Overview

How thought is mapped into words

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To English speakers, the distinctions between *blue* and *green*, *cup* and *glass*, or *cut* and *break* seem self-evident. The intuition is that these words label categories that have an existence independent of language, and language merely captures the pre-existing categories. But cross-linguistic work shows that the named distinctions are not nearly as self-evident as they may feel. There is diversity in how languages divide up domains including color, number, plants and animals, drinking vessels and household containers, body parts, spatial relations, locomotion, acts of cutting and breaking, acts of carrying and holding, and more. Still, studies documenting variability across languages also uncover striking commonalities. Such commonalities indicate that there are sources of constraint on the variation. Both the commonalities and divergences carry important lessons for Cognitive Science. They speak to the causal relations among language, thought, and culture; the possibility of cross-culturally shared aspects of perception and cognition; the methods needed for studying general-purpose, nonlinguistic concepts; and how languages are learned.

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INTRODUCTION

When English speakers talk or write, they routinely distinguish colors called *blue* from those called *green*, drinking vessels called *cup* from those called *glass*, and actions called *cutting* from those called *breaking*. These distinctions seem self-evident to the native speaker. The intuition is that words for them exist because these words are labeling things (properties, objects, or relations) that are intrinsically different from one another. That is, the distinctions have an existence independent of language, and language, sensibly, acknowledges them by providing words to capture them.

This intuition carries the implication that many of the word meanings of English would be shared by everyone, regardless of language or culture. The word forms, of course, would differ. Words for English *blue* and *green* would sound like French (*bleu* and *vert*), Spanish (*azul* and *verde*), or Turkish (*mavi* and *yeşil*), and so on—but the meanings would be parallel. At first glance, this intuition seems reasonable. After all, blue looks different from green, cups have different shapes and uses from glasses, and so on. These differences ought to be noted and encoded in words by speakers of all languages.

But this logic is really just re-stating the original intuition. A closer look shows why it does not necessarily hold up. Consider the case of color. Light waves vary continuously in length, and the human eye is capable of discriminating millions of different hues from one another.[1] Or take drinking vessels. They come in china tea cups and tall water glasses, but they also come in tall plastic cups, short, roundish brandy glasses, medium paper cups, and many other combinations of size, shape, material, and use. Languages never provide unique labels for every discriminable variation within a domain. Doing so would create a huge burden for language acquisition and for memory. Instead, words encode only a small fraction of all perceivable distinctions in the world.[2,3] This fact does not create a serious obstacle to communication, because a finite set of words can be combined in an infinite number of ways to convey additional subtleties of meaning. A particular shade

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of blue can be described in English as *deep blue*, *cornflower blue*, *deep cornflower blue*, *blue like the stone in your ring*, and so on. From this perspective, and given the vast number of perceivable distinctions in the world that could be labeled, one could entertain the opposite possibility that languages will rarely coincide in the distinctions they encode in words, especially those languages that are not closely related.

COGNITIVE SCIENCE AND THE MAPPING FROM THOUGHT TO WORDS

Understanding to what extent there are shared aspects of word meaning across languages, and where similarities or differences come from, has important implications for Cognitive Science. To whatever extent *commonalities* are identified, they stand to provide important lessons about the nature of human cognition. They help address the broad question of the causal direction of the relation between language and thought. Language broadly could be 'a cloak following the contours of thought', or individual languages could be 'molds into which infant minds are poured'.[2] The discovery of commonalities places limits on the extent to which language may mold minds. To the extent that commonalities are found, further questions are inspired: Do humans observe structure in the world so salient that certain groupings are 'crying out to be named'?[4] And are there other principles reflected in word meanings despite differing languages and cultures? Candidates include universals of perception and cognition, forces shaping the communication process, and shared human goals, motivations, and practices. In light of recent concerns that much of cognition and even basic perceptual processes may be more culture-specific than previously assumed,[5] and that there are no universals of language,[6] evidence in favor of commonalities would provide bounds on the nature of culture-specificity.

Understanding what *diversity* exists is an essential first step in addressing the possible influence of language on thought with regard to the lexicon. To the extent that diversity exists, a more detailed understanding of its nature and where it comes from also helps disentangle the relations among language, thought, and culture. For instance, if some pattern of lexicalization in a language reflects a cultural practice of its speakers,[7] then any parallelism between language and thought in that instance may reflect the impact of the culture on thought rather than the impact of language on thought. Diversity also raises challenges for the widespread practice of using words of a single language such as English to identify nonlinguistic concepts assumed to be shared across speakers of other languages.[8] Finally, diversity raises important issues about how children learn their native language(s) and the process of mastering other languages later in life. We will consider these implications after reviewing the evidence.

DIVERSITY IS PERVASIVE

A surge of research comparing word meanings across languages in the past decades has begun to shed light on the issues and possibilities just described. One clear-cut finding is that there is widespread diversity. Some degree of diversity has been found across every domain that has been scrutinized. These domains include color, taste, odor, concrete objects and parts of objects, spatial relations, kinship, and actions including human locomotion, cutting and breaking, and carrying and holding.

If the diversity observed were a matter of simple variation in how fine-grained the distinctions are in a domain, the interpretation would be straightforward. Perhaps people from various cultures simply differ in how much they routinely need to differentiate within a domain. The apocryphal case of Eskimo snow words would be an example (if it were true[9,10]). In a culture where snow is highly important, speakers might develop more words to talk about kinds of snow. Skiers, if not Eskimos, have developed an elaborated snow lexicon, and experts in many fields do in their domain of expertise. But the relations among meanings are more complex than merely 'having more words'. There can be multiple differences within a domain. For instance, English *in* and Dutch *in* are similar in meaning, but Dutch divides English *on* into two distinct terms: *op* which is used when the spatial arrangement is stable (as for a plate on a table), and *aan* which is used when it is less so (wind might cause the clothes to fly off the washline so the preposition of choice is *aan*).[11] Many languages, like Guugu Yimithirr spoken in Australia, do not have terms for *left of* and *right of*. Such languages usually do have terms for left and right hand, but they do not extend these to spatial descriptions.[12,13] English distinguishes *brother* from *sister* and *mother* from *father* on the basis of gender but not cousins, although French does (*cousin* versus *cousine*). English does not, however, lexically distinguish whether the siblings are older or younger; whereas most languages do.[14] English recognizes *mother* with a label distinct from mother's sister and father's sister (*aunt*) but in Hawaiian, a mother, mother's sister, and father's sister are all called by the same term.[15] An example of cross-cutting categories would be English and Navajo

terms for actions involving grasping an object and either standing or moving with it. English distinguishes *holding* from *carrying*, regardless of how the object is being held, based on whether the person is standing still or taking the object somewhere. Navajo terms, however, are used across a variety of situations that English distinguishes. Aside from carrying and holding actions, Navajo terms apply to throwing, putting, and other acts upon the object. However, Navajo does make a distinction based on the nature of the object and how it is supported by the person: in both arms, on the back, held at the side, etc.[16] In this sort of case, entirely different dimensions are used in dividing up the action space by name.

These examples defeat the lay intuition that English words label unique partitions of the world, and that many of the word meanings of English should therefore be shared by everyone, regardless of language or culture. But these case studies, by themselves, say little about the balance between diversity and commonality, or what the sources of each might be. For this, a more detailed examination of the data is needed.

DOMAINS IN DETAIL

As the preceding examples suggest, researchers have examined varied domains of human experience when considering how experiences are mapped onto words. These domains can be grouped roughly into three categories: Properties (such as color, taste, and odor); objects (human-made and natural) and their parts; and relations between entities (including those involving spatial location, kinship, and how one entity acts upon another). We now consider each of these categories in turn. Our review does not exhaust every domain that has been investigated, by any means, but highlights major trends and issues pursued.

Properties

In the study of word meaning, most ink has been shed in the domain of color, which has also become the paradigmatic example of how to (and how not to) compare lexicons across languages. The lynchpin empirical study on the topic was conducted by Brent Berlin and Paul Kay.[17] They demonstrated that large-scale systematic comparison of word meaning across languages was possible and the results illuminating. They also developed some key distinctions still in use today. They defined 'basic' color words as contrastive, nonoverlapping terms that are assumed to exhaustively partition color space. These can be identified by a number of criteria, including the fact that they are a single word (not a complex phrase); they are not linked to specific sources (as are, for example, *lime-colored* and *salmon-colored*); and they are not loan words from a foreign language. Berlin and Kay also distinguished between the extension or boundaries of a word's meaning and its central or focal point, a distinction which was to be very important in future work.

The major finding from their study was that languages differ in their repertoire of basic color words. Some languages have only two basic color terms, while others have three, four, five, or more. Despite this variation in number, color lexicons show astonishing regularities, too. Berlin and Kay proposed that the cap on the number of basic color words was eleven, as illustrated by English *black*, *white*, *red*, *yellow*, *green*, *blue*, *brown*, *purple*, *pink*, *orange*, and *grey*. Over the years, there have been proposals for additional basic categories but these claims have been contested.[18,19] Nevertheless, using a number of measures it is clear now that many languages have 12 basic color terms consisting of Berlin and Kay's original 11 plus a distinction between light and dark blue. These languages include Russian, Ukrainian, Polish, Italian, Spanish, Greek, Turkish, Japanese, and Chinese,[20–23] while Korean is said to have 15 basic color words.[24,25]

Berlin and Kay classified languages according to how many basic color terms each had. Based on this typology, an implicational hierarchy of how color lexicons evolve was then constructed. For instance, if a language had a word for yellow, it would also have a word for black, white, and red. The regularity with which languages follow this pattern reinforces the notion that color vocabularies develop under similar constraints.

Critics[26–30] of Berlin and Kay pointed out, however, that there were problems in the number and sampling of languages, the choice of participants (who were a small number of bilingual speakers from similar backgrounds), and the language data (which came in part from these speakers and in part from dictionaries). So although Berlin and Kay[17] felt that 'color words translate too easily among various pairs of unrelated languages for the extreme linguistic relativity thesis to be valid', a few years later Lyons[31] said of the same data 'it is a well-established fact that word-for-word translation of color terms across languages is frequently impossible'. These contrasting views illustrated another problem: the need for statistical testing of the data to objectively measure the degree of correspondence between languages.

The World Color Survey[32] sought to address these concerns and produced further evidence for constraints on color word meaning. Data from 110 unwritten languages were collected from large

numbers of native speakers using Munsell color chips and were then modeled statistically. The outcome was that color terms are not randomly distributed over color space.[33] Across languages, the best examples of color terms cluster together,[34] and each language's set of color terms partition color space so that similarity is maximized within categories and minimized between them.[35,36]

In light of the evidence that color lexicons exhibit both diversity (in size) and constraints (on where boundaries and focal points occur), many now acknowledge that arguing over universality versus culture-specificity is hampering progress.[37,38] There has been an important shift in the questions asked, with exciting new ideas emerging about possible constraints and variation in this domain. For example, are the shared elements of color naming a result of how the physical environment is perceived,[39,40] irregularities of the perceptual color space,[35,41] or a product of how convergence on a shared set of names is achieved by members of a language community for communicative efficiency?[42] Each of these proposals has received some support (and they are not necessarily mutually exclusive).

In terms of variation, could different terminologies be the result of different environments—urban, desert, or jungle, for example? Or might they be the product of differences in sunlight? Lindsey and Brown[43,44] suggest that increased exposure to UV-B light may make people on the equator less able to perceive the differences between blue and green because of physiological changes to the lens, which in turn leads to collapsing the blue–green area under a single term. A recent study lends further weight in this direction: People born in the winter months above the Arctic Circle demonstrate differences in color discrimination compared to those born below the Arctic circle.[45,46] However, a direct link between changes in perception and color naming has still to be established.[47,48] Another possibility is that individual differences within populations may cause differences in color lexicons. For instance, differences in the incidence of color-blindness in different populations may lead to shifts in the lexicon due to pressures for a common effective language code.[49,50]

Yet a third possibility is that the lexical differences result from variable cultural practices.[27,29,36] One prime candidate is the development of dyeing technology. The colors of familiar objects account for the most obvious etymologies and semantic associations across languages.[28,51] For example, English *orange* (from an Arabic loan word) was used only as a fruit name for 300 years after its introduction to the language. It was not until the 17th century that it gained its status as a color term. Many other color words come from dyes. For example, the term *purple* comes from the name of a Mediterranean shell fish, but it came into prominence because it was a highly prized dye. In the Middle Ages the form was *purpur*, which became *purpel* in the 15th century. Included in earlier color meanings were many shades of red, as well as darker blues and purples, a fact that is most likely related to variations in the dye-stuffs. The term *mauve* appears from 1856 with the advent of new dyes, and so on.[51] Languages borrow terms from other languages and all rapidly expand their color vocabulary when in contact with technologically advanced cultures, suggesting a strong role of culture and technology as well as the relevance of language contact in explanations of naming patterns. Although plausibly important, there is not yet any mechanistic account or formal test of how color vocabulary might change and spread.

Astonishingly little is known about vocabulary for other sensory domains. At the turn of the previous century, there were two large-scale questionnaire/observational surveys on taste lexicons[52,53] which demonstrated comparable variation in this domain. There has been very little pursuit since. Some recent studies begin to redress this gap, and they show comparable variation in terms for other perceptual properties.[54] Languages differ markedly in their lexicons for smell,[55–60] touch,[61–63] sound,[64–66] temperature,[67,68] and pain.[69–71] Explanations offered for some of the observed variation include (1) that subsistence patterns may impact smell lexicons[59] and (2) that culinary traditions could shape taste lexicons.[72] Further research is necessary to test these and other possible causal determinants of lexical elaboration and change in these domains.

Finally, if the quantity of items in a collection can be thought of as a property of the collection, a recent literature on numeration systems is relevant here.[73–76] It is possible that the use of fingers and toes for counting feeds into the nature of verbal numeration systems and contributes to the frequency of systems based on 5, 10, or 20. However, whether body counting sequences emerged before verbal numeration systems and have a direct causal influence has not been established.[77] Even if there is a causal relation, however, abundant diversity exists. For instance, despite common origins in a base-10 system, Polynesian and Micronesian counting systems have diverged over time. Polynesian languages usually contain, in addition to the abstract numeration system, specialized counting sequences that apply to specific types of objects and that entail different counting units. Micronesian languages, on the other hand, tend to incorporate numeral classifiers from their

syntax into their numeration systems.[76] (Numeral classifiers are grammatical morphemes that accompany nouns in statements of quantity in some languages but need not be informative by themselves regarding quantity.) The differing systems may reflect both the cultural importance of tracking the flow of large quantities of goods or people, as well as properties of the language structure (i.e., morpho-syntax).[76] Numeration systems of dramatically different sorts, such as those having only a few, imprecise words for quantities may, conversely, reflect lack of cultural need.[78,79]

Objects and Their Parts

Work on labeling of objects across languages has largely taken place in two traditions. One is about how different cultures 'classify' plants and animals. Because the study of 'classification' schemes has depended heavily on observations about what things are given the same name, the data are relevant for the current purposes. The other tradition is about how people label human-made objects across languages. Despite different methodologies and objects of study, early work in the two traditions shared a seminal idea. This idea, adopted from biology, was that there are natural discontinuities in the distribution of properties of living things that produce groupings of things evident to all observers.[4,80] This proposal suggests the world provides a strong constraint on naming.

The idea that natural discontinuities would be respected by all observers in classification, regardless of culture, provided a counterpoint to the possibility that cultures each construct their own way of organizing the world[81,82] based on the practical value of the plants or animals to the culture.[83] It is difficult to directly compare classification across cultures because existent plants and animals differ by location. The strategy was therefore to see whether classification systems in individual cultures are similar to those developed by Western science. Studies of nonindustrialized cultures showed substantial correspondence of folk to scientific classification. In one of the most extensive programs of research, Berlin analyzed folk classification systems for plants among the Tzeltal Maya of Mexico and the Aguaruna Jivaro of Peru.[4] He found that about 60% of labeled groupings corresponded closely to species identified by botanists. In another extensive study, Hunn[80] examined classification of animals by the Tzeltal using a measure that took into account correspondence of folk categories to scientific groupings at levels not restricted to species and found an even higher level of correspondence. Data from these and other studies support the idea that named groupings of plants and animals reflect clusters of correlated properties.[84–87]

The correspondences to scientific classification are not perfect, of course. Some divergences are inevitable because lay people do not have access to all of the information used to make scientific classifications. But other types of divergences occur as well. Larger organisms, being perceptually prominent, are more likely to be finely discriminated,[88] suggesting that salience of the organism matters. Some named groupings at a higher level of abstraction, like English *bush* versus *tree*, may be based on their relation to human height. In addition, the degree of differentiation may vary due to cultural utilities. For instance, communities that depend on fish as food may discriminate more fish species by name than bird species.[83] Finally, specific belief systems can influence naming practices. For instance, one term that encompassed most birds for the Karam of New Guinea excluded the cassowary, which has a special cultural status not granted to other birds.[89] (See Refs 84, 87 for further discussion of divergences.)

Early work on artifact labeling was also influenced by the idea of natural discontinuities in the world. Rosch and colleagues,[90,91] echoing Berlin and Hunn, suggested that artifacts fall into natural groups given by correlational structure in the world. They found evidence that members of English noun categories such as *chair*, *car*, and *apple* share many properties with other things called by the same name and few with things called by contrasting names. Perhaps implicitly assuming some constraint along these lines, others have suggested that common nouns for concrete objects should have similar meanings across languages.[92–95] But a different picture emerged from empirical tests. In one study[96] comparing naming patterns for 11 drinking vessels in English, Hebrew, and Japanese, three different ways of segmenting them were found. English speakers distinguished *cup* from *glass*. Hebrew speakers made a different two-way distinction, separating coffee and tea cups from all the rest. Japanese made a three-way distinction with wine glass split off under its own name. A recent study[97] comparing English and Russian naming patterns for 60 drinking vessels found similar divergences. There is no single set of named distinctions for drinking vessels dictated by clusters of correlated properties in the world.

Household objects other than drinking vessels show the same diversity.[98,99] When speakers of English, Spanish, and Mandarin named various containers, the dominant responses for English speakers were *bottle*, *jar*, or *container*. For the same objects Spanish speakers used many more terms, and the

Mandarin speakers looked different yet again from English and Spanish speakers.[98] Similar differences were found between Dutch and French speakers in Belgium, despite the fact the language groups live in close proximity and largely share culture.[99] The patterns were not completely unrelated to each other, however. For instance, all 19 objects called *jar* in English were included under a single term in the other two languages. Some distinctions appear to be salient enough to be observed by all. Why, then, is there so much variability in this domain? Multidimensional scaling solutions of similarity sorting of the objects in the same studies provide some insight. Some objects (such as those labeled *jar* in English) do form clusters in the similarity space, but others are scattered fairly continuously throughout the space, providing no clear perceptual segmentation. Where discontinuities exist in the domain, naming patterns may respect them, but the world seems to provide less structure here than it does in the case of plants and animals.

But the existence of fewer constraints does not reveal what creates the observed variation. Potential contributors include historical sociocultural factors, such as what containers were invented/available in each culture and how they were incorporated into the lexicon over time. Also potentially influencing the observed pattern are the morpho-syntactic properties of the languages. For instance, Spanish easily forms new names for containers by adding suffixes to root morphemes (e.g., *-era* added to *talc* produces *talquera*, a container for dispensing talc). This linguistic property lends itself to more flexible differentiation within the container lexicon for Spanish.[100]

Another interesting domain for assessment is body parts, because joints create a segmentation of the human body that is both visually and kinesthetically salient. Arguably, humans around the world experience the body and its segmentation with little variation. If salient discontinuities in the world constrain labeling, a high degree of consistency in naming patterns might be expected. For instance, one might predict that languages will tend to label the head, trunk, arm (and perhaps hand), and leg (and perhaps foot).[101] Case studies of body part terms across diverse languages reveal that there is far from universal recognition of these units with unique terms.[102,103] For instance, some languages lack a word for the head,[104] and some label arms and legs together with only a single word.[105] Some give a single term to the foot plus leg (and some do so for the arm plus hand), while others distinguish foot, lower leg (up to the knee) and upper leg. The joints thus do not produce a single shared naming scheme across languages. Still, there are commonalities in that terms for limbs are often bounded by joints.[102,103] For instance, it is rare (although still possible) for a term for the leg to cover only up to mid-leg.[106] While not yielding a single way of dividing up the body, the physical discontinuities provided by joints do seem to provide a constraint on variation.

Finally, a recent entry into the study of the concrete is labeling of the natural landscape.[107,108] Landscape features such as mountains, rivers, and valleys present discontinuities on the earth's surface. Because they are attached to or contiguous with the earth, they could be considered more analogous to the case of body parts than to objects. Whether considered objects or parts, the presence of salient discontinuities predicts shared patterns of labeling in this domain. The available data reveal that, again, cross-linguistic variation arises in the meanings and extensional ranges of roughly similar terms, despite any such constraints. For instance, the terms most similar to English *mountain* in other languages are not necessarily simple translation equivalents. In some languages, the closest equivalent term encompasses hills or smaller features such as crab mounds on a beach,[107] or even a rock or stone.[109] Some languages appear to have forms that crosscut familiar English terms: for instance, a language of northwestern Australia has a word for any landscape feature that is low, smooth, and rounded, including a rise in a road and a rounded gully.[110] Perceptual salience, cultural interests and needs, and interactions with other language characteristics all are likely sources of variation.[107] Because the reports in this domain to date have been case studies of individual languages, though, it is hard to assess the relative degree of shared versus nonshared meaning.

Relations

Some scholars[92–94] have argued that cross-linguistic variation should be most evident in the words for relational notions, which entail interactions between entities or components. Relations can be coded in verbs (e.g., *cut*, *walk*), spatial prepositions (e.g., *in*, *on*), or even nouns (e.g., *mother*, *uncle*). Perhaps the properties of relations do not cohere as tightly together as the properties of objects and therefore readily yield many solutions for packaging into words.

In some domains, the basic actions expressed in language differ as a function of which 'covert categories' are implied.[16] To talk about dressing, for example, English speakers use a single expression *put on* no matter what item is placed on which body part. The covert category that is the object of putting on, then, is the whole body. However, speakers of Tswana, a Bantu language of Botswana, use one term

for putting clothing on the extremities, including head, hands and arm, and feet (*gòrwálà*), and a different term for putting things on the central trunk and legs (*gòàpàrà*). Japanese speakers use different verbs for placing clothing on the head (*kaburu*) versus above the waist (*kiru*) or below the waist (*haku*). Korean speakers make more distinctions again and use different verbs if they put clothing on the head (*ssuta*), trunk or legs (*ipta*), feet (*sinta*), or wrist and waist (*chata*). Similarly, English speakers use *carry* irrespective of what is being carried where on the body, but Mayan languages, such as Tzeltal and Tzotzil, use distinct terms as a function of the body part involved: back, shoulders, head, or arms. Languages like Navajo, on the other hand, also have different verbs depending on what type of object it is: living, long, bulky, etc. (See also Refs 111, 112).

These examples demonstrate a form of diversity distinct from the others described so far. Here, components of an event are differentially packaged together across languages. This holds even for how simple movement along a trajectory is expressed in verbs.[113] Some languages, like English, typically use verbs expressing both the fact of motion and the manner of motion (e.g., *slide*, *roll*, *run*). Other languages, such as Spanish, more often use verbs packaging together the fact of motion with its path (e.g., *entrar* 'to go in', *salir* 'to go out', *pasar* 'to go through', *subir* 'to go up'). (Manner is optionally expressed in a satellite, e.g., 'by running'.) Still other languages, such as Atsugewi, a Hokan language of California, often use verbs that put together motion with information about the thing moving (e.g., *-caq-* 'for a slimy lumpish object to move/be located'). These patterns of groupings are not absolute within a language. English has verbs like *enter* that conflate motion with path, and Spanish has verbs like *correr* 'run' that express manner. Nevertheless, languages differ in their dominant pattern of use.[114–116]

This difference in lexical packaging could impact naming of human locomotion. Human gaits, such as walking and running, have characteristic clusters of co-occurring features. In fact, as speed increases people transition abruptly from one gait (an alternating stride where one foot is always on the ground) to another (an impact-and-recoil action where both feet are off the ground at one point) without any intermediate stage.[117] Malt and colleagues[118] examined whether this biomechanical discontinuity was recognized across languages that came from different typological stock. Two of the languages (English and Dutch) were of the first type introduced above—they typically express manner in the verb; whereas the other two languages (Spanish and Japanese) typically express path information. In all cases, the verbs used to describe video-clips depicting a person moving on a treadmill respected the discontinuity of the gaits. That is, there was a sharp lexical boundary between 'walking' gaits and 'running' gaits. So for these basic gaits, languages appear to categorize motions in very similar ways, despite differences in the broader lexicalization patterns. Despite this shared lexical recognition of the biomechanical discontinuity, variation appeared in how many verbs were used to name gaits in a way consistent with the linguistic typology. English and Dutch, the 'manner verb languages', made more fine-grained distinctions.

A study of the same languages using a wider-range of gait types[119] also shows broad agreement across languages in respecting the biomechanical distinctions of different gait types. And, once again, there is nevertheless considerable variation in the number of distinctions made lexically: There were many more dominant terms for the manner-rich languages (e.g., 14 in English but only 5 in Spanish). There are broad constraints from the physical structure of locomotion, but structural properties of the language appear to also shape individual languages' lexical characteristics.

Differences in the granularity of verb semantics can be seen in another domain too—that of 'cutting and breaking'. In the largest study of event categorization in language to date, Majid, Boster, and Bowerman,[120,121] in collaboration with a team of linguists, collected primary data from 28 languages. Native speakers of a wide range of languages, including many small-scale communities from Africa, the Americas, Asia, and Australia, were presented with a standardized set of video-clips depicting an agent separating various objects. Some of the events were reversible separations (i.e., opening events) but others were permanent severances (e.g., cutting, breaking, slicing, hacking). Speakers described the events in their native language and the verbs obtained were subjected to statistical analysis to identify the common patterns of categorization. Across all languages, the same semantic dimensions were uncovered. First, all languages distinguished the reversible separations from the permanent ones. Within those, all languages distinguished separations with a highly predictable end state (e.g., a knife slicing a carrot—the location of separation is predictable from where the knife is placed) from less predictable ones (e.g., smashing a plate—the plate may shatter in any number of pieces). Additional dimensions distinguished tearing events, smashing-snapping events, and so forth.

Despite this uniformity in the dimensions encoded in the verbs of the 28 languages, the precise range of events included under individual verbs varied. Yélî Dnye speakers, who live on an isolated island of Papua New Guinea, used merely three verbs, each of which has a relatively broad extension.[122] In contrast, Tzeltal speakers from Mexico used more than 50 different verbs, each with subtly specific semantics.[123] What accounts for this variation? Besides the possibility of a link to structural characteristics of the languages, culture in the form of technology might be relevant, as it is for color vocabulary. The homeland of Yélî Dnye speakers, Rossel Island, has no flint, obsidian, or other sharp stone, and until recently, Rossel Islanders did not have access to sharp instruments from outside. The smaller lexicon in this domain could be the result of this technological limitation. Technology is not the whole story, though. For example, Dutch, Swedish, and Mandarin have different verbs for cutting-things-with-scissors versus for cutting-with-other-instruments, a distinction not made in English, German, or Hindi, even though the available instruments are similar. Other forces not yet identified must be at play.

Similar diversity in packaging can be seen in how speakers of different languages talk about spatial relations[11,124,125] and kinship,[126–128] which were touched upon briefly in the introduction. These are particularly interesting because recent investigations suggest similar forces shaping lexicons in these domains as in others discussed earlier. For example, across languages spatial relations demonstrate 'optimal partitioning',[129] as does color.[35] Communication pressures for efficiency appear to influence kinship terminologies[127,128] as well as color terms,[42] and historical factors are as relevant for kinship[126] as they are for artifact terms.[100] We explore these similarities further in the next sections.

IMPLICATIONS OF COMMONALITIES

Where Commonalities Come From

Evans and Levinson,[6] arguing against a nativist account of language universals, suggest that shared tendencies '. . . emerge from the crucible of biological and cognitive constraints, functional constraints, and historically inherited material.' This characterization is compatible with the evidence discussed here. There are broad principles at play across domains, cultures, and languages. Relevant *biological* constraints include the properties of human perceptual systems. For instance, one possible explanation of the finding that focal instances of color terms cluster together across languages is that there are 'bumps' of particular salience in perceptual color space.[35] Among likely *cognitive* constraints are the discovery of a common set of dimensions used in naming actions.[120] Despite different specific distinctions drawn across languages, these common dimensions imply shared sensitivity to certain properties of events, and such shared sensitivities may exist for other domains. *Functional* constraints can be seen in numeration systems and in the biological domain where cultural utilities influence local practices of naming.[83] There are constraints from the *structure in the physical world*. Where discontinuities in property distribution or a physical segmentation of a domain exist, they provide a guide for creating named groupings that appears to dominate other ways of grouping. *Communication pressures* to create simple but informative systems provide another set of constraints.[42,128] Similar semantic systems might be found across languages as a by-product of converging on shared names even where there is little or no statistical structure in the input. Finally, *historically inherited material* is clearly relevant for the lexicon, because both borrowing of terms during language contact, as well as shared language origins, can create commonalities.[98,126]

The Causal Relation Between Language and Thought

We noted at the outset that to whatever extent commonalities are identified in how thought is mapped to words, they stand to provide important lessons about the nature of human cognition. One fundamental issue is the relation between language and thought. The evidence reviewed here shows that, despite pervasive variation in word meanings across languages, commonalities can be identified. Without denying the possibility that language may influence thought, the commonalities indicate that there are important aspects of how the world is perceived and understood that are shared across speakers of different languages. Whatever influence language may have on thought, it works against a background in which much may be shared.

Could Perception and Cognition Be Culture-Dependent All the Way Down?

The observation of commonalities, in conjunction with their possible sources, yields a further implication. Despite concerns that many aspects of perception or cognition identified on the basis of a single population may not generalize beyond that population,[5] these commonalities provide some reassurance that there may be identifiable generalities. Furthermore,

the understanding of origins of commonalities in naming patterns that has begun to emerge provides a toehold into what some of those might be.

IMPLICATIONS OF DIVERSITY

Where Diversity Comes From

The evidence reviewed suggests four broad and overlapping sets of forces creating divergences in the way that languages segment domains by name. *Sociocultural* influences include current social organization and culture-specific beliefs, practices, and motivations. For instance, matrilineal versus patrilineal inheritance systems may influence kin naming patterns;[130,131] the complexity of commerce[76] or cuisines[72] may influence numeration or taste systems; beliefs about properties of certain animals may influence the extension of an animal term.[89] Sociocultural influences also include cultural history, since the pattern of lexicalization present at a given moment is a function not only of current speakers' experiences but many years of cultural and linguistic evolution. For instance, development of dye technology may have led over time to elaboration of color vocabulary;[51,132] earlier eras of the vessels used for containing in a culture may have shaped the set of container terms passed forward even as some disappear from current use.[98,133] Influences of the *physical environment* will feed into the sociocultural influences, since variation in materials for creating tools,[122] color in the landscape and landscape forms,[27,28] and the plants and animals present[84,87] will help shape cultural practices and with it language. The physical environment may also influence human sensory systems,[39] and through that, what is considered name-worthy, as in the proposal that color vision changes with latitude.[43,46] *Linguistic* influences encompass the impact of language structure, such that morpho-syntactic possibilities,[100] typical patterns of conflation of information in verbs,[113] and presence or absence of a numeral classifier system[74] are reflected in the lexical structure of a domain. Linguistic influences also come in the form of language contact, which can cause convergences (by adding to a language's lexicon, with attendant adjustment of word meanings within the semantic field) as well as divergences (because differential patterns of contact can cause previously similar languages to evolve in different directions). Finally, *population variability* is a recent entry into the arena with the suggestion that incidence of color blindness in a population may influence what color distinctions can successfully be used in language.[43,44,49,134]

Where and Under What Circumstances May Language Influence Thought?

The studies we reviewed provide rich information about diversity in how languages divide the world up by name. They offer not only the conclusion that diversity is pervasive but many details about its manifestation across languages and domains. These differences provide fertile grounds for future studies of where lexical diversity may have an influence on thought. But much research on the possible influence of language on thought has proceeded without consideration of the origins of the diversity in question. The studies reviewed here provide insights into possible origins of diversity, as discussed above. These insights give hints about where parallelism between language and thought may be mediated by culture rather than directly from language to thought. They also raise a further point to consider. The fact that current naming patterns can reflect historical and not current cultural conditions might argue that these naming patterns are not optimal for contemporary action on the world and so, in such cases, independence of thought from language can be found.[133] The fact that, synchronically, language and culture do not correlate perfectly makes this area of research an experimentalist's dream since it provides the possibility of teasing apart the effect of each. Cases where current naming patterns do not reflect distinctions of current cultural importance can be examined and compared to cases of the converse for their relative impact on thought.

Using Words to Find Concepts

Philosophers, psychologists, and cognitive neuroscientists have devoted much effort to the study of concepts, generally taken to be general-purpose representations not directly derived from linguistic knowledge. Diversity challenges the widespread practice of using words of a single language (e.g., *triangle*, *table*, *robin*), to identify the concepts to be studied. If the words of a language can reveal these general-purpose concepts, then a sizeable portion of these concepts must be directly given by language and must vary considerably across speakers of different languages.[135,136] On the other hand, if the concepts are taken to be shared across speakers of different languages, then words of a single language are of little use in identifying them. New approaches to finding nonlinguistic conceptual content are needed, including using information extracted from aggregating words across languages to identify shared underlying components of domain knowledge.[8,120,137]

Word Learning

Diversity across languages in how words partition domains highlights the challenges for language learning. If naming patterns for many domains vary from language to language, then much of what a child learns about word meanings and usage must be language-specific and not fully given by pre-linguistic understanding of the world.[11,138] A study of naming patterns for common household artifacts by Dutch-speaking Belgian children found that the children were 14 years old before they fully matched the naming patterns of the adults, even though they had the terms used by adults in their productive vocabularies earlier.[139] This extended learning needed to master a single language's naming pattern implies that the challenges are greater when learning two or more languages in parallel or a second one after a first has been acquired. Nonnative speakers of English who have been immersed in English for up to 18 years still deviate significantly from the native speakers in their use of some common words.[140] Furthermore, those who acquire two languages in parallel use the words of the two languages in ways distinct from those of monolingual speakers of the languages,[99] and second-language speakers who spend considerable time in the second-language environment may begin to show an influence of the second-language usage patterns on word use in their own native language.[97,141,142]

FUTURE DIRECTIONS

A difficulty in drawing conclusions about commonalities and diversity across studies lies in the varying research methodologies used. There are many beautifully rich case studies of individual languages. Looking across these studies, one can see that diversity in how domains are lexicalized is substantial. However, by themselves these reports provide little information about the extent or nature of any commonalities (and, as such, may also foster an impression that diversity is unconstrained). Even when commonalities are examined, different methods are used and the focus is on different aspects of the problem. Some evaluate conformity of lexical category boundaries to an external (nonpsychological) standard;[4,80,118] some the optimality of the categories;[35,129] some whether prototypes are similar across languages;[34,100] some whether there are shared dimensions involved in making whatever lexical distinctions exist.[120,121] The differing emphases leave open the possibility of as-yet-unexplored commonalities. For instance, although artifact terms may vary across languages in their prototypes and boundaries, they still may be based on contrasts on the same dimensions, but no direct test has yet been made of this aspect of the data. Further studies applying consistent data collection techniques and formal methods of analysis will help answer the most fundamental questions about where meaning comes from.

CONCLUSION

English is but one of thousands of languages spoken today. The meanings encoded by its words, although feeling obvious to native speakers, are by no means the only way to carve up the world. The languages spoken today showcase the diverging sociocultural, environmental and linguistic histories each language has undergone. Full one-to-one correspondence of word meanings is rare, if attested at all. Despite these divergences, there are recurring patterns to be found that point to a set of domain-general constraints on how word meaning and patterns of word use develop. The commonalities and divergences carry important implications for Cognitive Science about the causal relations among language, thought, and culture, the possibility of cross-culturally shared aspects of perception and cognition, the methods needed for studying general-purpose, nonlinguistic concepts, and how languages are learned.

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