Chapter 12

Language and Thought

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Language is not indispensable for thought. Nonhuman animals solve complex cognitive tasks while lacking anything close to the human communication system; and human children achieve incredible cognitive feats long before they are able to participate in conversations. Still, language is our most powerful tool for the bulk of cognitive activities we frequently engage in, from the categorization of our perceptions to the planning of our actions. But the language we speak as our mother tongue is also a tool with a history and of a specific shape. It is structured through and through, in ways that differ from one language to the next, and it comprises classification systems, sets of contrasts, and requests for specifications that would seem to afford and suggest some lines of thought more easily than others. As we know from research on problem-solving (see Chapter 9, "Problem Solving"), tools are typically used in a specific context and for specific purposes, while using them in novel ways is challenging for humans (e.g., Duncker, 1935). A similar phenomenon might therefore be expected for language when used as a tool for describing observations, categorizing them, or drawing inferences from them. This analogy raises a tantalizing question: Do speakers of different languages develop different views of the world?

Suggestive phrasings that influence interpretation and memory (Carmichael et al., 1932; Loftus & Palmer, 1974), requests for using gender-neutral or -inclusive language to reduce gender discrimination (Irmen & Kurovskaja, 2010; Prewitt-Freilino et al., 2012), and the finding that repetitions of wrong statements make them sound true (the *illusory truth effect*; Bacon, 1979; Hasher et al., 1977), all attest to the power that language can unfold in shaping the social world (see Chapter 11, "The Nature of Language"). But does it gain this power by only shaping the world we live in or also by directly affecting our cognition? To what extent do systematic differences between languages and their grammatical structures cause differences in how their speakers perceive, categorize, reason, or make decisions?

To address these questions, we first present the *principle of linguistic relativity* and its various readings (sections 12.1 and 12.2). Two of the most plausible readings are then examined in more detail, illustrated with one example each: color perception and numerical cognition (section 12.3). Against this backdrop we then elaborate on the role of language as a cognitive tool (section 12.4).

12.1 The Principle of Linguistic Relativity

The idea that language may affect thought can be traced back at least to the 18th century, to scholars like Johann Gottfried Herder (1744–1803) or Wilhelm von Humboldt (1767–1835). Today, however, it is most strongly associated with the names of ethnolinguists Edward Sapir (1884–1939) and Benjamin Lee Whorf (1897–1941), which is why

https://doi.org/10.17885/heiup.470.c6675

the idea in more recent literature is often referred to as the "Sapir Whorf hypothesis" or the "Whorfian hypothesis". Whorf (1956) himself used the term **"principle of linguistic relativity"**, deliberately in the style of Einstein's *principle of relativity* in physics—for two reasons. First, Whorf made a claim similar to Einstein's, namely, that objective or absolute descriptions of the world independent of a given viewpoint are impossible (hence "relativity"), in this case because our perceptions and categorizations are influenced by the linguistic structures implicit in our native languages. Second, Whorf considered this linguistic relativity a premise for research, not its target (hence a "principle" and not a "hypothesis"). In the cognitive sciences, and specifically in cognitive psychology, this idea is still highly controversial, even to this date.

12.1.1 Fundamental Theses

The principle of linguistic relativity is based on three general theses (Lucy, 1997; Wolff & Holmes, 2011):

- Languages differ with regard to how they describe the world. [Thesis 1]
- The specific way in which a language describes the world affects the experiences made by its speakers. [Thesis 2]
- Speakers of different languages therefore experience the world differently. [Thesis 3]

Let us illustrate this argument with a concrete example. Even closely related languages differ with regard to classes into which they sort their nouns (Thesis 1). So-called formal gender languages assign a grammatical gender to every single noun. Romance languages like French, Italian, or Spanish, for instance, contain two of these classes: *masculine* and *feminine*. Other Indo-European languages like Greek, German, or Russian make use of a *neuter* in addition to the masculine and feminine. Parts of Norwegian, Swedish, or Dutch conflate two of these, namely, masculine and feminine gender as *common gender* in opposition to the neuter gender. And English has given up all gender distinctions (at least those that are not grounded in biological gender) and hence is no longer a formal gender language. Still, it differentiates gender in personal pronouns ("he", "she", "it"), but even this apparently basic categorization is not a linguistic universal. Polynesian languages such as Tongan, for instance, distinguish between a single person, pairs of persons, and groups of persons, and between selections of people that do or do not include the addressee, but they do not care about gender.

According to Thesis 2, linguistic categorizations like gender classes or inclusion criteria for personal pronouns help us to organize and structure the "kaleidoscopic flux of impressions" in which the world is presented (Whorf, 1956, p. 213f.). Since the linguistic categories constitute the largely indiscernible background against which our conscious considerations take place, they do their organizing work without our noticing it. It may appear only consistent, therefore, to assume that linguistic categories in the language in which one forms one's thoughts would contribute to shaping those very thoughts. Applied to our example, such organizing would be at work if speakers of German associated the sun more strongly with female attributes because *die Sonne* is feminine, and the moon more strongly with male attributes because *der Mond* is masculine—in contrast to, for instance, speakers of Spanish, for which *el sol* is masculine and *la luna* feminine (Koch et al., 2007).

Thesis 3, finally, implies that speakers of German differ in their associations of sun and moon from speakers of Spanish precisely because the two languages assign grammatical gender reversely to these two words. Examples like these are the key target of crosslinguistic studies on linguistic relativity, and we come back to findings from such studies in section 12.2.

12.1.2 Do Languages Differ in their Description of the World?

As you may have noticed, if you read Chapter 7 on deductive reasoning carefully, the three theses form a syllogistic argument, in which Thesis 3 follows logically from Theses 1 and 2. In other words, if the first two theses are considered true, the third one must also be considered true. But even the apparently least controversial Thesis 1 was rejected for several decades in both psychology and linguistics. Distinguished scholars advocated the position that the commonalities of human languages, which they attributed to a "universal grammar" module in humans, by far outweigh the differences between languages (e.g., Chomsky, 1986; Pinker, 1994). On this account, the diversity in, for instance, gender categories and gender assignment to nouns across languages would be considered a minor detail that would be irrelevant to how people perceive objects and their properties.

With more indepth investigations of a broad range of languages, however, the differences between languages are now taken more seriously (Dabrowska, 2015; Evans & Levinson, 2009), and some of these differences are involved in coding and emphasizing relevant information in sensible, if even in language-specific ways. For instance, when expressing motion by way of verbs, some languages (such as English, Russian, or Chinese) emphasize the manner of the movement over its path whereas others (including Spanish, Greek, or Japanese) emphasize path over manner. For illustration, compare the following two sentences which are borrowed from Papafragou and Selimis (2010, p.227, footnote 2):

(1) The bird is flying out of the cage.

(2) The bird is exiting from the cage (flying).

In (1), the emphasis rests on the *manner* of motion (here: flying in contrast to, say, tripping), while in (2) it rests on the *path* of motion (exiting in contrast to, say, entering). In English, the manner of motion is expressed by the verb itself ("flying"), whereas path information is expressed by way of a preposition ("out of"). A roughly comparable statement in Greek (2) expresses information on the path of motion in the verb ("exiting") whereas the manner of motion would have to be explicated by way of an attribute (here as "flying") or actually in a second sentence with a new verb.

Such language-specific differences are also documented for other types of semantically meaningful categories (such as tense in verbs, or the distinction between countable objects and substances; see, Wolff & Holmes, 2011, for an overview). For this reason, the controversial debate has shifted in recent years and is now focusing on Thesis 2: Does the specific way in which a language describes the world really affect the experiences of its speakers? In other words: Do speakers of English and of Greek *perceive* motions in distinct and different ways?

12.1.3 Do Different Descriptions of the World Affect Our Experiences?

The most radical position with regard to the relation of language and thought is the position of behaviorism, as represented by John Watson. Watson conceived of thought simply as inner speech—a position that soon turned out to be untenable. The position at the opposite end of the spectrum is advocated, for instance, by Noam Chomsky, the linguist who became famous in the 1950s for crushing behaviorist accounts of language. The view he made popular is that language and thought are two entirely separate and distinct modules (e.g., Chomsky, 1986), hence precluding, by definition, any potentiality of linguistic relativity (Pinker, 1994). Prevailing for decades, this view still has supporters, but is slowly losing ground. Specifically, developmental psychologists in the tradition of Lev Vygotsky and Jean Piaget have been arguing that, while cognition and language may emerge and develop independently from one another, they become entangled later on in a complex relationship. This view is further supported by empirical evidence that cognitive development more generally spurs on language development (overview in Harley, 2014).

The principle of linguistic relativity differs from both the behaviorist and the modular position in that it considers language and thought neither as identical nor as entirely separate. Nor do proponents of linguistic relativity dispute that thought is possible without language or that it (at least ideally) precedes language use. However, they emphasize more strongly than others the possibility that properties of the language one speaks may also affect aspects of how one thinks. Unfortunately, neither Sapir nor Whorf elaborated their ideas on linguistic relativity into a coherent theory. As one consequence, research in this field is plagued to this date by a plurality of possible readings. Our attempt to systematize these readings follows the overview presented by Wolff and Holmes (2011).

One of the central dimensions on which possible readings differ is concerned with the question of whether language and thought are structurally parallel or different. The former case would support the position of **linguistic determinism**: In this case we would be able to engage only in those thoughts that our language permits. This most extreme form of linguistic relativity—frequently associated with Whorf even though he himself was rather ambivalent on this view (Whorf, 1956; and see Lee, 1996)—is of little intuitive plausibility and also refuted by empirical research (overview in Wolff & Holmes, 2011). This research demonstrated clearly that thought is more strongly guided by properties of the world than by linguistic labels (Imai & Gentner, 1997; Malt & Wolff, 2010).

Even if one accepts that language and thought may be structured in distinct ways, linguistic relativity could still unfold in one of several ways (Wolff & Holmes, 2011; and see Figure 12.1). Depending on the specific reading, these would assume an influence of language during

- *thinking before language*, that is, when we organize our thoughts to prepare a linguistic utterance (i.e., *thinking for speaking*),
- *thinking with language*, that is, when linguistic representations enter into conflict with, or instead support, non-linguistic representations (language as *meddler* or as *augmenter*, respectively),
- *thinking after language*, that is, when linguistic effects linger on and thereby 'color' our thoughts in language-specific ways (language as *spotlight* and language as *inducer*).

In section 12.2, we explain in more detail the first and third reading (thinking before and after language) as they are closely associated, before turning to two examples of the second reading (thinking with language) in section 12.3.

12.2 Thinking before and after Language

12.2.1 Thinking before Language ("Thinking for Speaking")

Lexical items make differentiations possible, as for distinguishing between pastel green, moss green, and turquoise. Grammatical structures do not simply *afford* such differentiations but *require* them. When we put our thoughts into words—and even before we can begin doing this—a number of decisions need to be made. These include having relevant information available that need to be specified according to the grammar/grammatical rules of the language we intend to use. For illustration, take the categories of tense and aspect that in many languages tend to be realized in the verb. Both categories provide information on time, but they focus on different facets

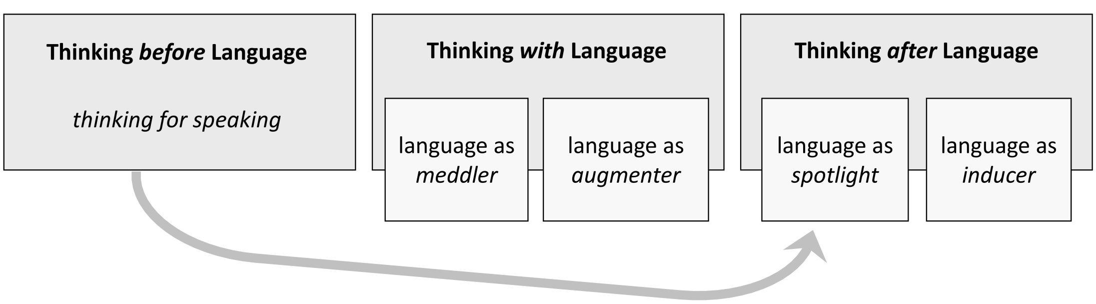

Figure 12.1: The most plausible ways in which language may affect thinking (according to Wolff & Holmes, 2011), and the relation between them.

of time: *Tense* specifies the time in which an event takes place (e.g., in the past, present, or future), while *aspect* specifies how this event extends over time (e.g., whether it is ongoing versus terminated, or whether it is progressive versus habitual).

In German, each verb form always requires an instantiation of tense—for example, the present tense in (3) and the past tense in (4)—but largely disregards aspect.

(3) *Dieser Papagai redet.* ["This parrot talks"]

(4) *Dieser Papagai redete.* ["This parrot talked"]

In English, aspect needs to be specified in addition to tense, with (5) indicating habitual action, whereas (6) indicates progressive action:

(5) This parrot talks.

(6) This parrot is talking.

In Tongan and other Polynesian languages, or in Chinese, neither tense nor aspect is expressed in the verb.

In order to form a grammatically correct sentence, speakers of German therefore need to specify *when* an event is happening, but need not specify whether it is or is not *ongoing*. In other words: The aim to express something in language forces one to pay attention to specific types of information while we may safely ignore others. This effect of language on thought, famously labeled "**thinking for speaking**" by Slobin (1996), emerges *before* language is actually used and can be observed in various domains (Gennari et al., 2002; Papafragou et al., 2008). A second example for this type is the distinct focus, described earlier (in section 12.1.2), that languages direct at either the manner or the path of motion (Papafragou & Selimis, 2010).

12.2.2 Thinking after Language

If we accept an influence of thinking for speaking, it follows almost naturally that an entire life of occasions in which we need to verbalize our thoughts would form habits regarding what we pay attention to. These habits should have a certain likelihood to linger on also in contexts in which respective information is not immediately required for verbalization, that is, during thinking without imminent need for speaking. In emphasizing some distinctions—say, with regard to time point or temporal course—more than others through compulsory grammatical categories (here: tense or aspect), languages would therefore still direct attention to the same types of information in a regular and sustained manner, like a spotlight (this is why Wolff & Holmes, 2011, dub this instance of thinking after language the *spotlight effect*). One of the instances Wolff and Holmes cite for this effect is the gender distinction mentioned earlier.

Yet, both in terms of theoretical plausibility and of empirical support, the category of grammatical gender has remained a rather controversial case. Semantic gender languages assign a gender only to living things that possess a biological gender (sex), whereas formal gender languages extend the gender distinction to all nouns regardless of whether their referents have a sex. English is an example of the former, German of the latter. The two languages alike assign masculine gender to living things like "man", "son", or "rooster", and feminine gender to "woman", "daughter", or "hen". But while almost all inanimate things are neuter in English, a large proportion of them are categorized as masculine or feminine in German (e.g., *der Mond* [the$_{\text{masc}}$ moon], *die Sonne* [the$_{\text{fem}}$ sun]). Hence, as a formal class, grammatical gender does not reflect genuine differences in the world. It serves the purely linguistic function to generate congruence within sentences, and particularly between the noun and the accompanying article and adjective, as in (7) and (8):

(7) ein_ heller Mond ["a bright moon"]

(8) eine helle Sonne ["a bright sun"]

Notably, also, relatively few languages distinguish exactly between the two genders of interest, namely, masculine and feminine gender; many others categorize on different grounds, with some even conflating the two (such as Swedish or Dutch) and some distinguishing up to 20 different genders (Corbett, 1991).

Gender distinctions have still attracted considerable interest as a subject for studies on linguistic relativity (e.g., Boroditsky et al., 2003; Konishi, 1993). A popular measure in these studies is the *gender congruency effect* (see Chapter 11, "The Nature of Language"). It emerges if the grammatical gender of a noun (e.g., masculine in the case of *Mond*) is congruent with the association of the respective referent with a specific sex (here: moon as male). However, the more sophisticated the methods used for investigation (e.g., adopting implicit tasks instead of direct assessments), the more difficult it turned out to replicate the initially positive findings (overview in Bender et al., 2018).

For better suited and more convincing examples of the spotlight effect we therefore need to turn to domains in which linguistic categories do reflect—and make salient—genuine characteristics of the world. Only then do they have the potential and the power to habitually redirect attention to these characteristics.

One such example is spatial referencing. A frame of reference (FoR) is a linguistic tool for describing relations between entities. It provides a coordinate system for locating a thing (say: a ball) in reference to another thing (say: a boy) and comes in three types (Levinson, 2003): The *absolute* FoR is aligned with external fixed points such as the cardinal directions or a river; the *intrinsic* FoR is aligned with the point of reference (here the boy); and the *relative* FoR is aligned with the perspective of an observer. Importantly, languages differ in which of these FoRs they can use or prefer, and this in turn affects people's wayfinding skills, their cospeech gestures, how they memorize relations and orders, or how they think about time (Bender & Beller, 2014; Levinson, 2003; Majid, Bowerman, Kita, Haun, & Levinson, 2004).

12.3 Thinking with Language

Besides the obvious case of *thinking for speaking* and the likely case of the *spotlight effect*, both of which arise from the need to focus on information requested by one's grammar, two more readings of linguistic relativity have been investigated quite extensively in the past decades: one focusing on the possibility that linguistic representations enter into conflict or interfere with non-linguistic representations (language as *meddler*), the other focusing on the possibility that linguistic representations support, augment, or even make possible non-linguistic representations (language as *augmenter*). In both of these cases, it is the role of language as a cognitive tool that opens up an influence of language on thought.

12.3.1 Language as Meddler: The Case of Color Perception

Color is an excellent example for investigating the influence of language on perception and other cognitive processes because colors can be exactly defined and measured in terms of the wavelength of light. The color terms we use to denote different colors verbalize a categorical system that we impose on the physically unstructured color spectrum, and hence are a product of thought. The interesting question now is whether these color terms, once established, also impact on thought. That is: If two languages divide the color spectrum in different ways, will the speakers of these languages also perceive the colors in different ways?

That languages indeed differ in how they divide the color spectrum has been well known for half a century (Berlin & Kay, 1969), systematically documented in the *World-Color-Survey*, a large-scale research program at the University of California, Berkeley (http://www1.icsi.berkeley.edu/wcs/). This research program focuses on basic color terms—words that are elementary, generally applied, and broadly understood. In order to qualify as elementary, a color term needs to be a single word; composed expressions like "dark red" or "forest green" are therefore excluded. A color term is considered general if it can be applied to any kind of object; a term like "blond" is hence excluded because its usage is restricted to hair. Terms like “magenta” or “burgundy”, finally, do not qualify because they are not widely known.

Following these specifications, English is considered to comprise eleven basic color terms: “black”, “grey”, and “white” for achromatic colors, and “red”, “yellow”, “green”, “blue”, “orange”, “pink”, “purple”, and “brown” for chromatic colors (Berlin & Kay, 1969). Many languages have fewer basic color terms than English, but some languages also have more. For instance, English uses different terms for *green and blue*, whereas Welsh subsumes them under one term (Lazar-Meyn, 2004), and both Italian (Paggetti et al., 2016) and Russian (Davies & Corbett, 1994) distinguish *blue* further into a *light blue* and a *dark blue* (Table 12.1).

Do, therefore, speakers of Welsh, English, and Italian or Russian perceive the respective colors differently? This question can be investigated by selecting colors with equal intervals in their hue so that the selected colors in one language all fall into the same category (e.g., *blue*), while they are separated by a categorical boundary in the other language, as with *goluboj* versus *sinij* (see Figure 12.2a). If the linguistic categorization has an impact on perception, the difference between hues that are separated by the categorical boundary should be overestimated, compared to the identical difference between two hues that belong to the same category. In our example, this would be the case for speakers of Russian, but not English. In adopting this strategy, several studies could demonstrate that such a categorical boundary does not influence color perception per se, but does influence other cognitive processes involved in similarity judgments, rapid distinctions between hues, learning of new color categories, or the recognition of hues (Kay & Kempton, 1984; Mitterer et al., 2009; Roberson et al., 2005).

One such study (Winawer et al., 2007) investigated whether a categorical boundary affects color discrimination in speakers of Russian compared with speakers of English, using stimuli from the color range denoted as “blue” in English (Figure 12.2a). Participants were shown squares in different shades of blue arranged in a triad and were asked which of the two on the bottom matches the one on the top (Figure 12.2b). In some trials, the non-identical hue at the bottom was from the same color category as the target hue; in others, it was from the complementary color category. It turned out that shades of blue were indeed easier to distinguish if they belonged to different categories than if they belonged to the same category. Interestingly, this holds particularly for stimuli projected onto the right visual field, which is connected to the left hemisphere in the brain (Gilbert et al., 2006). Brain areas involved in color perception and language processing are activated faster and more strongly by the distinction of colors that belong to different categories (Siok et al., 2009) and of colors that are easy to name (Tan et al., 2008).

Whether such effects of categorical boundaries originate from conscious processes has not been conclusively clarified. At first glance, it seems plausible that people use a naming strategy and that different naming of colors leads to differently remembered

Table 12.1: Basic color terms in four Indo-European languages for the green-blue section.

Welsh		*glas*	
English	*green*	*blue*	
Italian	*verde*	*azzurro*	*blu*
Russian	*zelenyj (Зелёный)*	*goluboj (голубо́й)*	*sinij (си́ний)*

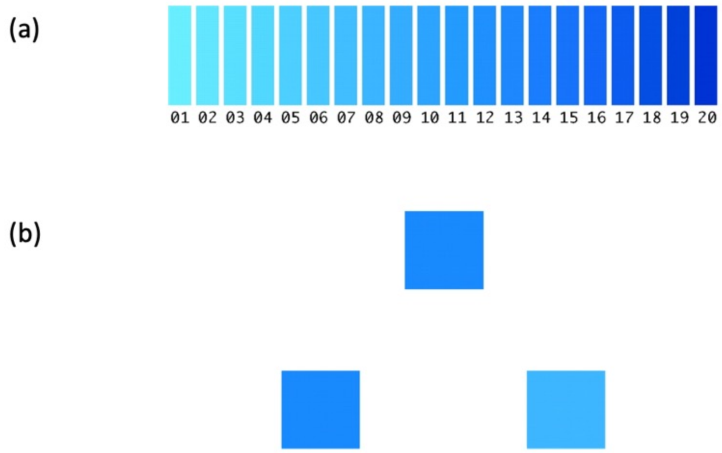

Figure 12.2: Stimuli used in the study by Winawer and colleagues (2007): the different shades of blue (a) and an example of a stimuli triad (b). Participants were asked to pick one of the two squares from the lower row that matched the color of the single square above (©(2007) National Academy of Sciences, U.S.A.; permission to reprint granted).

colors (Mitterer et al., 2009). However, participants themselves reported that the colors they categorized as different actually *looked* different (Kay & Kempton, 1984, p.75). At least in this type of task, it seems, therefore, that what tips the scales is not the explicit verbal naming of the color but rather an automatic, non-conscious activation of categorical information.

The studies on color perception are the classic in the field of linguistic relativity and have contributed greatly to advancing the field in terms of both theoretical clarification and methodological elaboration. Still, the potential effects of the (color) lexicon should not be overrated. While the lexicon provides options for differentiation from which speakers can choose, these options can easily be complemented in case they turn out to be insufficient. If you deem neither “red” nor “brown” the appropriate label for the color of a chestnut, you can consider using “red-brown” or “chestnut-colored” or simply invent a new label such as “maroon”. But the fact that color perception is strongly determined by biological and anatomic factors renders findings in this domain still significant. After all, color vision is based on the exact same mechanism in all members of our species (apart from those with color blindness); the photoreceptor cells responsible for human color vision are particularly sensitive for certain wavelengths of light and hence for certain color experiences. In other words: If verbally mediated differentiations are able to modify cognitive processes even in this fundamental domain, an even stronger influence might be expected in domains in which biological constraints are less pronounced.

12.3.2 Language as Augmenter: The Case of Numerical Cognition

Handling numbers is a key skill in modern daily lives. While mathematics is something that many people try to keep at arm’s length, the ability to precisely assess the number of a set of items certainly strikes most as utterly simple. And yet, competently dealing with numbers is not at all natural. A biologically evolved precondition that we share with many other species is the ability to perceive quantity. This includes the ability to keep track of up to four distinct items by way of immediate perception (called *subitizing*) and to approximately estimate larger quantities (Feigenson et al., 2004). By contrast, the ability for exact quantification (i.e., accurately assessing, remembering, and reconstructing numbers beyond the subitizing range) is uniquely human. It presupposes cultural mediation, specifically a cultural tool, and extensive training (Núñez, 2017). The prototypical tool essential for acquiring this competence is a conventionalized counting sequence: an ordered list of number representations (*numerals*), each of which refers to a clearly defined exact number (Wiese, 2003).

Not all natural languages used by humans comprise such counting sequences. Mundurukú, for instance, a language spoken in Amazonia, is counted among the few attestable cases in which numerals do occur, but lack precise numerical meaning. The fifth numeral *pũg põgbi*, for instance, does not mean *precisely* 5, but only *roughly* 5, and can refer to values from 4 up to 12, depending on context (Pica et al., 2004). Pirahã, another Amazonian language, is claimed to comprise no numerals at all (Everett, 2005). Psychological studies in these two Amazonian groups indicate that the lack of precise numerals impairs the ability to exactly memorize, recall, and match larger quantities (Frank et al., 2008; Gordon, 2004; Pica et al., 2004). Similar issues are also observed in home-signers. A home-sign is a rudimentary sign language typically developed by deaf children to hearing parents. As home-signs are created in the absence of linguistic input, they typically lack conventionalized and stable counting sequences (Spaepen et al., 2011). And even students of US American Ivy League universities experience the very same challenges in numerical tasks if they are prevented (e.g., by verbal interference) from actively using number words (Frank et al., 2012).

However, the potential for differences between languages is not confined to the presence or absence of counting sequences. Counting sequences themselves can also vary extensively in terms of their properties, which depend on the number and shape of the elements in a sequence, their order and relations, or the modality in which they are realized (Bender & Beller, 2012; Chrisomalis, 2010; Widom & Schlimm, 2012). No two number systems on this planet would therefore be exactly alike. Even a number as simple and small as 5 can be denoted in

Table 12.2: A selection of possibilities for representing 5.

<table>
<tr><th>Language/Cultural Example</th><th>Representation</th><th>Decomposition / Translation</th><th>Range</th></tr>
<tr><td>Pirahã (Amazonia/Brazil)</td><td>“hói”, “hoí”, or “baágiso” (depending on elicitation order)</td><td>“somewhat larger size or amount”</td><td>[1 – 6] (hói)
[2 – 10] (hoí)
[3 – 10] (baágiso)</td></tr>
<tr><td>Mundurukú (Amazonia/Brazil)</td><td>“pũg põgbi“</td><td>one hand</td><td>[4 – 12]</td></tr>
<tr><td>English (various places)</td><td>“five”</td><td>5</td><td>[5]</td></tr>
<tr><td>French (various places)</td><td>“cinq”</td><td>5</td><td>[5]</td></tr>
<tr><td>Tongan (Polynesia)</td><td>“nima”</td><td>5</td><td>[5]</td></tr>
<tr><td>Adzera (Papua New Guinea)</td><td>“iruʔ da iruʔ da bits”</td><td>2 + 2 + 1</td><td>[5]</td></tr>
<tr><td>various</td><td>||||| or 卌</td><td>1 + 1 + 1 + 1 + 1</td><td>[5]</td></tr>
<tr><td>various</td><td></td><td>1 + 1 + 1 + 1 + 1</td><td>[5]</td></tr>
<tr><td>Roman (Early Middle Ages; Mediterranean)</td><td></td><td>5</td><td>[5]</td></tr>
</table>

Sources: Beller & Bender (2008), Frank et al. (2008), Pica et al. (2004), and Turner (1951).

fundamentally different ways (for some concrete examples, see Table 12.2): vaguely as “many”, by an elementary word like “five”, by a compound translating into “2 + 2 + 1”, by five distinct notches on a stick (or four upright notches crossed by a transverse notch), or by presenting a hand with all fingers extended (or closed).

The most obvious property in which counting sequences can differ is the modality in which they are implemented: through objects such as tally sticks or knotted strings (in the case of *material* systems); through fingers and body parts more generally (in the case of *body-based* systems); through number words (in the case of *verbal* systems); and through written notation such as the Hindu-Arabic digits or the Roman numerals (in the case of *notational* systems). Other properties (illustrated below) involve the presence or absence of a base and perhaps a sub-base, the size of such bases, or the regularity and transparency of how larger number words are composed.

Crucially, these properties have cognitive implications, that is, they affect how numbers are represented and processed (Bender & Beller, 2017; Bender et al., 2015; Schlimm & Neth, 2008). The *Hindu-Arabic digits*, for instance, constitute a decimal system; digits from 1 through 9 are represented by distinct symbols, the base 10 and the powers to which it is raised (e.g., 100, 1000, etc.) are represented by position (this is why the principle is often called “place-value”: the value of a number is co-determined by its place). The *Roman numerals*, by contrast, constitute a system that uses sub-base 5 in addition to base 10; basic numbers are largely represented in a cumulative manner (as I, II, III), whereas sub-base, base, and their powers are represented by distinct symbols (V, X, L, C, D, and M). Due to this cumulative representation of basic numbers instead of a place-value principle, it is actually easier to execute basic arithmetic operations such as addition or multiplication with the (original) Roman numerals than with Hindu-Arabic digits (Schlimm & Neth, 2008).

Let us illustrate this for the addition of **16** and **27**. All additions require both declarative and procedural knowledge. *Declarative knowledge* in the Hindu-Arabic system includes the numerical value to which a symbol refers as well as the sums of all relevant 100 single-digit addition facts. In other words: One need to know *beforehand* that the sum of 6 and 7 is 13, and that adding 1, 1, and 2 yields 4. *Procedural knowledge* includes, minimally, that numbers need to be written so that the smallest values (the most rightward number in each number representation) are aligned, that numbers need to be added by position, starting from the right, and what to do with carries:

$$\begin{array}{r} \mathbf{2\ 6} \\ + \ {}_{1}\mathbf{1\ 7} \\ \hline \mathbf{4\ 3} \end{array}$$

Adding the very same numbers with Roman numerals (**XXVI** and **XVII**) also requires declarative and procedural knowledge. Here, however, the *declarative knowledge* only needs to include the order of the basic symbols (according to their value) and the simplification rules inherent in the counting sequence, such as IIIII → V and VV → X. *Procedural knowledge* gets by with a few very simple tricks: start by joining the symbols of the addends

X X V I X V I I

order them according to their values

X X X V V I I I

and then simplify, with **V V** → **X**:

X X X X I I I

As this example illustrates, the manner in which numbers are represented in each of the two systems has an impact on how numerical information is processed—some operations are just more straightforward with one type of representation than with another. This phenomenon is called **representational effect** (Zhang & Norman, 1995), and it emerges not only for notational systems but for number systems in general (Bender & Beller, 2012, 2018).

Another instance of this effect is that a system will be understood, learned, and mastered more easily if it is regularly structured and transparent. Compared to number systems in East-Asian and Polynesian languages (Bender et al., 2015; Miura, 1987), the systems in many Indo-European languages including English are pretty irregular. The number words from 1 through 10 are distinct and arbitrary, as in all decimal verbal systems. Once base 10 is reached, starting a new counting cycle with regularly composed number words such as “ten-and-one”, “ten-and-two”, etc. would reveal the base 10 structure. English, however, blurs this structure with its specific number words “eleven” and “twelve”. Not even “thirteen” is recognizable as “ten-and-three”, which is why only at “fourteen” may a novice begin to sense a recurrent pattern in the suffixed “-teen” (Bender & Beller, 2018). Moreover, the difference between numerals like “thirteen” and “thirty” hinges on a crucial distinction between *-teen* and *-ty*, both of which refer to the same number (10) though and should therefore actually be identical. As a consequence of these irregularities, English-speaking children take more time than Chinese-speaking children to learn their system and require more effort for grasping its decimal structure and the algorithms based on it (Fuson & Kwon, 1991; Miller et al., 1995).

12.4 Language as Tool for Thought

As should have become clear by now, language is an important tool for thought, aiding the coding, categorization, and storing of information as well as processes of reasoning, decision making, and problem solving. As we know from classic experiments in psychology (see Chapter 9, “Problem Solving”), the properties of a tool and the habits acquired during its usage tend to affect how the tool is applied. One instance illustrating this influence is the phenomenon of *functional fixedness*: the tendency to use a tool in conventional ways even if a new problem requires a novel application (Duncker, 1935; Glucksberg & Danks, 1968). A second instance is the so-called *set effect* (or *Einstellung effect*): the tendency to stick to a procedure that has worked before even if the new problem requires a novel approach (Luchins & Luchins, 1959). Applied to the case of language, we distinguish in this last section two states of familiarity: the standard state of a familiar language serving as a well-known tool (sections 12.4.1), and the implications that arise from using a foreign language as an unfamiliar tool (sections 12.4.2). In contrast to the familiar tool, which reinforces our cognitive habits, the unfamiliar tool seems to reset these habits to some extent.

12.4.1 Familiar Tool: Thinking by Language

The first language we acquire is our native language or mother tongue, and this language is with us during major parts of cognitive development, while we learn to categorize the things we perceive, discover the world of numbers, or try to figure out solutions for reasoning tasks and decision problems. As noted by developmental psychologists in the tradition of Vygotsky and Piaget, language and thought become entangled in a complex relationship during this process. In other words: language itself is like a glue that keeps our non-domain-specific, cross-modular, propositional thoughts together, “not just in the sense that language is a necessary condition for us to entertain such thoughts but in the stronger sense that natural language representations are the bearers of those propositional thought-contents” (Carruthers, 2002).

An example of the crucial role of language is the emergence and development of a “theory of mind” in children, which seems to benefit greatly from linguistic support (Pyers & Senghas, 2009; de Villiers, 2007). Theory-of-mind abilities emerge in all normally developing human children; their onset, however, depends on the amount of mental-state talk in parent-child interactions. For instance, whereas in the Western world, reflections on others’ mental states are a topic of widespread interest and conversation, numerous societies across the world appear to adopt a perspective according to which mental states are private and opaque (Luhrmann 2011). This reluctance to openly speculate about the feelings, intentions, or thoughts of others affects the ease with which children acquire an understanding of such notions (Vinden 1996; Wassmann et al. 2013).

A second example for illustrating the role of language for cognition in a more general sense is numerical cognition, for here the invention of number words was indispensable for processes of counting and calculating (see section 12.3.2). In this case, specific linguistic representations are so essential for cognitive processing that they are considered a component of cognition itself. Such instances constitute cases of *extended cognition*, in which information is distributed to both mental and non-mental states and in which cognitive processing involves both types of information (Clark & Chalmers, 1998; Hutchins, 1995; Norman, 1993). For instance, the computation of 26 and 17 described earlier requires information on what each numerical symbol means or how to execute a column addition (stored mentally), but also relies on the presence of the numerals (stored on a piece of paper).

Explanations of why using language as a tool would affect thought follow a slightly different track, where perception and categorization are concerned. Explanations in this domain are based on the well-known fact that information processing unfolds as an interplay between bottom-up processing of sensory signals and top-down predictions about what these signals might be. In this interplay, language plays a key role in that it serves as a main source for generating predictions. If these predictions happen to match the stimulus perceived, they help to discover things that would have otherwise been missed (Lupyan & Clark, 2015; Lupyan & Ward, 2013).

This approach is refined by Cibelli and colleagues (2016) for the controversial case of color perception. It takes its point of departure in the *category adjustment model* proposed by Huttenlocher and colleagues (1991), according to which we tend to use information from two different sources when we have to draw inferences under uncertainty. One source is a fine-grained representation of the perceived stimulus itself, the other source is a categorical system devoted to the organization of perceptions and memories. If, for instance, we try to recall the exact color of a stimulus, the two sources would be the color seen and the linguistic color category in which it falls. An influence of language on memory would here be diagnosed when the recalled color shade shifts in the direction of the prototypical shade of the respective color category. This should be the stronger, the less certain we are with regard to our sensory impression, for instance because the stimulus perception itself was imprecise or because our memory of it is fading away.

It is exactly this correlation that Cibelli and colleagues (2016) observed, both in empirical studies in which they manipulated the time span between the presentation of the stimulus and the recall of the memory, and in computer simulations of data from cross-linguistic studies. Their account also provides an elegant explanation of why effects of linguistic relativity are not always reliably replicated—namely, when experimental designs enable relatively high degrees of certainty in participants' perception or memory. Finally, this model also allows accounting for influences of language on cognition while at the same time supposing a universal foundation for cognition.

In the two instances described in sections 12.3.1 and 12.3.2, language is actively used as an aid to coding, storing, and reasoning: the color terms provided by language as a tool for identifying and memorizing color, and number words as a tool for counting and calculating. In these cases, language directly affects cognitive processes, either because the linguistic representations enter into conflict with non-linguistic representations (*language as meddler*) or because the linguistic representations support, augment, or even make possible the non-linguistic representations (*language as augmenter*). Typically, this kind of *online* influence diminishes when participants are prevented from making use of language, for instance, by way of a verbal interference task (e.g., Frank et al., 2012; Roberson & Davidoff, 2000). The same holds, of course, for instances of *thinking for speaking*, as in the absence of a need for speaking the effect will not arise. Instances of *thinking after language* are different. Here, the language-inherent need to pay attention to some information more than other information has led to a form of habituation that renders grammatically relevant aspects salient (*spotlight effect*) even without immediate involvement of language. An indirect or *offline* influence of language like this is less likely suppressed by verbal interference.

Table 12.3: Framing variants of the Asian Disease task.

	Alternative A (certain)	*Alternative B (uncertain)*
positive framing	200 people will be saved.	1/3 probability that all 600 will be saved, 2/3 probability that none will be saved.
negative framing	400 people will die.	1/3 probability that nobody will die, 2/3 probability that all 600 will die.

12.4.2 Unfamiliar Tool: Thinking in a Foreign Language

Speaking a second language has implications for how one thinks. While habituated patterns of thought typically develop in line with the dominant language, bilinguals seem to switch between patterns of thought, rather than transferring the pattern from their dominant to the non-dominant language (Kousta et al., 2008). In fact, learning a new language with novel grammatical categories appears to entail a cognitive restructuring in the bilingual mind (Athanasopoulos, 2007). But using a second language *while* thinking may also have more general effects on the outcome of the thinking process.

Keysar and colleagues (2012) first described what has since been called the **foreign language effect**: When their participants worked on a set of classic decision tasks in a foreign language, their decisions differed significantly from those observed with the same type of problems in their native language. A robust finding in this research field is, for instance, that the decisions we make depend upon framing (Tversky & Kahneman, 1981): We avoid risks if the task is framed positively (as something we can gain), but are risk-seeking if the—actually identical—result is framed negatively (as a loss), as in the case of the "Asian disease" task (Table 12.3).

The participants in the study by Keysar and colleagues (2012) exhibited the well-known pattern when working on the task in their native language. When working on it in a foreign language, however, the extent to which they opted for the safe versus risky option was independent of the framing.

A series of studies has now documented such a foreign language effect for various tasks and contexts, including gambling, mental book-keeping, risk awareness, or moral judgments (overview in Hayakawa et al., 2016). In moral dilemmas, for instance, people using a foreign language are more inclined to make utilitarian decisions by weighing the result more strongly than the means or intentions that lead to it (Geipel et al., 2016). When confronted with the (hypothetical) dilemma of sacrificing one human life to save five others, participants find it more acceptable to do so if they only have to hit a switch (thereby diverting a trolley so that it runs over a single person instead of five people) than if they were to actively push the single person from a bridge (thereby bringing the trolley to a halt and preventing it from running over the five people). The outcome is the same in both cases (five lives saved at the cost of one), but the reluctance is much greater in the second case—normally. If, by contrast, the dilemma is presented in a foreign language, the greater good outweighs the moral rule of not inflicting damage on another person, and pushing the single person appears much more acceptable (Costa et al., 2014; Geipel et al., 2015).

The exact mechanism underlying such effects of foreign language usage is not yet clear. Keysar and colleagues (2012) interpret their findings as evidence for the assumption that the cognitive processing in the foreign language is accompanied by a greater psychological distance and is not anchored emotionally to the same extent as is the case for processing in the native language (see also Hayakawa et al., 2016; Pavlenko, 2012). This would also explain why swearwords appear less insulting, declarations of love less romantic, and books less exciting in a foreign language (Caldwell-Harris, 2015).

12.4.3 Conclusion

For several decades, the principle of linguistic relativity was disregarded as a topic of interest in the cognitive sciences, largely due to Chomsky's influence. Reintroduced as a topic worthy of scientific investigation in the 1990ies (Gumperz & Levinson, 1996; Lee, 1996; Lucy, 1992a, 1992b, 1997), it is today one of the most thriving and thrilling fields in cognitive science (e.g., Boroditsky, 2001; Dolscheid et al., 2013; Gentner & Goldin-Meadow, 2003; Haun et al., 2011). As mentioned in the introduction, the discussion is still controversial, but evidence in support of at least some versions of linguistic relativity is accumulating. The same is true for theoretical attempts to reconcile the idea that cognition may be susceptible to influences of language on the one hand with one of the key assumptions of cognitive science, the universality of cognitive processes, on the other (e.g., Cibelli et al., 2016; Lupyan & Clark, 2015).

Language provides structure that leads us to pay more attention to some information than to other information; it provides categorical systems that are used to adjust uncertain assessments, and it provides conceptual bricks that help scaffold cognitive skills. Still, we are not at the mercy of these tools—if they cease to serve their purpose or to achieve their goal, we are able and apt to adjust them, for instance by simply inventing new color terms or increasing the range of number words needed for counting (Beller & Bender, 2008). It is exactly for this reason that humans in the history of their species were able to attain ever greater goals with increasingly well suited tools (Miller & Paredes, 1996). This also holds for language as our most important tool for thought.

Acknowledgment

This chapter is based in large parts on collaborative work with my former colleague and partner, the late Sieghard Beller, to whom I remain indebted for inspiration, fruitful exchange of ideas, and critical feedback. I also wish to thank Stina Hellesund Heggholmen for proofreading and helpful comments on an earlier draft as well as Julia Karl for her terrific work with the typesetting.

Summary

According to the principle of linguistic relativity, most prominently proposed by Whorf, the language we speak affects the way we think. Three theses are central to this account: that languages differ in how they describe the world; that the way in which a language describes the world affects the experiences had by its speakers; and that speakers of different languages therefore have different experiences. The underlying idea is still controversial in parts of cognitive science, but evidence is accumulating in support of its three most plausible readings, namely that language may affect thought in terms of thinking *before* language (as *thinking for speaking*), *with* language (as *meddler* or as *augmenter*), and *after* language (as *spotlight*). In this chapter, we summarize research on four domains, to illustrate arguments and approaches in the field. In order to raise awareness for critical issues, we begin with grammatical gender, originally claimed as an instance of the spotlight effect, but used here as a counter-example. More convincing instances are spatial references (for the spotlight effect), the influence of the color lexicon on color categorization (language as meddler), and the role of number words for numerical cognition (language as augmenter). In conclusion, we elaborate on the role of language as a tool for thought, including the differences that occur when using a foreign language while thinking.

Review Questions

1. In section 12.1.3 we briefly present several accounts of the relation between language and thought. Which of these qualify as versions of linguistic relativity?
2. Why is grammatical gender a tempting candidate for investigations of linguistic relativity, and why is it still not the most suitable candidate?
3. How are *thinking for speaking* and the *spotlight effect* related?
4. In section 12.3.2, we claimed that a conventionalized sequence of number representations is a crucial tool for counting and calculation. How important is it that this sequence consists of number words rather than, say, notches on a stick?
5. How does the foreign language effect speak to the claim that language affects thought?

Hot Topic: Is Grammatical Gender an Instance of Linguistic Relativity?

Andrea Bender

The relationship between culture, language, and cognition, as well as their (co-)evolution, has fascinated me since the beginning of my academic career when I was working as a cultural anthropologist, and it constitutes the main area of my research in cognitive science and psychology today. My interests include number representations and their cognitive implications, spatial and temporal references, the evolution and cultural constitution of causal cognition, and the possible influence of linguistic categories on thought (known as *linguistic relativity*).

A topic that has been controversially debated for decades is whether grammatical gender qualifies as an instance of linguistic relativity. In languages with a formal gender system, all nouns are assigned to one of several classes that determine the declension of associated words. For instance, the moon has masculine gender in German (*der Mond*), whereas the sun has feminine gender (*die Sonne*). Is, therefore, the sun conceived as more feminine than the moon by German speakers? One indicator for such an influence is the "gender congruency effect". It emerges if the grammatical gender of a noun (masculine for *Mond*) is congruent with the association of its referent with a specific sex (here: as male).

In previous research, participants were often directly asked for such associations. A major issue with explicit measures like this is that information on grammatical gender can be actively used to aid the decision. In our own work with speakers of German, we therefore used an implicit measure. Participants were asked to categorize nouns according to criteria not obviously related to gender associations. Critically, the stimuli themselves constituted either congruent or incongruent cases; faster and/or more accurate responses in the congruent than the incongruent cases would then attest to a gender congruency effect. We examined nouns for which grammatical gender and biological sex were congruent or incongruent (Bender, Beller, & Klauer, 2016a), for which grammatical gender and allegorical association were congruent or incongruent (Bender, Beller, & Klauer, 2016b), or for which grammatical gender was related to sex (masculine/feminine) or not related to sex (neuter) (Bender, Beller, & Klauer, 2018). Across these studies, a gender congruency effect emerged for all those nouns that had strong male or female connotations, almost regardless of their gender, suggesting that the semantic association of the nouns has a much stronger effect than their grammatical gender.

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Glossary

foreign language effect Processing information in a foreign language affects decision making under uncertainty, moral judgments, and emotional responses. 225

linguistic determinism Strongest version of linguistic relativity, according to which people would be able to engage only in those thoughts that their language permits; is of little intuitive plausibility and largely refuted by empirical research. 216

principle of linguistic relativity Proposed by Whorf and others, stating that humans cannot objectively describe the world because they are influenced in their perceptions and categorizations by the linguistic structures implicit in their mother tongue. 214

representational effect Information is processed differently depending on how it is represented. 222

thinking for speaking Coined by Dan Slobin for the fact that, in order to put our thoughts into words, we need to organize our thoughts in such a way that they specify all those aspects that are required by the grammatical structure of the respective language. 217