic themes and explanations believe that infants enter into language acquisition in a state of complete conceptual nakedness later redressed (perhaps we should say "dressed") by linguistic information. Rather, by general acclaim, infants are believed to possess some "core knowledge" that enters into first categorization of objects, properties, and events in the world (e.g., Carey, 1982; Kellman, 1996; Baillargeon, 1993; Gelman & Spelke, 1981; Leslie & Keeble, 1987; Mandler, 1996; Quinn, 2001; Spelke et al., 1992). The general question is how richly specified this innate basis may be and how experience refines, enhances, and transforms the mind's original furnishings. The specific question is whether language knowledge may be one of these formative or transformative aspects of experience. To our knowledge, none – well, very few – of those who adopt a nativist position on these matters reject as a matter of a priori conviction the possibility that there could be salience effects of language on thought. For instance, some particular natural language might formally mark a category whereas another does not; two languages might draw a category boundary at different places; two languages might differ in the computational resources they require to make manifest a particular distinction or category.

We will try to draw out aspects of these issues within several domains in which commentators and investigators are trying to disentangle cause and effect in the interaction of language and thought. We cannot discuss it all, of course, or even very much of what is currently in print on this topic.

There is too much of it (for recent anthologies, see Gumperz & Levinson, 1996; Bowerman & Levinson, 2001; Gentner & Goldin-Meadow, 2003).

Do We Think In Language?

We begin with a very simple question: Do our thoughts take place in natural language? If so, it would immediately follow that Whorf was right all along, since speakers of Korean and Spanish, or Swahili and Hopi would have to think systematically different thoughts.

If language directly expresses our thought, it seems to make a poor job of it. Consider for example the final (nonparenthetical) sentence in the preceding section:

1. There is too much of it.

Leaving aside, for now, the problems of anaphoric reference (what is "it"?), the sentence still has at least two interpretations that are compatible with its discourse context:

1a. There is too much written on linguistic relativity to fit into this article.
1b. There is too much written on linguistic relativity. (*Period*!)

We authors had one of these two interpretations in mind (guess which one). We had a thought and expressed it as (1) but English failed to render that thought unambiguously, leaving doubt between (1a) and (1b). One way to think about what this example portends is that language cannot, or in practice does not, express all and only what we mean. Rather, language use offers hints and guideposts to hearers, such that they can usually reconstruct what the speaker had in mind by applying to the uttered words a good dose of common sense – *aka* thoughts, inferences, and plausibilities – in the world.

The question of just how to apportion the territory between the underlying semantics of sentences and the pragmatic interpretation of the sentential semantics, of course, is far from settled in linguistic and philosophical theorizing. Consider the sentence *It is raining*. Does this sentence directly – that is, as an interpretive consequence of the linguistic representation itself – convey an assertion about rain falling *here*, in the immediate geographical environment of the speaker? Or does the sentence – the linguistic representation – convey only that rain is falling, leaving it for the common sense of the listener to deduce that the speaker likely meant raining here and now rather than raining today in Bombay or on Mars; likely, too, that if the sentence was uttered indoors, the speaker more likely meant *here* to convey "just outside of here" than "right here, as the roof is leaking." The exact division of labor between linguistic semantics and pragmatics has implications for the language–thought issue, because the richer (one claims that) the linguistic semantics is, the more likely it is that language guides our mental life. Without going into detail, we will argue that linguistic semantics cannot fully envelop and substitute for inferential interpretation, and the representations that populate our mental life therefore cannot be identical to the representations that encode linguistic (semantic) meaning.

Language Is Sketchy, Thought Is Rich

There are several reasons to believe that thought processes are not definable over representations that are isomorphic to linguistic representations. One is the pervasive ambiguity of words and sentences. *Bat*, *bank*, and *bug* all have multiple meanings in English and are associated with multiple concepts, but these concepts themselves are clearly distinct in thought, as shown *inter alia* by the fact that one may consciously construct a pun. Moreover, several linguistic expressions including pronouns (*he*, *she*) and indexicals (*here*, *now*) crucially rely on context for their interpretation whereas the thoughts they are used to express are usually more specific. Our words are often semantically general – i.e., they fail to make distinctions that nevertheless are present in thought: *Uncle* in English does not semantically specify whether the individual comes from the mother's or the father's side, or whether he is a relative by blood or marriage, but usually the speaker who utters "my uncle . . . " possesses the relevant information. Indeed, lexical items typically take on different interpretations tuned to the occasion of use (*He has a square face. The room is hot*.) and depend on inference for their precise construal in different contexts (e.g., the implied action is systematically different when we *open an envelope/a can/an umbrella/a book*, or when an instance of that class of actions is performed to serve different purposes: O*pen the window to let in the evening breeze/the cat*). Moreover, there are cases in which linguistic output does not even encode a complete thought or proposition (*tomorrow, maybe*). Finally, the presence of implicatures and other kinds of pragmatic inference ensures that – to steal a line from the Mad Hatter – although speakers generally mean what they say, they do not and could not say exactly what they mean.

From this and related evidence, it appears that linguistic representations underdetermine the conceptual contents they are used to convey: Language is *sketchy* compared with the richness of our thoughts (for a related discussion, see Fisher & Gleitman, 2002). In light of the limitations of language, time, and sheer patience, language users make reference by whatever catch-as-catch-can methods they find handy, including the waitress who famously told another that "The ham sandwich wants his check" (Nunberg, 1978). What chiefly matters to talkers and listeners is that successful reference be made, whatever the means at hand. If one tried to say all and exactly what one meant, conversation could not happen; speakers would be lost in thought. Instead, conversation involves a constant negotiation in which participants estimate and update each others' background knowledge as a basis for what needs to be said given what is mutually known and inferable (e.g., Grice, 1975; Sperber & Wilson, 1986; Clark, 1992; Bloom, 2002).

In limiting cases, competent listeners ignore linguistically encoded meaning if it patently differs from what the speaker intended – for instance, by smoothly and rapidly repairing slips of the tongue. Oxford undergraduates had the wit, if not the grace, to snicker when Reverend Spooner reputedly said, "Work is the curse of the drinking classes." Often, the misspeaking is not even consciously noticed but is repaired to fit the thought – evidence enough that the word and the thought are two different matters.[1] The same latitude for thought to range beyond established linguistic means holds for the speakers, too. Wherever the local linguistic devices and locutions seem insufficient or overly constraining, speakers invent or borrow words from another language, devise similes and metaphors, and sometimes make permanent additions and subtractions to the received tongue. It would be hard to understand how they do so if language were itself, and all at once, both the format and vehicle of thought.

All the cases just mentioned refer to particular tokenings of meanings in the idiosyncratic interactions between people. A different problem arises when languages categorize aspects of the world in ways that are complex and inconsistent. An example is reported by Malt et al. (1999). They examined the vocabulary used by English, Spanish, and Chinese subjects to label the various containers we bring home from the grocery store full of milk, juice, ice cream, bleach, or medicine (e.g., *jugs, bottles, cartons, boxes*). As the authors point out, containers share names based not only on some perceptual resemblances but also on very local and particular conditions with size, shape, substance, contents, and nature of the contents, not to speak of the commercial interests of the purveyor, all playing interacting and shifting roles. In present-day American English, for instance, a certain plastic container that looks like a bear with a straw stuck in its head is called *a juice box*, although it is not boxy either in shape (square or rectangular) or typical constitution (your prototypical American box is made of cardboard). The languages Malt et al. studied differ markedly in the set of terms available for this domain, and also in how their subjects extended these terms to describe diverse new containers. Speakers of the three languages differed in which objects (old and new) they classified together by name. For example, a set of objects distributed across the sets of *jugs*, *containers*, and *jars* by English speakers were unified by the single label *frasco* by Spanish speakers. Within and across languages, not everything square is a box, not everything glass is a bottle, not everything *not* glass is *not* a bottle, and so on. The naming, in short, is a complex mix resulting from perceptual resemblances, historical influences, and a generous dollop of arbitrariness. Yet Malt et al.'s subjects did not differ much (if at all) from each other in their classification of these containers by overall similarity rather than by name. Nor were the English and Spanish, as one might guess, more closely aligned than, say, the Chinese and Spanish. So here we have a case in which cross-linguistic practice groups objects in a domain in multiple ways that have only flimsy and sporadic correlations with perception without discernible effect on the nonlinguistic classificatory behaviors of users.[2]

So far, we have emphasized that language is a relatively impoverished and underspecified vehicle of expression that relies heavily on inferential processes outside the linguistic system for reconstructing the richness and specificity of thought. If correct, this seems to place rather stringent limitations on how language could serve as the original engine and sculptor of our conceptual life. Nevertheless, it is possible to maintain the idea that certain formal properties of language causally affect thought in more subtle, but still important, ways.

Use It or Lose It: Language Determines the Categories of Thought

We begin by mentioning the most famous and compelling case of a linguistic influence on perception: categorical perception of the phoneme (Liberman, 1970; Liberman et al., 1967; Kuhl et al., 1992). Children begin life with the capacity and inclination to discriminate among all of the acoustic–phonetic properties by which languages encode distinctions of meaning – a result famously documented by Peter Eimas (Eimas et al., 1971) using a dishabituation paradigm (for details and significant expansions of this basic result, see Jusczyk, 1985; and for extensions with neonates, Peña et al., 2003). These authors showed that an infant will work (e.g., turn its head or suck on a nipple) to hear a syllable such as *ba*. After some period of time, the infant habituates; that is, its sucking rate decreases to some base level. The high sucking rate can be reinstated if the syllable is switched to, say, *pa*, demonstrating that the infant detects the difference. These effects are heavily influenced by linguistic experience. Infants only a year or so of age – just when true language is making its appearance – have become insensitive to phonetic distinctions that are not phonemic (play no role at higher levels of linguistic organization) in the exposure language (Werker & Tees, 1984). Although these experience-driven effects are not totally irreversible in cases of long-term second-language immersion, they are pervasive and dramatic (for discussion, see Werker & Logan, 1985; Best, McRoberts, & Sithole, 1988). Without special training or unusual talent, the adult speaker–listener can effectively produce and discriminate the phonetic categories required in the native tongue, and little more. Not only that, these discriminations are categorical in the sense that sensitivity to within-category phonetic distinctions is poor and sensitivity at the phonemic boundaries is especially acute. Although the learning and use of a specific language has not created perceptual elements *de novo*, certainly it has refined, organized, and limited the set of categories at this level in radical ways. As we will discuss, several findings in the concept-learning literature have been interpreted analogously to this case.

An even more intriguing effect in this general domain is the reorganization of phonetic elements into higher-level phonological categories as a function of specific language spoken. For example, American English speech regularly lengthens vowels in syllables ending with a voiced consonant (e.g., *ride* and *write*) and neutralizes the *t*/*d* distinction in favor of a dental flap in certain unstressed syllables. The effect is that (in most dialects) the consonant sounds in the middle of *rider* and *writer* are physically the same. Yet the English-speaking listener seems to perceive a *d*/*t* difference in these words all the same, and – except when asked to reflect carefully – fails to notice the characteristic difference in vowel length that his or her own speech faithfully reflects. The complexity of this phonological reorganization is often understood as a reconciliation (interface) of the cross-cutting phonetic and morphological categories of a particular language. *Ride* ends with a *d* sound; *write* ends with a *t* sound; morphologically speaking, *rider* and *writer* are just *ride* and *write* with *er* added on; therefore, the phonetic entity between the syllables in these two words must be *d* in the first case and *t* in the second. Morphology trumps phonetics (for discussion see Bloch & Trager, 1942; Chomsky, 1964; Gleitman & Rozin, 1977).

When considering linguistic relativity, one might be tempted to write off the phonetic categorical perception effect as one that merely tweaks the boundaries of acoustic distinctions built into the mammalian species – a not-so-startling sensitizing effect of language on perception. But the phonological effect just discussed is no mere tweak. There has been a systemic reorganization creating a new set of lawfully recombinatorial elements – one that varies very significantly cross-linguistically.

Much of the literature on linguistic relativity can be understood as raising related issues in various perceptual and conceptual domains. Is it the case that distinctions of lexicon or grammar made regularly in one's language sensitize one to these distinctions and suppress or muffle others? Even to the extent of radically reorganizing the domain? An important literature has investigated this issue using the instance of color names and color perception. Languages differ in their terms for hue and brightness (Berlin & Kay, 1969; cf. Kay & Regier, 2002). Do psychophysical judgments differ accordingly? For instance, are adjacent hues that share a name in a particular language judged more similar by its speakers than equal-magnitude differences in wavelength and intensity that are consensually given different names in that language? And are the similarity spaces of speakers of other languages different in the requisite ways? Such language-caused distinctions have been measured in various ways – for example, discrimination across hue labeling boundaries (speed, accuracy, confusability), memory, and population comparisons. By and large, the results of such cross-linguistic studies suggest a remarkable independence of hue perception from labeling practice (e.g., Brown & Lenneberg, 1954; Heider & Oliver, 1972). One relevant finding comes from red–green color-blind individuals (Jameson & Hurwich, 1978). The perceptual similarity space of the hues for such individuals is systematically different from that of individuals of normal vision; that is what it means to be colorblind. Yet a large subpopulation of red–green colorblind individuals names hues, even of new things, consensually with normal-sighted individuals and orders these hue labels consensually. That is, these individuals do not perceptually order a set of color chips with the reds at one end, the greens at the other, and the oranges somewhere in between; yet they organize *the words* with *red* semantically at one end, *green* at the other, and *orange* somewhere in between. In short, the naming practices and perceptual organization of color mismatch in these individuals, which is a fact that they rarely notice until they enter the vision laboratory.

Overall, the language–thought relations for one perceptual domain (speech-sound perception) appear to be quite different from those in another perceptual domain (hue perception). Language influences acoustic phonetic perception much more than it influences hue perception. As a result, there is no deciding in advance that language does or does not influence perceptual life. Moreover, despite the prima facie relevance of these cases and the elegance of the literature that investigated them, the perception of relatively low-level perceptual categories, the organization of which we share with many nonhuman species, are less than ideal places to look for the linguistic malleability of thought.[3] However, these instances serve to scaffold discussion of language influences at higher levels and therefore for more elusive aspects of conceptual organization.

Do the Categories of Language Become the Categories of Thought?

A seminal figure in reawakening interest in linguistic relativity was Roger Brown, the great social and developmental psychologist who framed much of the field of language acquisition in the modern era. Brown (1957) performed a simple and elegant experiment that demonstrated an effect of lexical categorization on the inferred meaning of a new word. Young children were shown a picture, for example, of hands that seemed to be kneading confettilike stuff in an overflowing bowl. Some children were told *Show me the sib*. They pointed to the bowl (a solid rigid object). Others were told *Show me some sib*. They pointed to the confetti (an undifferentiated mass of stuff). Others were told *Show me sibbing*. They pointed to the hands and made kneading motions with their own hands (an action or event). Plainly, the same stimulus object was represented differently depending on the linguistic cues to the lexical categories count noun, mass noun, and verb. That is, the lexical categories themselves have notional correlates – at least in the minds of these young English speakers.

Some commentators have argued that the kinds of cues exemplified here – that persons, places, and things surface as nouns – are universal and can play causal roles in the acquisition of language – of course, by learners who are predisposed to find just these kinds of syntactic–semantic correlations natural (Pinker, 1984; Gleitman, 1990; Fisher, 1996; Bloom, 1994a; Lidz, Gleitman, & Gleitman, 2003; Baker, 2001, *inter alia*). Brown saw his result the other way around. He supposed that languages would vary arbitrarily in these mappings onto conceptual categories. If that is so, then language cannot play the causal role that Pinker and others envisaged for it – that is, as a cue to antecedently "prepared" correlations between linguistic and conceptual categories. Rather, those world properties yoked together by language would cause a (previously uncommitted) infant learner to conceive them as meaningfully related in some ways (Brown, 1957, p. 5):

> *In learning a language, therefore, it must be useful to discover the semantic correlates for the various parts of speech; for this discovery enables the learner to use the part-of-speech membership of a new word as a first cue to its meaning . . . Since [grammatical categories] are strikingly different in unrelated languages, the speakers [of these languages] may have quite different cognitive categories.*

As recent commentators have put this position, linguistic regularities are part of the correlational mix that creates ontologies, and language-specific properties therefore will bend psychological ontologies in language-specific ways (Smith, Colunga, & Yoshida, 2001). The forms of particular languages – or the habitual language usage of particular linguistic communities – by hypothesis, could yield different organizations of the fundamental nature of one's conceptual world: what it is to be a thing or some stuff, or a direction or place, or a state or event. We will discuss some research on these category types and their cross-linguistic investigation. But before doing so, we want to mention another useful framework for understanding potential relations between language and thought: that the tweakings and reorganizations language may accomplish happen under the dynamic control of communicative interaction, of "thinking for speaking."

Thinking for Speaking

It is natural to conceive conversation as beginning with a thought or mental message one wishes to convey. This thought is the first link in a chain of mental events that, on most accounts, gets translated into successively more languagelike representations, eventuating in a series of commands to the articulatory system to utter a word, phrase, or sentence (Levelt, 1989; Dell, 1995). As we have just described matters, there is a clear distinction at the two ends of this process – what you meant to say and how you express it linguistically. But this is not so clear. Several commentators, notably Dan Slobin (1996, 2003), have raised the possibility of a more dynamic and interactive process in which what one chooses to mean and the expressive options that one's language makes available are not so neatly divorced. It may not be that speakers of every language set out their messages identically all the way up to the time that they arrange the jaw, mouth, and tongue to utter *one two three* versus *un deux trois*. Instead, the language one has learned causes one to "intend to mean" in somewhat different ways. For instance, and as we will discuss in more detail, it may be that as a speaker of English, with its myriad verbs of *manner* of motion, one comes to inspect – and speak of – the world in terms of such manners, whereas a speaker of Greek or Spanish, with a vocabulary emphasizing verbs relating to *path* of motion, inspects – and speaks of – the world more directly in terms of the paths traversed. The organization of the thought, on this view, might be dynamically impacted along its course by specific organizational properties of the individual language.

Slobin (2001) and Levelt (1989) have pointed to some cases in which a distinction across languages in the resources devoted to different conceptual matters seems almost inevitable. This case is the closed-class functional vocabulary, the "grammatical" words such as modals, auxiliaries, tense and aspect markers, determiners, complementizers, case markers, prepositions, and so forth. These words play rather specific grammatical roles in marking the ways in which noun phrases relate to the verb and how the predications within a sentence relate to each other. These same grammatical words usually also have semantic content – for example, the directional properties of *from* in *John separated the wheat from the chaff.* Slobin has given a compendium of the semantic functions known to be expressed by such items and these number at least in the several hundreds, including not only tense, aspect, causativity, number, person, gender, mood, definiteness, and so on, found in English, but also first-hand versus inferred knowledge, social status of the addressee, existence–nonexistence, shape, and many others. Both Slobin and Levelt have argued as follows: As a condition of uttering a well-formed English sentence, the speaker of English must decide for example, whether the number of creatures being referred to is one or more in order to choose *the dog* or *the dogs*. Some modicum of mental resources, no matter how small, must be devoted to this issue repeatedly – hundreds of times a day every day, every week, every year – by English speakers. But speakers of Mandarin need not think about number, except when they particularly want to, because its expression is not grammaticized in their language. The same is true for all the hundreds of other properties. So either all speakers of languages covertly compute all these several hundred properties as part of their representations of the contents of their sent and received messages or they compute only some of them – primarily those that they *must* compute to speak and understand the language of their community. On information-handling grounds, one would suspect that not all these hundreds of conceptual interpretations and their possible combinations are computed at every instance. But if one computes only what one must for the combined purposes of linguistic intelligibility and present communicative purpose, then speakers of different languages, to this extent, must be thinking differently. As Slobin (2001, p. 442) puts it, "From this point of view, grammaticizable notions have a role in structuring language-specific mental spaces, rather than being there at the beginning, waiting for an input language to turn them on." On the basis of this reasoning, it is plausible to entertain the view of a language-based difference in the dynamics of converting thought to speech. How far such effects percolate downstream is the issue to which we now turn. Do differences in phraseology, grammatical morphology, and lexical semantics of different languages yield underlying disparities in their modes of thought?

Semantic Arenas of the Present Day Language–Thought Investigation

Objects and Substances

The problem of reference to *stuff* versus *objects* has attracted considerable attention because it starkly displays the indeterminacy in how language refers to the world (Chomsky, 1957; Quine, 1960). Whenever we indicate a physical object, we necessarily indicate some portion of a substance as well; the reverse is also true. Languages differ in their expression of this distinction (Lucy & Gaskins, 2001). Some languages make a grammatical distinction that roughly distinguishes object from substance. Count nouns in such languages denote individuated entities; such as, object kinds. These are marked in English with determiners and are subject to counting and pluralization (*a horse, horses, two horses*). Mass nouns typically denote nonindividuated entities – that is, substance rather than object kinds. These are marked in English with a different set of determiners (*more porridge*) and need an additional term that specifies quantity to be counted and pluralized (*a tube of toothpaste* rather than *a toothpaste*). Soja, Carey, and Spelke (1991) asked whether children approach this aspect of language learning already equipped with the ontological distinction between things and substance or whether they are led to make this distinction through learning count and mass syntax. Their subjects, English-speaking two-year-olds, did not yet make these distinctions in their speech. Soja et al. (1991) taught these children words in reference to various types of unfamiliar displays. Some were solid objects such as a T-shaped piece of wood, and others were nonsolid substances such as a pile of hand cream with sparkles in it. The children were shown such a sample, named with a term presented in a syntactically neutral frame that identified it neither as a count nor as a mass noun – for example, *This is my blicket* or *Do you see this blicket?* In extending these words to new displays, two-year-olds honored the distinction between object and substance. When the sample was a hard-edged solid object, they extended the new word to all objects of the same shape, even when made of a different material. When the sample was a nonsolid substance, they extended the word to other-shaped puddles of that same substance but not to shape matches made of different materials. Soja et al. took this finding as evidence of a conceptual distinction between objects and stuff, independent of and prior to the morphosyntactic distinction made in English.

This interpretation was put to stronger tests by extending such classificatory tasks to languages that differ from English in these regards: Either these languages do not grammaticize the distinction, or they organize it in different ways (see Lucy, 1992; Lucy & Gaskins, 2001, for findings from Yucatec Mayan; Mazuka & Friedman, 2000; Imai & Gentner, 1997, for Japanese). Essentially, nouns in these languages all start life as mass terms, requiring a special grammatical marker (called *a classifier*) to be counted. One might claim, then, that substance is in some sense linguistically basic for Japanese whereas objecthood is basic for English speakers because of the dominance of its count-noun morphology.[4] So if children are led to differentiate object and substance reference by the language forms themselves, the resulting abstract semantic distinction should differ cross-linguistically. To test this notion, Imai and Gentner replicated the tests of Soja et al. with Japanese and English children and adults. Some of their findings appear to strengthen the evidence for a universal prelinguistic ontology that permits us to think about both individual objects and portions of stuff because both American and Japanese children (even two-year-olds) extended names for complex hard-edged nonsense objects on the basis of shape rather than substance. The lack of separate grammatical marking did not put Japanese children at a disadvantage in this regard.

Another aspect of the results hints at a role for language in categorization, however. Japanese children tended to extend names for mushy hand cream displays according to their substance, for example, whereas American children were at chance for these items. There were also discernible language effects on word extension for certain very simple stimuli (e.g., a kidney bean–shaped piece of colored wax) that seemed to fall at the ontological midline between object and substance. Whereas the Japanese at ages two and four years were at chance on these items, English speakers showed a tendency to extend words for them by shape.

How are we to interpret these results? Several authors have concluded that ontological boundaries literally shift to where language makes its cuts; that the substance versus object distinction works much like the categorical perception effects we noticed for phonemes (and perhaps colors; for an important statement, see Gentner & Boroditsky, 2001). Lucy and Gaskins (2001) bolster this interpretation with evidence that populations speaking different languages differ increasingly in this regard with age. Whereas young Mayan speakers do not differ much from their English-speaking peers, by age nine years members of the two communities differ significantly in relevant classificatory and memorial tasks. The implication is that long-term use of a language influences ontology with growing conformance of concept grouping to linguistic grouping. Of course, the claim is not for a rampant Procrustean reorganization of thought; only for boundary shifting. For displays that blatantly fall to one side or the other of the object/substance boundary, therefore, the speakers of all the tested languages sort the displays in the same ways.

As usual, neither the findings nor the interpretations of such experiments are easy to attain at the present state of the art. For one, thing, Mazuka and Friedman (2000) failed to reproduce Lucy's effects for Mayan versus English-speaking subjects' classificatory performance in the predicted further case of Japanese. As these authors point out, the sameness in this regard between Japanese and English speakers, and the difference in this regard between Mayan and English speakers, may best be thought of as arising from cultural and educational differences between the populations rather than linguistic differences.

In light of all the findings so far reviewed, there is another interpretation of the results that does not implicate an effect of language on thought but only an effect of language on language: One's implicit understanding of the organization of a specific language can influence one's interpretation of conversation. Interpretations from this perspective have been offered by many commentators. Bowerman (1996), Brown (1958), Landau and Gleitman (1985), and Slobin (1996, 2001) propose that native speakers not only learn and use the individual lexical items their language offers but also learn the *kinds* of meanings typically expressed by a particular grammatical category in their language and come to expect new members of that category to have similar meanings. Slobin calls this "typological bootstrapping." Languages differ strikingly in their common forms and locutions – preferred fashions of speaking, to use Whorf's phrase. These probabilistic patterns could bias the interpretation of new words. Such effects occur in experiments when subjects are offered language input (usually nonsense words) under conditions in which implicitly known form-to-meaning patterns in the language might hint at how the new word is to be interpreted.

Let us reconsider the Imai and Gentner object–substance effects on this hypothesis. As we saw, when the displays themselves were of nonaccidental-looking hard-edged objects, subjects in both language groups opted for the object interpretation.

But when the world was uninformative (e.g., for softish waxy lima bean shapes), the listeners fell back upon linguistic cues, if available. No relevant morphosyntactic clues exist in Japanese, so Japanese subjects chose at random for these indeterminate stimuli. For English-speaking subjects, the linguistic stimulus in a formal sense also was interpretively neutral: *This blicket* is a template that accepts both mass and count nouns (*this horse/toothpaste*). But here principle and probability part company. Recent experimentation leaves no doubt that child and adult listeners incrementally exploit probabilistic facts about word use to guide the comprehension process on line (e.g., Snedeker, Thorpe, & Trueswell, 2001). In the present case, any English speaker equipped with even a rough subjective probability counter should take into account the massive preponderance of count nouns over mass nouns in English and conclude that a new word, *blicket*, used to refer to some indeterminate display, is probably a new count noun rather than a new mass noun. Count nouns, in turn, tend to denote individuals rather than stuff and so have shape predictivity (Smith, 2001; Landau, Smith, & Jones, 1998).

Applying this interpretation, it is not that speaking English leads one to tip the scales toward object representations of newly seen referents for perceptually ambiguous items, but that hearing English leads one to tip the scales toward count-noun representation of newly heard nominals in linguistically ambiguous structural environments. Derivatively, then, count syntax hints at object representation of the newly observed referent. Notice that such effects can be expected to increase with age as massive lexical–linguistic mental databases are built, consistent with the findings of Lucy and Gaskins (2001).[5]

Spatial Relationships

Choi and Bowerman (1991) studied the ways in which common motion verbs in Korean differ from their counterparts in English. First, Korean motion verbs often contain location or geometric information that is more typically specified by a spatial preposition in English. To describe a scene in which a cassette tape is placed into its case, for example, English speakers would say "We put the tape *in the case*." Korean speakers typically use the verb *kkita* to express the *put in* relation for this scene. *Kkita* does not have the same extension as *put in*. Both *put in* and *kkita* describe an act of putting an object in a location; but *put in* is used for all cases of containment (fruit in a bowl, flowers in a vase) whereas *kkita* is used only in case the outcome is a tight fit between two matching shapes (tape in its case, one Lego piece on another, glove on hand). Notice that there is a cross-classification here: Whereas English appears to collapse across tightnesses of fit, Korean makes this distinction but conflates across *putting in* versus *putting on*, which English regularly differentiates. Very young learners of these two languages have already worked out the language-specific classification of such motion relations and events in their language, as shown by both their usage and their comprehension (Choi & Bowerman, 1991).

Do such cross-linguistic differences have implications for spatial cognition? McDonough, Choi, and Mandler (2003) focused on spatial contrasts between relations of tight containment versus loose support (grammaticalized in English by the prepositions *in* and *on* and in Korean by the verbs *kkita* and *nohta*) and tight versus loose containment (both grammaticalized as *in* in English but separately as *kkita* and *nehta* in Korean). They showed that prelinguistic infants (nine to fourteen months old) in both English- and Korean-speaking environments are sensitive to such contrasts, and so are Korean-speaking adults (see also Hespos & Spelke, 2000, who show that five-month-olds are sensitive to this distinction). Their English-speaking adult subjects, however, showed sensitivity only to the tight containment versus loose support distinction, which is grammaticalized in English (*in* versus *on*). The conclusion drawn from these results was that some spatial relations that are salient during the prelinguistic stage become less salient for adult speakers if language does not systematically encode them: "Flexible infants become rigid adults."

This interpretation again resembles that for the perception of phoneme contrasts, but by no means as categorically. The fact that English speakers learn and readily use verbs such as *jam*, *pack*, and *wedge* weakens any claim that the lack of common terms seriously diminishes the availability of categorization in terms of tightness of fit. One possibility is that the observed language-specific effects with adults are attributable to verbal mediation: Unlike preverbal infants, adults may have turned the spatial classification task into a linguistic task. It therefore is useful to turn to studies that explicitly compare performance when subjects from each language group are instructed to classify objects or pictures by *name*, as opposed to when they are instructed to classify the same objects by *similarity*. In one such study, Li et al. (1997) showed Korean- and English-speaking subjects pictures of events such as putting a suitcase on a table (an example of "on" in English, and of "loose support" in Korean). For half the subjects from each language group (each tested fully in their own language), these training stimuli were labeled by a videotaped cartoon character who performed the events (*I am Miss Picky and I only like to put things on things. See?*), and for the other subjects, the stimuli were described more vaguely (*. . . and I only like to do things like this. See?*). Later categorization of new instances followed language in the labeling condition: English speakers identified new pictures showing tight fits (e.g., a cap put on a pen) as well as the original loose-fitting ones as belonging to the category that Miss Picky likes, but Korean speakers generalized only to new instances of loose fits. These language-driven differences radically diminished in the similarity sorting condition in which the word (*on* or *nohta*) was not invoked; in this case the categorization choices of the two language groups were essentially the same. The "language on language" interpretation we commended in discussing the object/substance distinction in this case, too, seems to encompass the various laboratory effects in dealing with spatial relations.

Motion

Talmy (1985) described two styles of motion expression characterizing different languages: Some languages, including English, typically use a verb plus a separate path expression to describe motion events. In such languages, manner of motion is encoded in the main verb (e.g., *walk*, *crawl*, *slide*, or *float*), and path information appears in nonverbal elements such as particles, adverbials, or prepositional phrases (e.g., *away*, *through the forest*, *out of the room*). In Greek or Spanish, the dominant pattern instead is to include path information within the verb itself (e.g., Greek *bjeno*, "exit" and *beno*, "enter"); the manner of motion often goes unmentioned or appears in gerunds, prepositional phrases, or adverbials (*trehontas*, "running"). These patterns are not absolute. Greek has motion verbs that express manner, and English has motion verbs that express path (*enter*, *exit*, *cross*). But several studies have shown that children and adults have learned these dominance patterns. Slobin (1996) showed that child and adult Spanish and English speakers vary in the terms they typically use to describe the same picture-book stories with English speakers displaying greater frequency and diversity of manner of motion verbs. Papafragou, Massey, and Gleitman (2002) showed the same effects for the description of motion scenes by Greek- versus English-speaking children and, much more strongly, for Greek-versus English-speaking adults.

Do such differences in event encoding affect the way speakers think about motion events? Papafragou et al. (2002) tested their English- and Greek-speaking subjects on either memory of path or manner details of motion scenes, or categorization of motion events on the basis of path or manner similarities. Even though speakers of the two languages exhibited an asymmetry in encoding manner and path information in their verbal descriptions, they did not differ in terms of classification or memory for path and manner.[6] Similar results have been obtained for Spanish versus English by Gennari et al. (2002). Corroborating evidence also comes from studies by Munnich, Landau, and Dosher (2001), who compared English, Japanese, and Korean speakers' naming of spatial locations and their spatial memory for the same set of locations. They found that, even in aspects in which languages differed (e.g., encoding spatial contact or support), there was no corresponding difference in memory performance across language groups.

Relatedly, the same set of studies suggests that the mental representation of motion and location is independent of linguistic naming *even within a single language*. Papafragou et al. (2002) divided their English- and Greek-speaking subjects' verbal descriptions of motion according to whether they included a path or manner verb, regardless of native language. Although English speakers usually chose manner verbs, sometimes they produced path verbs; the Greek speakers also varied but with the preponderances reversed. It was found that verb choice did not predict memory for path or manner aspects of motion scenes or choice of path or manner as a basis for categorizing motion scenes. In the memory task, subjects who had used a path verb to describe a scene were no more likely to detect later path changes to that scene than subjects who had used a manner verb (and vice versa for manner). In the classification task, subjects were not more likely to name two motion events they had earlier categorized as most similar by using the same verb. Naming and cognition, then, are distinct under these conditions: Even for speakers of a single language, the linguistic resources mobilized for labeling underrepresent the cognitive resources mobilized for cognitive processing (e.g., memorizing, classifying, reasoning, etc.).

An obvious conclusion from these studies of motion representation is that the conceptual organization of space and motion is robustly independent of language-specific labeling practices. Just as obvious, however, is that specific language usage influences listeners' interpretation of the speaker's intended meaning if the stimulus situation leaves such interpretation unresolved. In another important demonstration of this language-on-language effect, Naigles and Terrazas (1998) asked subjects to describe and categorize videotaped scenes – for example, of a girl skipping toward a tree. They found that Spanish- and English-speaking adults differed in their preferred interpretations of new (nonsense) motion verbs in manner-biasing (*She's kradding toward the tree* or *Ella está mecando hacia el árbol*) or path-biasing (*She's kradding the tree* or *Ella está mecando el árbol*) sentence structures. The interpretations were heavily influenced by syntactic structure. But judgments also reflected the preponderance of verbs in each language – Spanish speakers gave more path interpretations and English speakers gave more manner interpretations. Similar effects of language-specific lexical practices on presumed word extension have been found for adjectives (Waxman, Senghas, & Benveniste, 1997).

A fair conclusion from this and related evidence is that verbal descriptions are under the control of many factors related to accessibility, including the simple frequency of a word's use, as well as of faithfulness as a description of the scene. As several authors have argued, the dynamic process of expressing one's thoughts is subject to the exigencies of linguistic categories that can vary from language to language. Given the heavy information-processing demands of rapid conversation, faithfulness often is sacrificed to accessibility. For these and other reasons, verbal reports do not come anywhere near exhausting the observers' mental representations of events. Language use, in this sense, is "sketchy." Rather than "thinking in words," humans seem to make easy linguistic choices that, for competent listeners, serve as rough but usually effective pointers to those ideas.

Spatial Frames of Reference

Certain linguistic communities (e.g., Tenejapan Mayans) customarily use an externally referenced (absolute) spatial coordinate system to refer to nearby directions and positions ("to the north"); others (e.g., Dutch speakers) use a viewer-perspective (relative) system ("to the left"). Brown and Levinson (1993) and Pederson et al. (1998) recently suggested that these linguistic practices affect spatial reasoning in language-specific ways. In one of their experiments, Tenejapan Mayan and Dutch subjects were presented with an array of objects (toy animals) on a tabletop; after a brief delay, subjects were taken to the opposite side of a new table (they were effectively rotated 180 degrees), handed the toys, and asked to reproduce the array "in the same way as before." The overwhelming majority of Tenejapan (absolute) speakers rearranged the objects so they were heading in the same cardinal direction after rotation, whereas Dutch (relative) speakers massively preferred to rearrange the objects in terms of left–right directionality. This covariation of linguistic terminology and spatial reasoning seems to provide compelling evidence for linguistic influences on nonlinguistic cognition.

As so often is the case in this literature, however, it is quite hard to disentangle cause and effect. For instance, it is possible that the Tenejapan and Dutch groups think about space differently because their languages pattern differently; but it is just as possible that the two linguistic–cultural groups developed different spatial-orientational vocabulary to reflect (rather than cause) differences in their spatial reasoning strategies. Li and Gleitman (2002) investigated this second position. They noted that absolute spatial terminology is widely used in many English-speaking communities whose environment is geographically constrained and includes large stable landmarks such as oceans and looming mountains. The absolute terms *uptown*, *downtown*, and *crosstown* (referring to North, South, and East–West) are widely used to describe and navigate in the space of Manhattan Island, Chicagoans regularly make absolute reference to the lake, etc. It is quite possible, then, that the presence or absence of stable landmark information rather than language spoken influences the choice of absolute versus spatial coordinate frameworks. After all, the influence of such landmark information on spatial reasoning has been demonstrated with nonlinguistic (rats; Restle, 1957) and prelinguistic (infants; Acredolo & Evans, 1980) animals. To examine this possibility, Li and Gleitman replicated Brown and Levinson's rotation task with English speakers, but they manipulated the presence or absence of landmark cues in the testing area. The result, just as for the rats and the infants, was that English-speaking adults respond absolutely in the presence of landmark information (after rotation, they set up the animals going in the same cardinal direction) and relatively when it is withheld (they set up the animals going in the same relative – left or right – direction).

Flexibility in spatial reasoning in this regard should come as little surprise. The ability to navigate in space is hard-wired in the brain of moving creatures, including bees and ants. For all of these organisms, reliable orientation and navigation in space are crucial for survival (Gallistel, 1990). Accordingly, neurobiological evidence from humans and other species that the brain routinely uses a multiplicity of coordinate frameworks in coding for the position of objects to prepare for directed action (Gallistel, 2002). It would be quite amazing if, among all the creatures that walk, fly, and crawl on the earth, only humans, by virtue of acquiring a particular language, lose the ability to use both absolute and relative spatial coordinate frameworks flexibly. The case is by no means closed even on this issue, however, because successive probes of the rotation situation have continued to yield conflicting results both within and across languages (e.g., Levinson, Kita, & Haun, 2002; Li & Gleitman, in preparation]. One way of reconciling these findings and theories has to do with the level of analysis to which the Levinson groups' findings are thought to apply. Perhaps we are prisoners of language only in complex and highly derived tasks and only when behavior is partly under the control of verbal instructions that include vague expressions such as "make it the same." But it is fair to say that the jury is still out on this phenomenon.

Evidentiality

One of Whorf's most interesting conjectures concerned the possible effects of evidentials (linguistic markers of information source) on the nature of thought. Whorf pointed out that Hopi – unlike English – marked evidential distinctions in its complementizer system. Comparing the sentences *I see that it is red* vs. *I see that it is new*, he remarked (Whorf, 1956, p. 85):

> *We fuse two quite different types of relationship into a vague sort of connection expressed by 'that', whereas the Hopi indicates that in the first case seeing presents a sensation 'red,' and in the second that seeing presents unspecified evidence for which is drawn the inference of newness.*

Whorf concluded that this grammatical feature was bound to make certain conceptual distinctions easier to draw for the Hopi speaker because of the force of habitual linguistic practices.

Papafragou, Li, Choi, and Han (in preparation) sought to put this proposal to test. They compared English, which mainly marks evidentiality lexically (*I saw/heard/inferred that John left*), with Korean, in which evidentiality is encoded through a set of dedicated morphemes. Given evidence that such morphemes are produced early by children learning Korean (Choi, 1995), they asked whether Korean children develop the relevant conceptual distinctions earlier and with greater reliability than learners of English, in which evidentiality is not grammatically encoded. In a series of experiments, they compared the acquisition of nonlinguistic distinctions between sources of evidence in three- and four-year-olds learning English or Korean: No difference in nonlinguistic reasoning in these regards was found between the English and Korean group. For instance, children in both linguistic groups were equally good at reporting how they found out about the contents of a container (e.g., by looking inside or by being told); both groups were also able to attribute knowledge of the contents of a container to a character who had looked inside but not to another character who had had no visual access to its content. Furthermore, Korean learners were more advanced in their nonlinguistic knowledge of sources of information than in their knowledge of the meaning of linguistic evidentials. In this case, then, learned linguistic categories do not seem to serve as a guide for the individual's nonlinguistic categories in the way that Whorf conjectured. Rather, the acquisition of linguistically encoded distinctions seems to follow, and build upon, the conceptual understanding of evidential distinctions. The conceptual understanding itself appears to proceed similarly across diverse language-learning populations.

Time

Thus far, we have focused on grammatical and lexical properties of linguistic systems and their possible effects on conceptual structure. Here we consider another aspect of languages as expressive systems – their systematically differing use of certain networks of metaphor; specifically, metaphor for talking about time (Boroditsky, 2001). English speakers predominantly talk about time as if it were horizontal (one *pushes deadlines back*, *expects good times ahead*, or *moves meetings forward*), whereas Mandarin speakers more usually talk about time in terms of a vertical axis (they use the Mandarin equivalents of *up* and *down* to refer to the order of events, weeks, or months). Boroditsky showed that these differences predict aspects of temporal reasoning by speakers of these two languages. In one of her manipulations, subjects were shown two objects in vertical arrangement, say, one fish following another one downward, as they heard something like *The black fish is winning*. After this vertically oriented prime, Mandarin speakers were faster to confirm or disconfirm temporal propositions (e.g., *March comes earlier than April*) than if they were shown the fish in a horizontal array. The reverse was true for English speakers. Boroditsky concluded that spatiotemporal metaphors in language affect how people reason about time. She has suggested, more generally, that such systematic linguistic metaphors are important in shaping habitual patterns of thought.

However, these results are again more complex than they seem at first glance. For one thing, and as Boroditsky acknowledges, vertical metaphors of time are by no means absent from ordinary English speech (e.g., *I have a deadline coming up*), although they are more sporadic than in Mandarin. So again we have a cross-linguistic difference of degree, rather than a principled opposition. Moreover, Boroditsky briefly trained her English-speaking subjects to think about time vertically, as in Mandarin. After such training, the English speakers exhibited the vertical (rather than the former horizontal) priming effect. Apparently, fifteen minutes of training on the vertical overcame and completely reversed twenty-plus years of the habitual use of the horizontal in these speakers. The effects of metaphor, it seems, are transient and fluid without long-term influence on the nature of conceptualization or its implicit deployment to evaluate propositions in real time.

Number

Prelinguistic infants and nonhuman primates share an ability to represent both exact numerosities for very small sets (roughly up to three objects) and approximate numerosities for larger sets (Dehaene, 1997). Human adults possess a third system for representing number that allows for the representation of exact numerosities for large sets; in principle has no upper bound on set size; and can support the comparison of numerosities of different sets, as well as processes of addition and subtraction. Crucially, this system is *generative* because it possesses a rule for creating successive integers (the successor function) and therefore is characterized by discrete infinity (see Gallistel & Gelman, Chap. 23).

How do young children become capable of using this uniquely human number system? One powerful answer is that the basic principles underlying the adult number system are innate; gaining access to these principles gives children a way of grasping the infinitely discrete nature of natural numbers, as manifested by their ability to use verbal counting (Gelman & Gallistel, 1978; Gallistel & Gelman, Chap. 23). Other researchers propose that children come to acquire the adult number system by conjoining properties of the two prelinguistic number systems via natural language. Specifically, they propose that grasping the *linguistic* properties of number words (e.g., their role in verbal counting or their semantic relations to quantifiers such as *few, all, many, most*; see Spelke & Tsivkin, 2001a and Bloom, 1994b; Carey, 2001 respectively) enables children to put together elements of the two previously available number systems to create a new, generative number faculty. In Bloom's (1994b, p. 186) words, "in the course of development, children 'bootstrap' a generative understanding of number out of the productive syntactic and morphological structures available in the counting system."

Upon hearing the number words in a counting context, for instance, children realize that these words map onto both specific representations delivered by the exact-numerosities calculator and inexact representations delivered by the approximator device. By conjoining properties of these two systems, children gain insight into the properties of the adult conception of number (e.g., that each of the number words picks out an exact set of entities, that adding or subtracting exactly one object changes number, etc.). Ultimately, it is hypothesized that this process enables the child to compute exact numerosities even for large sets (such as *seven* or *twenty-three*) – an ability not afforded by either of the prelinguistic calculation systems.

Spelke and Tsivkin (2001a, b) experimentally investigated the thesis that language contributes to exact large-number calculations. In their studies, bilinguals who were trained on arithmetic problems in a single language and later tested on them were faster on large-number arithmetic if tested in the training language; however, no such advantage of the training language appeared with estimation problems. The conclusion from this and related experiments was that the particular natural language is the vehicle of thought concerning large exact numbers but not about approximate numerosities. Such findings, as Spelke and her collaborators have emphasized, can be part of the explanation of the special "smartness" of humans. Higher animals, like humans, can reason to some degree about approximate numerosity, but not about exact numbers. Beyond this shared core knowledge, however, humans have language. If language is a required causal factor in exact number knowledge, in principle this could explain the gulf between creatures like us and creatures like them.

How plausible is the view that the adult number faculty presupposes linguistic mediation? Recall that, on this view, children infer the generative structure of number from the generative structure of grammar when they hear others counting. However, counting systems vary cross-linguistically, and in a language like English, their recursive properties are not really obvious from the outset. Specifically, until number eleven, the English counting system presents no evidence of regularity, much less of generativity: A child hearing *one, two, three, four, five, six*, up to *eleven*, would have no reason to assume – based on properties of form – that the corresponding numbers are lawfully related (namely, that they successively increase by one). For larger numbers, the system is more regular, even though not fully recursive because of the presence of several idiosyncratic features (e.g., one can say *eighteen* or *nineteen* but not *tenteen* for twenty). In sum, it is not so clear how the "productive syntactic and morphological structures available in the counting system" will provide systematic examples of discrete infinity that can then be imported into number cognition (see Grinstead et al., 2003, for detailed discussion).

Can properties of other natural language expressions bootstrap a generative understanding of number? Quantifiers have been proposed as a possible candidate (Carey, 2001). However, familiar quantifiers lack the hallmark properties of the number system: They are not strictly ordered with respect to one another, and their generation is not governed by the successor function. In fact, several quantifiers presuppose the computation of cardinality of sets – for example, *neither* and *both* apply only to sets of two items (Keenan & Stavi, 1986; Barwise & Cooper, 1981). Moreover, quantifiers compose in quite different ways from numbers. For example, the expression *most men and women* cannot be interpreted to mean a large majority of the men and much less than half the women (A. Joshi, personal communication). In light of the semantic disparities between the quantifier and integer systems, it is hard to see how it is possible to bootstrap the semantics of one from the other.

Recent experimental findings suggest, moreover, that young children understand certain semantic properties of number words well before they know those of quantifiers. One case involves the scalar interpretation of these terms. In one experiment, Papafragou and Musolino (2003) had five-year-old children watch as three horses were shown jumping over a fence. The children would not accept *Two of the horses jumped over the fence* as an adequate description of that event (even though it is necessarily true that if three horses jumped, then certainly two did). But at the same age, they will accept *Some of the horses jumped over the fence* as an adequate description even though it is true that all of the horses jumped. In another experiment, Hurewitz, Papafragou, Gleitman, and Gelman (in review) found that three-year-olds understand certain semantic properties of number words such as *two* and *four* well before they know those of quantifiers such as *some* and *all*. It seems, then, that the linguistic systems of number and natural-language quantification are developing rather independently. If anything, the children seem more advanced in knowledge of the meaning of number words than quantifiers so it is hard to see how the semantics of the former lexical type is to be bootstrapped from the semantics of the latter.

Orientation

A final domain we discuss is spatial orientation. Cheng and Gallistel (1984) found that rats rely on geometric information to reorient themselves in a rectangular space, and seem incapable of integrating geometrical with nongeometrical properties (e.g., color, smell, etc.) in searching for a hidden object. If they see food hidden at the corner of a long and a short wall, they will search equally at either of the two such walls of a rectangular space after disorientation; this is true even if these corners are distinguishable by one of the long walls being painted blue or having a special smell, and so on. Hermer and Spelke (1994, 1996) reported a very similar difficulty in young children. Both animals and young children can navigate and reorient by the use of either geometric or nongeometric cues; it is integrating across the cue types that creates trouble. These difficulties are overcome by older children and adults, who are able, for instance, to go straight to the corner formed by a long wall to the left and a short blue wall to the right. Hermer and Spelke found that success in these tasks was significantly predicted by the spontaneous combination of spatial vocabulary and object properties such as color within a single phrase (e.g., *to the left of the blue wall*).[7] Later experiments (Hermer-Vasquez, Spelke, and Katsnelson, 1999) revealed that adults who were asked to shadow speech had more difficulty in these orientation tasks than adults who were asked to shadow a rhythm with their hands; however, verbal shadowing did not disrupt subjects' performance in tasks that required the use of nongeometric information only. The conclusion was that speech-shadowing, unlike rhythm-shadowing, by taking up linguistic resources, blocked the integration of geometrical and object properties, which is required to solve complex orientation tasks. In short, success at the task seems to require encoding of the relevant terms in a specifically linguistic format.

In a recent review article, Carruthers (2002) suggests even more strongly that in number, space, and perhaps other domains, language is the medium of intermodular communication, a format in which representations from different domains can be combined to create novel concepts. In standard assumptions about modularity, however, modules are characterized as computational systems with their own proprietary vocabulary and combinatorial rules. Because language itself is a module in this sense, its computations and properties (e.g., generativity, compositionality) cannot be transferred to other modules because they are defined over – and can only apply to – language-internal representations. One way out of this conundrum is to give up the assumption that language is – on the appropriate level – modular:

> *Language may serve as a medium for this conjunction ... because it is a domain-general, combinatorial system to which the representations delivered by the child's ... [domain-specific] nonverbal systems can be mapped. (Spelke & Tsivkin, 2001b, p. 84).*

> *Language is constitutively involved in (some kinds of) human thinking. Specifically, language is the vehicle of nonmodular, nondomain-specific, conceptual thinking which integrates the results of modular thinking (Carruthers, 2002, p. 666).*

On this view, the output of the linguistic system just *is* Mentalese: There is no other level of representation in which the information *to the left of the blue wall* can be entertained. This picture of language is novel in many respects. In the first place, replacing Mentalese with a linguistic representation challenges existing theories of language production and comprehension. Traditionally, and as discussed earlier, it is assumed the production of sentences begins by entertaining the corresponding thought, which then mobilizes the appropriate linguistic resources for its expression (e.g., Levelt, 1989).

On recent proposals, however, Carruthers, (2002, p. 668) observed:

> *We cannot accept that the production of a sentence 'The toy is to the left of the blue wall' begins with a tokening of the thought THE TOY IS TO THE LEFT OF THE BLUE WALL (in Mentalese), since our hypothesis is that such a thought cannot be entertained independently of being framed in a natural language.*

Inversely, language comprehension classically is taken to unpack linguistic representations into mental representations that then can trigger further inferences. But in Carruthers' proposal, after hearing *The toy is to the left of the blue wall*, the interpretive device cannot decode the message into the corresponding thought because there is no level of Mentalese independent of language in which the constituents are lawfully connected to each other. Interpretation can only dismantle the utterance and send its concepts back to the geometric and landmark modules to be processed. In this sense, understanding an utterance such as *The picture is to the right of the red wall* turns out to be a very different process than understanding superficially similar utterances such as *The picture is to the right of the wall*, or *The picture is on the red wall*, which do not, on this account, require cross-domain integration.

Furthermore, if language is to serve as a domain for cross-module integration, then the lexical resources of each language become crucial for conceptual combination. Lexical gaps in the language will block conceptual integration, for instance, because there would be no relevant words to insert into the linguistic string. We know that color terms vary across languages (Kay & Regier, 2002); more relevantly, not all languages have terms for *left* and *right* (Levinson, 1996). It follows that speakers of these languages should fail to combine geometric and object properties in the same way as do English speakers to recover from disorientation. In other words, depending on the spatial vocabulary available in their language, disoriented adults may behave either like Spelke and Tsivkin's English-speaking population or like prelinguistic infants and rats. This prediction, although merely carrying the original proposal to its apparent logical conclusion, is quite radical: It allows a striking discontinuity among members of the human species, contingent not upon the presence or absence of human language and its combinatorial powers (as the original experiments seem to suggest) or even upon cultural and educational differences, but on vagaries of the lexicon in individual linguistic systems.

Despite its radical entailments, there is a sense in which Spelke's proposal to interpret concept configurations on the basis of the combinatorics of natural language can be construed as decidedly nativist. In fact, we so construe it. Spelke's proposal requires that humans be equipped with the ability to construct novel structured syntactic representations, insert lexical concepts at the terminal nodes of such representations (*left*, *blue*, etc.), and interpret the outcome on the basis of familiar rules of semantic composition (*to the left of the blue wall*). In other words, humans are granted principled knowledge of how phrasal meaning is to be determined by lexical units and the way they are composed into structured configurations. That is, what is granted is the ability to read the semantics off of phrase structure trees. Further, the assumption is that this knowledge is not attained through learning but belongs to the in-built properties of the human language device. But notice that granting humans the core ability to build and interpret phrase structures is already granting them quite a lot. Exactly these presuppositions have been the hallmark of the nativist program in linguistics and language acquisition (Chomsky, 1957; Pinker, 1984; Gleitman, 1990; Lidz, Gleitman, & Gleitman, 2002; Jackendoff, 1990) and the target of vigorous dissent elsewhere (Tomasello, 2000; Goldberg, 1995). To the extent that Spelke and Tsivkin's arguments about language and cognition rely on the combinatorial and generative powers of language, they already make quite deep commitments to abstract (and unlearnable) syntactic principles and their semantic reflexes. Notice in this regard that because these authors hold that *any* natural language will serve as the source and vehicle for the required inferences, the principles at work here must be abstract enough to wash out the diverse surface-structural realizations of *to the left of the blue* wall in the languages of the world. Independently of particular experiences, an organism with such principles in place could generate and *systematically* comprehend novel linguistic strings with meanings predictable from the internal organization of those strings and, for different but related reasons, *just as systematically* fail to understand other strings such as *to the left of the blue idea*. We would be among the last to deny such a proposal in its general form. We agree that there are universal aspects of the syntax–semantics interface. Whether these derive from or augment the combinatorial powers of thought is the question at issue here. For the present commentators, it is hard to see how shifting the burden of the acquisition of compositional semantics from the conceptual system to the linguistic system diminishes the radical nativist flavor of the position.

Conclusions and Future Directions

We have just tried to review the burgeoning psychological and anthropological literature that attempts to relate language to thought. We began with the many difficulties involved in radical versions of the linguistic relativity position, including the fact that language seems to underspecify thought and to diverge from it regarding the treatment of ambiguity, paraphrase, and deictic reference. Moreover, there is ample evidence that several forms of cognitive organization are independent of language: Infants who have no language are able to entertain relatively complex thoughts; for that matter, they can learn languages or even invent them when the need arises (Goldin-Meadow, 2003; Senghas et al., 1997). Many bilinguals, as a matter of course, "code-switch" between their known languages even during the utterance of a single sentence (Joshi, 1985). Aphasics sometimes exhibit impressive propositional thinking (Varley & Siegal, 2000). Animals can form representations of space, artifacts, and perhaps even mental states without linguistic crutches (Hauser & Carey, 1998; Gallistel, 1990; Hare, Call, & Tomasello, 2001; and Call & Tomasello, Chap. 25). In light of all these language–thought disparities, it would seem perverse to take an equative position on relations between the two.

At the same time, compelling experimental studies again and again document intimate, seemingly organic, relationships among language, thought, and culture, of much the kind that Whorf and Sapir drew out of their field experiences. What is to explain these deep correlations between culturally divergent ways of thinking and culturally divergent ways of talking? In certain cases, we argued that cause and effect had simply been prematurely placed on one foot or another because of the crudeness of our investigative tools. Inconveniently enough, it is often hard to study language development apart from conceptual and cultural learning or to devise experiments in which these factors can be prevented from interacting, so it is hard to argue back to origins. On the other hand, the difficulty of even engineering such language–thought dissociations in the laboratory is one significant point in favor of a linguistic–relativistic view. Why should it be so hard to pry them apart if they are so separate?

Over the course of the discussion, our reading of the evidence provides source global support for what we take to be the "typological bootstrapping" and "thinking for speaking" positions articulated in various places by Slobin [1996; 2001; 2003, *inter alia*]. Language influences thought "on line" and in many ways. For the learner, the particular speech events that one experiences can and do provide cues to nonlinguistic categorization – that is, a new linguistic label "invites" the learner to attend to certain types of classification criteria over others. Markman and Hutchinson (1984) found that if one shows a two-year-old a new object and says *See this one; find another one*, the child typically reaches for something that has a spatial or encyclopedic relation to the original object (e.g., finding a bone to go with the dog). But if one uses a new word (*See this fendle, find another fendle*), the child typically looks for something from the same category (e.g., finding another dog to go with the first dog). Similar effects have been obtained with much younger children: Balaban and Waxman (1997) showed that labeling can facilitate categorization in infants as young as nine months (cf. Xu, 2002). Beyond categorization, labeling has been shown to guide infants' inductive inference (e.g., expectations about nonobvious properties of novel objects), even more so than perceptual similarity (Welder & Graham, 2001). Other recent experimentation shows that labeling may help children solve spatial tasks by pointing to specific systems of spatial relations (Loewenstein & Gentner, 2003). For learners, then, the presence of linguistic labels constrains criteria for categorization and serves to foreground a *codable* category out of all the possible categories to which a stimulus could be said to belong.

To what extent these linguistic influences result in mere tweaks – slight shifts in the boundaries between categories – or to more radical reorganizations of the learners' conceptual world (as in the reorganizational principles that stand between phonetics and phonology) is hard to say at the present time. For competent adult users, thinking for speaking effects arise again to coax the listener toward certain interpretations of the speech he or she is hearing as a function of probabilistic features of a particular language. The clearest example in the analysis we presented is the series of inferences that lead to different cross-linguistic categorizations of novel not-clearly-individuatable stimulus items with nonsense names: If it is an English noun, it is probably an English count-noun; if it is an English count-noun, it is probably naming an individuatable object.

It appears to us that much discussion about the relationship between language and thought has been colored by an underlying disagreement about the nature of language itself. Many commentators, struck by observed cross-linguistic diversity in semantic and syntactic categories, have taken this diversity as a possible source of deeper cognitive discontinuities among speakers of different languages. But other commentators see this cross-linguistic diversity as much more limited and superficial than the blooming, buzzing confusion coming out of the tower of Babel. For instance, many studies in morphosyntax show that apparently distinct surface configurations of linguistic elements in different languages can be analyzed in terms of underlying structural similarities (Chomsky, 2000; Baker, 2001). Studies in linguistic semantics suggest that the properties and meanings of syntactic entities (e.g., determiners) are severely constrained cross-linguistically (Keenan & Stavi, 1986). Many of these principles of language organization seem to map quite transparently from core knowledge of the kinds studied in infants (e.g., Quinn, 2001; Baillargeon, 1993; and other sources mentioned throughout). For instance, scenes of kangaroos jumping come apart into the kangaroo (argument) part and jumping (predicate) part in every natural language, but also in the prelinguistic parsing of events by children, including those learning language under circumstances of extreme linguistic and sensory deprivation (e.g., blind or isolated deaf children: Goldin-Meadow, 2003; Landau & Gleitman, 1985; Senghas et al., 1997). Focus on this kind of evidence suggests that cross-linguistic diversity is highly constrained by rich and deep underlying similarities in the nature of thought. Thus, rather than pointing to cognitive discontinuities among speakers of different languages, cross-linguistic diversity could reveal principled points of departure from an otherwise common linguistic–conceptual blueprint humans share as a consequence of their biological endowment.

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Notes

1. In one experimental demonstration, subjects were asked: *When an airplane crashes, where should the survivors be buried?* They rarely noticed the meaning discrepancy in the question (Barton & Sanford, 1996).
2. The similarity test may not be decisive for this case, as Malt, Sloman, and Gennari (2003), as well as Smith, Colunga, and Yoshida (2001), among others, have pointed out. Similarity judgments applied as the measuring instrument could systematically mask various nonperceptual determinants of organization in a semantic–conceptual domain, some potentially language-caused. Over the course of this chapter, we will return to consider other domains and other psychological measures. For further discussion of the sometimes arbitrary and linguistically varying nature of the lexicon, even in languages that are typologically and historically closely related, see Kay (1996). He points out, for example, that English speakers use *screwdriver* whereas the Germans use *Schraubenzieher* (literally, "screwpuller"), and the French *tournevise* (literally, "screwturner") for the same purposes; our turnpike exit–entry points are marked *exit*, whereas the Brazilians have *entradas*; and so forth.
3. Categorical perception for speech sounds has been documented for other species, including chinchillas and macaques (e.g., Kuhl & Miller, 1978). Moreover, studies from Kay and Kempton (1984) and Roberson, Davies, and Davidoff (2000) suggest that even for hue perception, the relationship between linguistic and perceptual categorization is not so clear with categorical perception effects obtained or not obtained depending on very delicate choices of experimental procedure and particular characteristics of the stimulus. For an important review, see Munnich and Landau (2003).
4. This argument is not easy. One might argue that English is a classifier language much like Yucatec Mayan or Japanese – that is, that all its words start out as mass nouns and become countable entities only through adding the classifiers *the* and *a* (compare *brick* the substance to *a brick*, the object). Detailed linguistic analysis, however, suggests there is a genuine typological difference here (Slobin, 2001 and Lucy & Gaskins, 2001; Chierchia, 1998; Krifka, 1995, for discussion). The question is whether, because all languages formally mark the mass or count distinction in one way or another, the difference in particular linguistic means could plausibly rebound to impact ontology.
5. We should point out that this hint, at best, is a weak one, another reason why the observed interpretive difference for Japanese and English speakers, even at the perceptual midline, is also weak. Notoriously, English often violates the semantic generalization linking mass noun morphology with substancehood (compare, for example, *footwear, silverware, furniture*).
6. Subsequent analysis of the linguistic data revealed that Greek speakers were more likely to include manner of motion in their verbal descriptions when manner was unexpected or noninferable, whereas English speakers included manner information regardless of inferability (Papafragou, Massey, & Gleitman, 2003). This suggests that speakers may monitor harder-to-encode event components and choose to include them in their utterances when especially informative. This finding reinforces the conclusion that verbally encoded aspects of events vastly underdetermine the subtleties of event cognition.
7. Further studies show that success in this task among young children is sensitive to the size of the room: In a large room, more four-year-olds succeed in combining geometric and landmark information (Learmonth, Nadel, & Newcombe, in press). Moreover, it is claimed that other species (chickens, monkeys) can use both types of information when disoriented (Vallortigara, Zanforlin, & Pasti, 1990; Gouteux, Thinus-Blanc, & Vauclair, in press). For discussion, see Carruthers (2002).

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