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New Perspectives on Language and thought

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ABSTRACT

This chapter discusses the question of whether, how, where, and to what extent language plays a causally fundamental role in creating categories of thought, and in organizing and channeling thought that is already mentally present. In general, both logic and currently available evidence suggest a disclamatory view of strongest proposals (e.g., Benjamin Whorf, 1956) according to which particulars of certain human languages are important progenitors of thought, such that elements of perception or conception would be permanently altered by learning one or another language. However, several credible lines of experimental and developmental evidence suggest significant influence of linguistic representation during on-line processing in many cognitive and perceptual domains: Insofar as languages differ in the short-term processing demands that they pose to listeners, interpretational outcomes and styles, including characteristic ambiguity resolution, may look quite different cross-

linguistically as a function of concomitant population differences (e.g., age-group) and task demands.

Keywords: *categorical perception; Whorf; linguistic relativity; linguistic determinism*

The presence of language is one of the central features that distinguishes humans from other species. Even in very early infancy, during the (misnamed) prelinguistic stage of life, infants respond positively to strangers who are speaking in the special melodies of the exposure language, but shrink away from those speaking a different language or dialect (Kinzler, Shutts, DeJesus & Spelke, 2009). Cultures materially define themselves by the way that they and "others" speak, down to the smallest details. Blood has in many times and places been spilled in consequence. A famous case, and the origin of the word itself, is the biblical tale of *shibboleth.*[1]

In light of this intimate bond between language and cultural identification, it is easy to understand the intense interest for laypersons and specialists alike in the topic of this chapter: *the relations between language and thought*. Many people actually identify these two notions; they share the intuition that they

[1] 'Gilead then cut Ephraim off from the fords of the Jordan, and whenever Ephraimite fugitives said, 'Let me cross,' the men of Gilead would ask, 'Are you an Ephraimite?' If he said, 'No,' they then said, 'Very well, say "Shibboleth".' If anyone said, "Sibboleth", because he could not pronounce it, then they would seize him and kill him by the fords of the Jordan. Forty-two thousand Ephraimites fell on this occasion.' (Judges 12-5-6; as cited in Wikipedia)

think “in” language, hence that the absence of language would, *ipso facto*, be the absence of thought itself. One compelling version of this self-reflection is Helen Keller’s (1955) report that her recognition of the signed symbol for ‘water’ triggered thought and emotional 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). On this kind of supposition, we may have no way to think many thoughts, conceptualize many of our ideas, without language, or outside of and independent of language. Moreover, different communities of humans, speaking different languages, would think differently to just the extent that their languages differ from one another. But is this so? Could it be so? That depends on how we unpack the notions so far alluded to so informally.

Do we think “in” language?

In the obvious sense, language has powerful and specific effects on thought. After all, 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 the thoughts and attitudes of others in just this way. This information transmission function is crucial for the structure and survival of cultures and societies in all their known forms (also see Rai, Chap. 29).

Traditionally, language has been considered mainly in this conduit role, as the vehicle for the expression of thought rather than as its progenitor. From Noam Chomsky's universalist perspective, 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." (Chomsky, 1975, p. 4)

This view is not proprietary to the rationalist position for which Chomsky is speaking here. Classical empiricist thought maintained that our concepts (sensory discriminations aside) derive from experience with properties, things, and events in the world and not, originally, from language:

> "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." (Hume, 1739; Book I).

And as a consequence of such experience with *things*, *ideas* arise in the mind and can receive linguistic labels:

> "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 … (Locke, 1690, Book 3.IX.9; italics ours).

Our question in this chapter is how far and what ways this chain may operate in reverse, such that language causes thought to be what it is. The issues here were raised most forcefully in the writings of Benjamin Whorf and Eric Sapir in the first half of the 20th century.[2] According to Whorf, the

[2] Whorf's own position, and specific claims, on all the matters discussed in this chapter was often metaphorical, highly nuanced, and to some extent inconsistent across his body of work. Sometimes his concentration was on cultural differences as reflected in language rather than on language as tailor of culture. Sometimes he asserted, but sometimes rejected, the idea that particular words, word classes, or grammatical devices ("surface" facts about language) were his intended causal vehicles of mental categories and functions. Owing to this partial inconsistency, perhaps a common property of scientific views in their earliest formulations, an industry of

grammatical and lexical resources of individual languages heavily constrain the conceptual representations available to their speakers.

> "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" (Whorf, 1956, p. 214).

This linguistic-relativistic view, in its richest form, entails that linguistic categories will be the "program and guide for an individual's mental activity" (ibid, 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. The importance of this position cannot be overestimated: language here becomes a vehicle for the growth of *new* concepts -- those which were not theretofore in the mind, and perhaps could not have been there without the intercession of linguistic experience. Thus it poses a challenge to the venerable view that one could not acquire a concept that one could not antecedently entertain (Plato, 5-4th century BCE; Descartes, 1662; Fodor, 1975, *inter alia*). At the limit it is a proposal for how new thoughts can arise in the mind as a

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interpreting Whorf – both by his defenders and detractors – has grown up, and is often heated. Our aim is to explicate the theoretical positions ("Whorfianism") that are indebted in one or another way to this thinker, not to present an intellectual biography of Whorf himself.

result of experience with language rather than as a result of experience with the world of objects and events.

By the 1950's the Whorf-Sapir hypothesis began to percolate into psychological theorizing, and seemed to proponents to provide a route to understanding how cognitive categories formed and jelled in the developing human mind. A major figure in this history 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, e.g., of hands that seemed to be kneeding confetti-like 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 kneeding 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, e.g., that persons, places, and things surface as nouns, are universal and thus can play causal roles in the acquisition of language by learners who are predisposed to find just these kinds of syntactic-semantic correlations "natural" (e.g., Pinker, 1984; Gleitman, 1990; Fisher, 1996; P. Bloom, 1994a; Landau & Gleitman, 1985; Lidz, Gleitman & Gleitman, 2003; Baker, 2001). Brown saw his result the other way around. He supposed that languages would vary arbitrarily in these form mappings onto conceptual categories. Those world properties thus yoked together by language would cause a (previously uncommitted) infant learner to conceive them as meaningfully related in some ways.

> "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". (Brown, 1957, p. 5).

These ideas have continued to be explored in the cognitive literature ever since. One recent formulation (Bowerman & Levinson, 2001, p. 13) states:

> "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".

In the strongest interpretations, the categories of language essentially become the default categories of thought:

> "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" (Pederson, Danziger, Wilkins, Levinson, Kita & Senft, 1998, p. 586).

Before turning to the recent literature on language and thought, so conceived, we want to emphasize that most current contributors fall somewhere between the extremes of such views. To our knowledge, none 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, infants are believed to possess some "core knowledge" that enters into the first categorizations of objects, properties, and events in the world (e.g. Carey, 1982; 2008; Kellman, 1996; Baillargeon, 1993; Gelman & Spelke, 1981; Gibson & Spelke, 1983; Leslie & Keeble, 1987; Mandler, 1996; Prasada, Ferenz, & Haskell, 2002; Quinn, 2001; Spelke, Breinliger, Macomber, & Jacobson, 1992). The viable question is how richly specified this innate basis may be and how experience refines, enhances, and transforms the mind's original furnishings; and, finally, whether specific language knowledge may be one of these formative or transformative aspects of experience. To our knowledge, none of those who adopt a nativist position on these matters reject as a matter of *a priori* conviction the possibility that there could be effects of language on thought. For instance, some particular natural language might formally mark a category that 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. These differences might, in turn, influence the representation or processing machinery for speech and comprehension.

We will try to draw out aspects of these issues within several domains in which commentators and investigators are currently 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; Malt & Wolff, 2010).

Border wars: Where does language end and inference begin?

We begin with a very simple question: Do our thoughts actually take place in a specific 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.

There are several reasons to suppose that, if tenable at all, such a position needs to reined in considerably. This is because, if language directly expresses our thought, it seems to make a poor job of it. Consider for example this sentence from 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 things open as between (1a) and (1b). One way to think about what this example portends is that language just 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 is, of course, 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*? That is, *in the immediate geographical environment of the speaker?* Or does the sentence itself -- 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'.[3] The exact division of labor between linguistic semantics and pragmatics has implications for the language-thought issue, since 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 – hence the representations that populate our mental life cannot be identical to the representations that encode linguistic (semantic) meaning.

Language is sketchy, thought is rich

There are several further 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 hence 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 while 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 are nevertheless 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 this

[3] We thank Jerry Fodor for discussion of these issues.

word (*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 itself 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: *open the window to let in the evening breeze/the cat.* Moreover, there are cases where linguistic output does not even encode a complete thought/proposition (*Tomorrow, Maybe*). Finally, the presence of implicatures and other kinds of pragmatic inference ensures that -- to steal a line from the Mad Hatter -- while 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 to the richness of our thoughts (for related discussions, see Fisher & Gleitman, 2002; Papafragou, 2007). 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). In this context, *Table 8*, *the ham sandwich*, and *the man seated at Table 8* are communicatively equivalent. 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 versus what is mutually known and inferable (e.g. Grice, 1975; Sperber & Wilson, 1986; H. Clark, 1992; P. Bloom, 2002).

In limiting cases, competent listeners ignore linguistically encoded meaning if it patently differs from (their estimate of) 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 said, or is reputed to have 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.[4] 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.

Arbitrary and inconsistent encodings

The cases just mentioned refer to particular tokenings of meanings in the idiosyncratic interactions between people. A related problem arises when languages categorize aspects of the world in ways that are complex and

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[4] 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).

inconsistent. An example is reported by Malt, Sloman, Gennari, Shi and Wang (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, contents, shape, substance, nature of the contents, not to speak of the commercial interests of the purveyor, all playing interacting and shifting roles. For instance, in present-day American English, a certain plastic container that looks like a bear with a straw stuck in its head is called “a juice box”, though 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, etc. 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 where 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.[5]

So far we have emphasized that language is a relatively impoverished and underspecified vehicle of expression, which 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. Phrasal paraphrase, metaphor and figurative language are heavily relied on to carry ideas that may not be conveniently lexicalized or grammaticized. Interpretive flexibility sufficient to overcome these mismatches is dramatically manifested by simultaneous translators at the United Nations who more or less adequately convey the speakers' thoughts using the words and structures of dozens of distinct languages, thus crossing not only

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[5] The similarity test may not be decisive for this case, as Malt, Sloman & Gennari (2003) as well as Smith et al. (2001), among others, have pointed out. Similarity judgments as the measuring instrument could be systematically masking various nonperceptual determinants of organization in a semantic-conceptual domain, some of these potentially language-caused. Over the course of this essay, 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 which are typologically and historically closely related, see Kay (1996). He points out, for example, that English speakers use *screwdriver* while 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.

differences in the linguistic idiom but enormous gulfs of culture and disagreements in belief and perspective.

Despite these many disclaimers, it is possible to maintain the idea that certain formal properties of language causally affect thought in more local, but still important, ways. In the remainder of this chapter we consider two currently debated versions of the view that properties of language influence aspects of perception, thinking, and reasoning. The first is that language exerts its effects more or less *directly and permanently*, by revising either the mental categories, shifting the boundaries between them, or changing their prominence ("salience"). The second is that particulars of a language exert *indirect and transient* effects imposed during the rapid-fire business of talking and understanding. The present authors believe that the latter position, which we will explicate and expand as we go along, comes closer than the former to unifying the present experimental literature, and, in essence, reunites the Whorf-inspired literature with what we might call "ordinary psycholinguistics," the machinery of on-line comprehension.

Use it or lose it: When language reorganizes the categories of thought

We begin with the most famous and compelling instance of language properties reconstructing perceptual categories: categorical perception of the phoneme (Liberman, 1970; Liberman, Cooper, Shankweiler, & Studdert-Kennedy, 1967; Kuhl, Williams, Lacerda, Stevens & Lindblom, 1992; Kuhl, 2000; Werker & Lalondee, 1988).

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, Siqueland, Jusczyk & Vigorito, 1971] using a dishabituation paradigm (for details and significant expansions of this basic result see, e.g., Jusczyk, 1985; Werker & DesJardins, 1995; Mehler & Nespor, 2004). 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]. While 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.

When considering these findings in the context of linguistic relativity, one might be tempted to write them off as a limited tweaking at the boundaries of acoustic distinctions built into the mammalian species, a not-so-startling sensitizing effect of language on perception (Aslin, 1980; Aslin & Pisoni, 1981). Moreover, it is unlikely that the limits on perception and production imposed by early learning are absolute. After all, depending on age, talent, and motivation, they can be altered once again in subsequent learning of a second (or third, etc.) language (Werker & Lalonde, 1988).

But a more radical restructuring, specific to particular languages, occurs as these phonetic elements are organized into higher-level phonological categories. For example, American English speech regularly lengthens vowels in syllables ending with a voiced consonant (compare *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 indistinguishable if removed from their surrounding phonetic context. Yet the English-speaking listener perceives 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 (Bloch & Trager, 1942; Chomsky, 1964; for extensions to alphabetic writing, see Gleitman & Rozin, 1977).

Much of the literature on linguistic relativity can be understood as adducing related reconstructions in various perceptual and conceptual domains that are mapped onto language. 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 and permanently reorganizing the domain? We now look at some likely further cases.

The perception of hue

Languages differ in their terms for color just as they do in their phonetic and phonemic inventories. A number of factors favor color variables in the study of potential influences of language on thought. First, there is a powerful tradition of psychophysical measurement in this area that allows for the creation of test materials that can be scaled and quantitatively compared, at least roughly, for difference-magnitudes, discriminability, etc. Second, the fact that humans can discriminate hundreds of thousands, if not millions, of hues, coupled with the fact that it is impossible to learn a word for each, makes this domain a likely repository of linguistic difference. Third, the case of hue appears quite analogous to the well-studied instance of learning effects on phonetic categorization, thus a plausible immediate extension in the relevant regard.

Accordingly, a very large descriptive and experimental literature has been directed toward the question of whether color memory, learning, and similarity are influenced by color category-boundaries in the languages of the world. Significant evidence supports the view that color labeling is at least partly conditioned by universal properties of perception. Berlin and Kay (1969), in a cross-linguistic survey, showed that color vocabularies develop under strong universal constraints that are unlikely to be describable as effects of cultural diffusion (for recent discussion and amplifications, see especially Regier, Kay, Gilbert, & Ivry, 2010). Nevertheless there is considerable variance in the number of color terms encoded, so it can be asked whether these linguistic labeling practices affect perception. Heider and Oliver (1972) made a strong case that they do not. They reported that the Dugum Dani, a preliterate Papuan tribe of New Guinea with only two color labels (roughly, warm-dark and cool-light) remembered and categorized new hues that they were shown in much the same way as English speakers who differ from them both culturally and linguistically.

Intriguing further evidence of the independence of perception and labeling practices comes from red-green color-blind individuals (deuteranopes; Jameson & Hurvich, 1978). The perceptual similarity space of the hues for such individuals is systematically different from that of individuals with normal trichromatic vision. Yet a significant subpopulation of deuteranopes *names* hues, even of new things, consensually with normal-sighted individuals and consensually orders these hue *labels* for similarity as well. That is, these individuals do not order a set of color chips by similarity with the reds at one end, the greens at the other end, and the oranges somewhere in between (rather, by alternating chips that the normal trichromat sees as reddish and greenish; that is what it means to be color blind). Yet they do organize the color words with *red* semantically at one end, *green* at the other, and *orange* somewhere in between. In the words of Jameson and Hurvich:

> "the language brain has learned denotative color language as best it can from the normal population of language users, exploiting whatever correlation it has available by way of a reduced, or impoverished, sensory system, whereas the visual brain behaves in accordance with the available

sensory input, ignoring what its speaking counterpart has learned to say about what it sees". (1978, p. 154).

Contrasting findings had been reported earlier by Brown and Lenneberg (1954), who found that colors that have simple verbal labels are identified more quickly than complexly named ones in a visual search task (e.g., color chips called "blue" are, on average, found faster among a set of colors than chips called "purplish blue", etc.), suggesting that aspects of naming practices do influence recognition. In a series of recent studies in much the same spirit, Gilbert, Regier, Kay, and Ivry (2006; see also Regier, Kay, & Khetarpal, 2007; Kay, Regier & Cook, 2005) have shown that reaction time in visual search is longer for stimuli with the same label (e.g., two shades both called "green" in English) than for stimuli with different labels (one a consensual "blue" and one a consensual "green"). Crucially, however, this was the finding only when the visual stimuli were delivered to the right visual field (RVF), i.e., projecting to the left, language-dominant, hemisphere. Moreover, the RVF advantage for differently labeled colors disappeared in the presence of a task that interferes with verbal processing but not in the presence of a task of comparable difficulty that does not disrupt verbal processing (see also Kay & Kempton, 1984; Winauer, Witthoft, Frank, Wu, & Boroditsky, 2007). This response style is a well-known index of categorical perception, closely resembling the classical results for phoneme perception.

Looking at the literature in broadest terms, then, and as Regier et al. (2010) discuss in an important review, the results at first glance seem contradictory: On the one hand, perceptual representations of hue reveal cross-linguistic labeling commonalities, and are independent of such terminological differences as exist within these bounds. On the other hand, there are clear effects of labeling practices, especially in speeded tasks, where within-linguistic category responses are slower and less accurate than cross-category responses. The generalization appears to be that when language is specifically mobilized as a task requirement (e.g., the participant is asked for a verbal label) or when linguistically implicated areas of the brain are selectively measured, the outcomes are sensitive to linguistic categories; otherwise, less so or not at all: Language tasks recruit linguistic categories and functions that do not come into play in nonlinguistic versions of very similar tasks.[6] As we next show, this generalization holds as well in a variety of further domains where linguistic effects on thinking have been explored.

[6] These results are fairly recent, and a number of follow-up studies suggest that the picture that finally emerges may be more complicated than foreseen in Gilbert et al. For instance, Lindsey et al. (2010) report that some desaturated highly codable colors (notably, certain pinks) are not rapidly identified. Liu et al. (2010) do replicate the between-category advantage finding of Gilbert et al. but, critically, not the hemispheric advantage. If so, the suggestion is that labeling practice is penetrating to the level of nonlinguistic cognition. Roberson and colleagues adopt this very view (e.g., Roberson, 2005; Roberson et al., 2000; Roberson et al., 2005), reporting, for example, that Berinmo speakers (members of another relatively isolated Papua New Guinea tribe) were better at recognizing and remembering best examples of their own linguistic categories than color labels than the best examples of English color labels. They use such results to claim that color naming is entirely arbitrary from the point of view of perception, being solely a matter of linguistic labeling practices (for a response, see Kay & Regier, 2007).

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 some 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. Some languages make a grammatical distinction that roughly distinguishes object from substance (Chierchia, 1998; Lucy & Gaskins, 2001]. Count nouns in such languages denote individuated entities, e.g., object kinds. These are marked in English with determiners like *a, the*, and are subject to counting and pluralization (*a horse, horses, two horses).* Mass nouns typically denote nonindividuated entities, e.g., 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 substances, or whether they are led to make this distinction through learning count/mass syntax. Their subjects, English-speaking 2-year-olds, did not yet make these distinctions in their own speech. Soja et al. 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 non-solid substances such as a pile of handcream 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, e.g., *This is my* *blicket* or *Do you see this blicket?* In extending these words to new displays, 2-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 non-solid 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 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, these languages' nouns all start life as mass terms, requiring a special grammatical marker (called *a classifier*) if their quantity is 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.[7] So if children are led to differentiate

[7] This argument is not easy. After all, one might argue that English is a classifier language much like Yucatec Mayan or Japanese, i.e., 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]. However, detailed linguistic analysis suggests that there is a genuine typological difference here; see Slobin, 2001 and Lucy & Gaskins, ibid., Chierchia, 1998, Krifka, 1995, for discussion). The question is whether, since all of the languages formally mark the mass/count

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 Soja et al.'s original tests with Japanese and English children and adults. Some of their findings appear to strengthen the evidence for a universal pre-linguistic ontology that permits us to think both about individual objects and about portions of stuff, for both American and Japanese children (even 2-year-olds) extended names for complex hard-edged nonsense objects on the basis of shape rather than substance. Thus the lack of separate grammatical marking did not put the Japanese children at a disadvantage in this regard.

But another aspect of the results hints at a role for language itself in categorization. For one thing, the Japanese children tended to extend names for mushy hand-cream displays according to their substance, while the 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. While the Japanese at ages 2 and 4 were at chance on these items, the 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/object distinction works much like the categorical perception effects we noticed for phonemes (and perhaps colors; see also Gentner & Boroditsky,

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distinction in one way or another, the difference in particular linguistic means could plausibly rebound to impact ontology.

2001). Lucy and Gaskins (2001) bolstered this interpretation with evidence that populations speaking different languages differ increasingly with increasing age. While their young Mayan speakers are much like their English speaking peers, by age 9 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 reorganization of thought; only for boundary shifting. Thus for displays that clearly fall to one side or the other of the object/substance boundary, the speakers of all the tested languages sort the displays in the same ways.

It may be of some importance that suitable stimuli -- those falling in the border area between stuff and thing -- are hard to devise and instantiate, as we will discuss further. For this and related reasons, neither the findings nor the interpretations of such experiments are easy to come by. In one attempted replication, Mazuka and Friedman (2000) failed to reproduce Lucy's effects for Mayan- versus English-speaking subjects' classificatory performance for the predicted further case of Japanese. As these authors point out, the sameness in this regard of Japanese and English speakers, and the difference in this regard between Mayan and English speakers, suggests that obtained population differences may be more cultural and educational than linguistic.

In fact, there is another interpretation of these results that does not imply that language is altering the very categories of perception and thought. Rather, the result may again be limited to the influence of linguistic categories on linguistic performances, as we have noted before for the cases of phoneme and hue perception. This time the ultimate culprit is the necessarily sketchy character of most utterances, given ordinary exigencies of time and attention. One does not say (or rarely says) "Would you please set the table that is made of wood, is 6 feet in length, and is now standing in the dining room under the chandelier?" One says instead just enough to allow reference-making to go through in a particular situational context. "Just enough," however, itself varies from language to language owing to differences in the basic vocabulary. Interpretations from this perspective have been offered by many commentators. Bowerman (1996), Brown (1958), Landau, Dessalegn, & Goldberg, in press; Landau and Gleitman (1985), Slobin (1996, 2001), and Papafragou, Massey, and Gleitman (2006), among others, 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. Languages differ strikingly in their most 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 come about 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 (1997) object-substance effects in light of 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, and so

Japanese subjects chose at random for these indeterminate stimuli. For the English-speaking subjects, the linguistic stimulus too was in a formal sense 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; Tanenhaus, 2007; Trueswell, Sekerina, Hill & Logrip, 1999; Gleitman, January, Nappa, & Trueswell, 2007). In the present case, any English speaker equipped with even a rough subjective probability counter should take into account the great preponderance of count nouns to mass nouns in English and so conclude that a new word *blicket,* used to refer to some indeterminate display, is very 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). On 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; only 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. Because Japanese does not have a corresponding linguistic cue, subjects choose randomly between the object/substance options where world-observation does not offer a solution. Such effects can be expected to increase with age as massive lexical-linguistic mental databases are built, consistent with the findings from Lucy and Gaskins (2001). [8]

Li, Dunham, and Carey (2009) recently tested the language-on-language interpretation conjectured by Fisher and Gleitman (2002) and Gleitman and Papafragou (2005; see also Papafragou et al., 2009), using an expanded set of object-like, substance-like, and neutral stimuli, in the Imai and Gentner (1997) paradigm. They replicated the prior finding in several comparisons of Mandarin and English speakers. However, they added a new task, one that, crucially, did not require the subjects to interpret the meaning of the noun stimuli. This manipulation completely wiped out the cross-linguistic effect. As so often, the implication is that it is the linguistic nature of the task that elicits linguistic categories and functions. Languages differ in their vocabulary and structural patterns, impacting the procedures by which forms resolve to their meanings. But in nonlinguistic tasks, individuals with different linguistic backgrounds are found to respond in terms of the same conceptual categories.

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. For example, to describe a scene in which a

[8] We should point out that this hint is itself at best 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 e.g. *footwear; silverware; furniture).*

cassette tape is placed into its case, 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. Second, *kkita* does not have the same extension as English *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), while *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: while 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 vs. loose support (grammaticalized in English by the prepositions *in* and *on* and in Korean by the verbs *kkita* and *nohta*) and tight vs. loose containment (both grammaticalized as *in* in English but separately as *kkita* and *nehta* in Korean). They showed that prelinguistic infants (9- to 14-month-olds) 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 5-month olds are sensitive to this distinction]. However, their English-speaking adult subjects showed sensitivity only to the tight containment vs. loose support distinction, which is grammaticalized in English (*in* vs. *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 their language does not systematically encode them: "flexible infants become rigid adults."

This interpretation again resembles the language-on-language effects in other domains, but in this case by no means as categorically as for the perception of phoneme contrasts. For one thing, the fact that English speakers learn and readily use verbs like *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 due to verbal mediation: unlike preverbal infants, adults may have turned the spatial classification task into a linguistic task. Therefore, it 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*, versus when they are instructed to classify the same objects by *similarity*.

In one such study, Li, Gleitman, Landau and Gleitman (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 thus unifies the various laboratory effects in dealing with spatial relations, much as it does for hue perception, and for the object-substance distinction.

Motion

Talmy (1985) described two styles of motion expression that are typical for different languages: Some languages, including English, usually 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*), while 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 dominant patterns. Berman and Slobin (1994) showed that child and adult Spanish and English speakers vary in the terms that they most frequently use to describe the very 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. Reasonably enough, the early hypothesis from Slobin and Berman was that the difference in language typologies of motion lead their speakers to different cognitive analyses of the scenes that they inspect. In the words of these authors, "children's attention is heavily channeled in the direction of those semantic distinctions that are grammatically marked in the language" (Berman & Slobin, 1994), a potential salience or prominence effect of the categories of language onto the categories of thought.

Later findings did not sustain so strong a hypothesis, however. Papafragou, Massey, and Gleitman (2002) tested their English- and Greek- speaking subjects on either (a) memory of path or manner details of motion scenes, or (b) 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 from each other in terms of classification or memory for path and manner.[9] Similar results have been obtained for Spanish vs. English by

[9] 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 non-inferable, while English speakers included manner information regardless of inferability (Papafragou, Massey & Gleitman, 2006). This suggests that speakers may monitor harder-to-encode event components and choose to include them in their utterances when especially

Gennari, Sloman, Malt and Fitch (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 where 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. Though English speakers usually chose manner verbs, sometimes they produced path verbs; the Greek speakers varied too but with the preponderances reversed. It was found that verb choice did not predict memory for path/manner aspects of motion scenes, or choice of path/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 in 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,

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informative. This finding reinforces the conclusion that verbally encoded aspects of events vastly underdetermine the subtleties of event cognition. As Brown and Dell had shown earlier (1987), English actually shows the same tendency, but more probabilistically: English speakers are less likely to express an inferable instrument, e.g., to say "He stabbed him with a knife" than a non-inferable one ("He stabbed him with an ice cutter").

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.; see also Papafragou & Selimis, 2010b, for further evidence). 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; nevertheless, specific language usage influences listeners' interpretation of the speaker's intended meaning if the stimulus situation leaves such interpretation unresolved.[10]

Other recent studies have shown that motion event representation is independent of language even at the earliest moments of event apprehension. Papafragou, Hulbert and Trueswell (2008) compared eye movements from Greek and English speakers as they viewed motion events while (a) preparing verbal descriptions, or (b) memorizing the events. During the verbal description task, speakers' eyes rapidly focused on the event components typically encoded in their native language, generating significant cross-language differences even

[10] In another demonstration of this language-on-language effect, Naigles and Terrazas (1998) asked subjects to describe and categorize videotaped scenes, e.g., 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 verb extension have been found for children (Papafragou & Selimis, 2010a).

during the first second of motion onset. However, when freely inspecting ongoing events (memorization task), people allocated attention similarly regardless of the language they spoke. Differences between language groups arose only after the motion stopped, such that participants spontaneously studied those aspects of the scene that their language did not routinely encode in verbs (e.g., English speakers were more likely to focus on the path and Greek speakers on the manner of the event). These findings indicate that attention allocation during event perception is not affected by the perceiver's native language; effects of language arise only when linguistic forms are recruited to achieve the task, such as when committing facts to memory. A separate study confirmed that the linguistic intrusions observed at late stages of event inspection in the memory task of Papafragou et al. (2008) disappear under conditions of linguistic interference (e.g., if people are asked to inspect events while repeating back strings of numbers) but persist under conditions of non-linguistic interference (e.g., if people view events while tapping sounds they hear; Trueswell & Papafragou, in press). Together, these studies suggest that cross-linguistic differences do not invade (non-linguistic) event apprehension. Nevertheless, language (if available) can be recruited to help event encoding, particularly in tasks that involve heavy cognitive load.

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) typically use a viewer-perspective ('relative') system ('to the left'). Brown and Levinson

(1993) and Pederson et al. (1998) claim 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 that they were heading in the same cardinal direction after rotation, while Dutch ('relative') speakers massively preferred to rearrange the objects in terms of left-right directionality. This co-variation of linguistic terminology and spatial reasoning seems to provide compelling evidence for linguistic influences on non-linguistic cognition.[11]

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[11] It might seem perverse to hold (as Levinson and colleagues do) that it is "lacking 'left'", rather than "having 'east'", that explains the navigational skills of the Mayans, and the relative lack of such skills in speakers of most European languages. The reason, presumably, is that all languages have and widely use vocabulary for geocentric location and direction, so to point to one language's geocentric vocabulary would not account for the presumptive behavioral.difference in navigational skill. Therefore, by hypothesis, it must be the mere presence of the alternate vocabulary (of body-centered terms) that's doing the damage. Here L. Boroditsky (2010) makes this position explicit: "For example, unlike English, many languages do not use words like "left" and "right" and instead put everything in terms of cardinal directions, requiring their speakers to say things like "there's an ant on your south-west leg". As a result, speakers of such languages are remarkably good at staying oriented (even in unfamiliar places or inside buildings) and perform feats of navigation that seem superhuman to English speakers. In this case, just a few words in a language make a big difference in what cognitive abilities their speakers develop."

However, as so often in this literature, it is quite hard to disentangle cause and effect. For instance, it is possible that 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. For instance the absolute terms *uptown, downtown, 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/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) creatures.

To examine this possibility, Li and Gleitman replicated Brown and Levinson's rotation task with English speakers, but they manipulated the presence/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 (in this case, they set up the animals going in the same body-relative direction).

More recent findings suggest that the spatial reasoning findings from these investigators are again language on language effects, the result of differing understanding of the instruction to make an array "the same" after rotation. Subjects should interpret this blatantly ambiguous instruction egocentrically if common linguistic usage in the language is of "left" and "right," as in English, but geocentrically if common linguistic usage is of "east" or "west" as in Tseltal. But what should happen if the situation is not ambiguous, i.e., if by the nature of the task it requires either one of these solution types or the other? If the subjects' capacity to reason spatially has been permanently "transformed" by a lifetime of linguistic habit, there should be some cost – increased errorfulness or slowed responding, for instance – in a task that requires the style of reasoning that mismatches the linguistic encoding. Li, Abarbanell, Gleitman, and Papafragou (in press) experimented with such non-ambiguous versions of the spatial rotation tasks, yielding the finding that all cross-linguistic differences disappeared. Tseltal-speaking individuals solved these unambiguous rotation tasks at least as well (often better) when they required egocentric strategies as when they required geocentric strategies.

Flexibility in spatial reasoning when linguistic pragmatics do not enter into the task demands 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 is crucial for survival (Gallistel, 1990); not surprisingly, neurobiological evidence from humans and other species that the brain routinely uses a multiplicity of coordinate frameworks in coding for the position of objects in order to prepare for directed action (Gallistel, 2002). It would be pretty amazing if, among all the creatures that walk, fly, and crawl on the earth, only humans in virtue of acquiring a particular language lose the ability to use both absolute and relative spatial coordinate frameworks flexibly.

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:

> "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, 1956, p. 85).

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 (2007) investigated this proposal. They compared English (which mostly marks evidentiality lexically: "I *saw/heard/inferred* that John left") to Korean (where evidentiality is encoded through a set of dedicated morphemes). There is evidence that such morphemes are produced early by children learning Korean (Choi, 1995). Papafragou et al.

therefore asked whether Korean children develop the relevant conceptual distinctions earlier and with greater reliability than learners of English, which does not grammatically encode this distinction. In a series of experiments, they compared the acquisition of non-linguistic distinctions between sources of evidence in 3- and 4-year-olds learning English or Korean: no difference in non-linguistic 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 non-linguistic 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 non-linguistic categories in the way that Whorf and several later commentators (e.g., Levinson 2003) have conjectured. Rather, the acquisition of linguistically encoded distinctions seems to follow (and build on) the conceptual understanding of evidential distinctions. The conceptual understanding itself appears to proceed similarly across diverse language-learning populations. Similar data have recently been obtained from Turkish, where the acquisition of evidential morphology seems to lag behind non-linguistic knowledge about sources of information (Ozturk & Papafragou, submitted).

Time

So 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. English speakers predominantly talk about time as if it were horizontal (one *pushes deadlines back, expects good times ahead*, or *moves meetings forward*). Boroditsky (2001) reports that 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; this recipe came down to me from my grandmother*), though they are said to be more sporadic than in Mandarin Other laboratories have failed to replicate the original finding (January & Kako, 2007). Moreover, Chen (2007) has disputed the phenomenon altogether, failing to find predominance of the vertical metaphor in a corpus analysis of Taiwanese newspapers. Assuming, though, that the difference does hold up in everyday speech contexts, it is a subtle cross-linguistic difference of degree, rather than a principled opposition.

In fact, the most telling finding reported in these studies is that the apparent inculcation of a generalization over a lifetime is easily erased—in fact, actually reversed—in a matter of minutes: Boroditsky explained to her English-speaking subjects how to talk about time vertically, as in Mandarin, and gave them several practice trials.   After this training, the English speakers exhibited the vertical (rather than the former horizontal) priming effect. Apparently, 15 minutes of training on the vertical overcame and completely reversed 20+ 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.   Again, these results are as predicted under a processing – language on language – account, in which there are immediate effects on memory (here, repetition and recency effects), but no permanent reorganization of "thought."

<u>Number</u>

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, which allows for the representation of exact numerosities for large sets, has (in principle) 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*, since it possesses a rule for creating successive integers (the successor function) and is thus characterized by discrete infinity.

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 thus 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; also see Opfer & Siegler, Chap. 30). Other researchers propose that children come to acquire the adult number system by conjoining properties of the two pre-linguistic 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 in order 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".

For instance, upon hearing the number words in a counting context, 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 which was not afforded by either one 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 (see also Penn & Povinelli, Chap. 27 for similar views). 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, this in principle could explain the gulf between creatures like us and creatures like them. In support of the dependence of the exact number system on natural language, recent findings have shown that members of the Pirahã community that lack number words and a counting system seem unable to compute exact large numerosities (Gordon, 2004).

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 due to 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.

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: e.g., *neither* and *both* apply only to sets of two items (Keenan & Stavi, 1986; Barwise

& Cooper, 1981). Moreover, quantifiers and numbers compose in quite different ways. 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. In light of the semantic disparities between the quantifier and the integer systems, it is hard to see how one could bootstrap the semantics of the one from the other.

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 5-year-old children watch as three horses are 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 would accept *Some of the horses jumped over the fence* as an adequate description even though it is again true that all of the horses jumped. In another experiment, Hurewitz, Papafragou, Gleitman and Gelman (2006) 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.

How then are we to interpret the fact that linguistic number words seem to be crucially implicated in non-linguistic number cognition (Spelke & Tsivkin, 2001a, b; Gordon, 2004)? One promising approach is to consider number words as a method for online encoding, storage, and manipulation of numerical information that complements, rather than altering or replacing, non-verbal representations. Evidence for this claim comes from recent studies that retested the Pirahã population in tasks used by Gordon (Frank, Everett, Fedorenko & Gibson, 2008), Pirahã speakers were able to perform exact matches with large numbers of objects perfectly but, as previously reported, they were inaccurate on matching tasks involving memory. Other studies showed that English-speaking participants behave similarly to the Pirahã population on large number tasks when verbal number representations are unavailable due to verbal interference (Frank, Fedorenko & Gibson, 2008). Nicaraguan signers who have incomplete or non-existent knowledge of the recursive count list show a similar pattern of impairments (Flaherty & Senghas, 2007). Together, these data are consistent with the hypothesis that verbal mechanisms are necessary for learning and remembering large exact quantities – an online mnemonic effect of language of a sort we have already discussed.

Orientation

A final domain that we will 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 non-geometrical 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 so even if these corners are distinguishable by one of the long walls being painted blue, or having a special smell. 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 makes the 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).*[12] Later experiments (Hermer-Vasquez, Spelke & 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 which required the use of non-geometric information only. The conclusion was that speech-shadowing, unlike rhythm-shadowing, by taking up linguistic resources, blocked the integration of

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[12] Further studies show that success in this task among young children is sensitive to the size of the room – in a large room, more 4-year-olds succeed in combining geometric and landmark information (Learmonth, Nadel & Newcombe, 2002). Also, when adults are warned about the parameters of the task they are able to fall back on alternative representational strategies (Ratliff & Newcombe, 2008). 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, 2001).

geometrical and object properties that 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 an influential review article, Carruthers (2002) suggests even more strongly that in number, space, and perhaps other domains, language is the medium of inter-modular communication, a format in which representations from different domains can be combined in order to create novel concepts. However, on standard assumptions about modularity, modules are characterized as computational systems with their own proprietary vocabulary and combinatorial rules. Since 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)

And:

> “Language is constitutively involved in (some kinds of) human thinking. Specifically, language is the vehicle of non-modular, non-domain-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, the production of sentences is assumed to begin by entertaining the corresponding thought, which then mobilizes the appropriate linguistic resources for its expression (e.g., Levelt, 1989). On some proposals, however,

> “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.”
> (Carruthers, 2002, p. 668).

Inversely, language comprehension is classically taken to unpack linguistic representations into mental representations, which can then 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, since 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. For instance, lexical gaps in the language will block conceptual integration, since there would be no relevant words to be inserted into the linguistic string. As we have discussed at length, 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 in order 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 pre-linguistic 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 on the presence or absence of human language and its combinatorial powers (as the original experiments seem to suggest), or even on 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 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 itself 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 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 et al., 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 make deep commitments to abstract (and unlearnable) syntactic principles and their semantic reflexes. Notice in this regard that since these authors hold that *any* natural language will do 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. An organism with such principles in place could -- independently of particular experiences -- 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 very 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.

Recent developmental studies from Dessalegn and Landau (2008) offer useful ways to understand the issue just raised (see also Landau, Dessalegn & Goldberg, 2009). These investigators studied 4-year olds' ability to keep track of two features of a visual array simultaneously: color and position. Classic work from Treisman and Schmidt (1982) has shown that such visual features are initially processed independently, so that under rapid presentation, a red "O" next to a green "L" might be reported as a green O even by adults. Young children are even more prone to such errors, often giving mirror-image responses to, e.g., a square green on its left side and red on its right. Directions such as "Look very hard" or "Look! The red is touching the green" do not reduce the prevalence of such errors. But subjects told "Look! The red is on the right" improve dramatically. Landau and colleagues point out that this finding in itself isn't very surprising – except ~~that they show~~ in light of the fact that an additional finding is that these preschoolers did not have a stable grasp of the meanings of the terms *left* versus *right*, when tested for this separately. Yet their partial, possibly quite vague, sensitivity to these egocentric spatial terms was enough to influence perceptual performance "in the moment." Two properties of these findings further support the interpretation that applies to most of the results we have reported. First, the linguistic influence is highly transient – a matter of milliseconds. Second, the effect, presumably like those of Hermer and Spelke, is independent of *which* language is being tested. Rather, as Landau and colleagues put it, there is a momentary "enhancement" of cognitive processing in the presence of very specific linguistic labeling.

Conclusions and Future Directions

We have just reviewed several topics within the burgeoning psychological and anthropological literature that are seen as revealing causal effects of language on thought, in senses indebted to Sapir and Whorf. We began discussion with the many difficulties involved in radical versions of the linguistic "determinism" position, including the fact that language seems to underspecify thought, and to diverge from it as to 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 (Feldman, Goldin-Meadow & Gleitman, 1978; Goldin-Meadow, 2003; Senghas, Coppola, Newport, & Suppala, 1997); many bilinguals as a matter of course "code-switch" between their known languages even within 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 (Gallistel, 1990;

Hare, Call & Tomasello, 2001; and Call & Tomasello, Ch. 22 of this volume). All these nonlinguistic instances of thinking and reasoning (also see Hegarty & Stull, Chap. 31) dispose of the extravagant idea that language just "is" thought.

However, throughout this chapter we have surveyed approximately half a century of investigation in many cognitive-perceptual domains that document systematic population differences in behavior, attributable to the particular language spoken. Consistent and widespread as these findings have been, there is little scientific consensus on their interpretation. Quite the contrary, recent positions range from those holding that specific words or language structures cause "radical restructuring of cognition" (e.g., Majid et al., 2003) to those that maintain – based on much the same kinds of findings -- that there is a "remarkable independence of language and thought" (e.g., Jameson & Hurvich, 1978; Heider & Oliver, 1972). To approach these issues, it is instructive to reconsider the following three steps that have always characterized the relevant research program:

(1) *Identify a difference* between two languages, in sound, word, or structure.

(2) *Demonstrate a concordant cognitive or perceptual difference* between speakers of the languages identified in (1).

(3) *Conclude that, at least in some cases, (1) caused (2)* rather than the other way round.

Though there is sometimes interpretive difficulty at step (3) – recall Eskimos in the snow – the major problem is to disambiguate the source of the differences discovered at step (2). To do so, investigators either compare results when a linguistic response is or is not part of the task (e.g., Jameson & Hurvich, 1978; Li et al., 2009; Papafragou et al., 2008;), or that do or do not interfere with simultaneous linguistic functioning (e.g., Kay & Kempton, 1984; Frank et al., 2008; Winauer et al., 2008; Trueswell & Papafragou, in press); or where hemispheric effects, implicating or not implicating language areas in the brain, can be selectively measured (e.g. Regier et al., 2010). The cross-language differences are usually diminished or disappear under those conditions where language is selectively excluded. Traditionally, investigators have concluded from this pattern of results that language categories do not penetrate deeply into nonlinguistic thought, and therefore that the Sapir- Whorf-conjecture has been deflated or discredited altogether.

But surprisingly, recent commentary has sometimes stood this logic on its head. Interpretation of these same patterns has been to the effect that, when behavioral differences arise if and only if language *is* implicated in the task, this is evidence *supporting* the Sapir-Whorf thesis, i.e., vindicating (!) the view that language causally impacts and transforms thought. Here is L. Boroditsky (2010) in a recent commentary on the color-category literature:

> “…disrupting people's ability to use language while they are making colour judgments eliminates the cross-linguistic differences. This demonstrates that language per se plays a causal role, meddling in basic perceptual decisions as they happen.”

Thus at first glance, investigators are in the quandary of fact-immune theorizing, in which no matter how the results of experimentation turn out, the hypothesis is confirmed. As Regier et al. (2010) put this in a recent review, such findings

> "… act as a sort of Rorschach test. Those who "want" the Whorf hypothesis to be true can point to the fact that the manipulation clearly implicates language. At the same time, those who "want" the hypothesis to be false can point to how easy it is to eliminate effects of language on perception, and argue on that basis that Whorfian effects are superficial and transient." (p. 179).

In the present chapter, we have understood the literature in a third way, one that situates the findings in each of the domains reviewed squarely within the "ordinary" psycholinguistic literature, as "language on language" effects: language-specific patterns of cognitive performance are a product of the on-line language processing that occurs during problem solving. These patterns are indeed transient in the sense that they do not change the nature of the domain itself (*pace* Whorf, 1953, and Pederson et al., 1993), but are by no means superficial. In some cases, such effects are outcomes of linguistic information handling, as these emerge on-line, in the course of understanding the verbal instructions in a cognitive task. For instance, because of the differential frequencies, etc., of linguistic categories across languages, slightly different problems may be posed to the processing apparatus of speakers of different languages by what appear to be 'identical' verbal instructions in an experiment (see discussion of Imai & Gentner's, 1997, results on object individuation). In other cases, linguistic information may be used on-line to recode non-linguistic stimuli even if the task requires no use of language. This is particularly likely to happen in tasks with high cognitive load (Trueswell & Papafragou, in press), because language is an efficient way to represent and store information. In neither case of linguistic intrusion does language reshape or replace other cognitive formats of representation, but it does offer a mode of information processing that is often preferentially invoked during cognitive activity (for related statements, see Fisher & Gleitman, 2002; Papafragou et al., 2003; Papafragou et al., 2008; Trueswell & Papafragou, in press).

Other well-known findings about the role of language in cognition are consistent with this view. For example, a major series of developmental studies demonstrate that a new linguistic label "invites" the learner to attend to certain types of classification criteria over others, or promote them in prominence. 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). 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 non-obvious 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 a stimulus could be said to belong to. Here, as well, the presence of linguistic labels does not intervene in the sense of replacing or reshaping underlying (non-linguistic) categories; rather, it offers an alternative, efficient system of encoding, organizing, and remembering experience.

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