

Is linguistic determinism an empirically testable hypothesis?

Helen De Cruz

Centre for Logic and Analytic Philosophy
University of Leuven, helen.decruz@hiw.kuleuven.be

This is the latest, uncorrected draft of a paper to appear in *Logique & Analyse*.

1 Linguistic determinism

Intuitively, language seems to be an important and necessary part of our everyday thinking. Studies reporting introspective awareness indicate that people experience as much as 50 % of their thoughts in ‘inner speech’ (Hurlburt, 1990). Language might shape cognitive processes by providing us with a structured medium to conceptualize the world, giving humans a degree of cognitive flexibility not found in other animals. This idea goes back at least to Descartes’ *Méditations* and it appears in the work of several contemporary philosophers of mind (e.g., Carruthers, 2003). If language determines or at the very least influences cognition, we expect speakers of different languages to have divergent conceptualizations of the world—as the linguist Whorf (1956, 213) put it ‘We dissect nature along lines laid out by our native language’.

The claims that language shapes the way we see the world, and that as a result, speakers of different languages conceptualize reality differently will here be referred to as *linguistic determinism*. Linguistic determinism comes both in strong versions (i.e., language determines thought entirely) and in weaker forms (i.e., language influences cognition to an important extent). It has generated a substantial body of research over the past half century, though many cognitive scientists (e.g., Bloom, 2000) remain skeptical and think that language only serves a purely communicative function. According to them, its role in cognition is restricted to the acquisition of information; once the information is acquired, cognitive processes are decidedly nonlinguistic. This view is backed up by studies that indicate high-level cognition in the absence of language: prelinguistic infants and non-human animals can make high-level categorizations, infer the intentions of others based on their actions, and perform rudimentary arithmetical operations (e.g., Fabre-Thorpe, Richard, & Thorpe, 1998). Devitt and Sterelny (1999, 224) concur with this view: ‘[T]he argument for an important linguistic relativity evaporates under scrutiny. The only

respect in which language clearly and obviously does influence thought turns out to be rather banal: language provides us with most of our concepts’.

The received view on linguistic determinism has repeatedly swayed from one extreme to the other, from strong versions of universalism (i.e., language does not influence cognitive processes) to strong versions of linguistic determinism. This indecision may point to problems with linguistic determinism as an empirically testable hypothesis. Some problems can be situated on a conceptual level. It remains unclear, for example, what counts as decisive evidence in favor of linguistic determinism. Whereas Devitt and Sterelny (1999) think that it is rather banal that language provides us with most concepts, other authors accord a privileged position to concepts in human cognition. Indeed, Prinz (2002, 1), in his introduction to *Furnishing the mind* goes as far as to say that ‘Without concepts, there would be no thoughts. Concepts are the basic timber of our mental lives.’ If this view of concepts is correct, then Devitt and Sterelny (1999) would actually be making a very strong claim for linguistic determinism. In response to this problem, namely that linguistic determinism makes very broad claims that are difficult to test empirically, some authors have proposed to focus on domains of conceptual cognition such as number words (e.g., Frank, Everett, Fedorenko, & Gibson, 2008a) and spatial cognition (e.g., Hermer-Vazquez, Moffet, & Munkholm, 2001). In this paper, I will argue that even in these controlled studies, it remains difficult to assess the influence of language on cognition. I will focus on developmental psychology and comparative linguistics, as within these disciplines linguistic determinism is frequently subjected to empirical tests. I will point out that it remains very difficult to tease apart linguistic and non-linguistic factors in both fields of enquiry. Thus linguistic determinism remains hard to test empirically.

2 Developmental psychology

As Quine (1960) already pointed out, it is computationally impossible to consider all logically possible meanings when learning the referent of a new word, since there are many objects and parts of objects in the environment in which a word is uttered (e.g., a speaker using the word ‘rabbit’ could refer to any object in the vicinity, or even to a part of the rabbit rather than to the animal in its entirety). Yet, young children are fast and efficient word learners. Quine conjectured that children narrow down the range of possible candidates by using grammatical cues. In the case of ‘rabbit’, they can notice that it is a count noun (place of the word in syntactic structure, use of an article), so it will probably refer to a countable object in its entirety. This claim is in agreement with linguistic determinism, which assumes that language shapes the way we parse the world. Alternatively, children could rely mainly on non-linguistic cues to learn the meanings of words, such as gestures or pointing, as Bloom (2000) suggested. How can we empirically decide which account is correct? Unfortunately, we cannot take linguistic differences in denoting concepts as *prima facie* evidence for cognitive differences in speakers of those languages, as

this would amount to circular reasoning. For example, unlike English, Japanese does not make a grammatical distinction between count nouns (e.g., cat, guitar) and mass nouns (e.g., gold, water): in English, only mass nouns are counted by adding classifiers, as in ‘five cups of water’, whereas in Japanese all words are counted with classifiers (e.g., ‘five animals of cat’). Yet, Japanese toddlers perform as well as their English-speaking peers in visual discrimination tasks between countable objects and mass-like substances (Imai & Gentner, 1997). The fact that Japanese does not distinguish between mass and count nouns does not mean that speakers of Japanese do not make a conceptual distinction between countable and uncountable objects.

Developmental psychologists study relationships between developmental changes in language acquisition and changes in conceptual knowledge. According to them, a given concept c is linguistically determined just in case its development coincides with relevant changes in language development. An example of this approach is Xu and Carey’s (1996) duck and truck experiment, which probes the development of sortal concepts. In the philosophical literature ever since Locke (1689), the term *sortal* has come to denote a concept that provides criteria for individuation and identity. For example, ‘how many red chairs are there in the room?’ is a meaningful question that yields a definite answer because ‘chair’ is a sortal concept that refers to a specific category of countable objects. In contrast, we cannot ask ‘how many red is there in the room’, as this could refer to red objects, but also to parts of these and/or other objects. Xu and Carey (1996) investigated the role of noun comprehension in the development of sortal concepts. In their experiment, infants were shown a screen from which two dissimilar looking toys (a yellow duck and a red truck) emerge. First, the duck appears from the left of the screen and goes back behind it, then the truck comes into view from the right side of the screen and returns behind it. The screen is subsequently lowered to reveal either one or two items. If infants are able to discriminate between the objects, i.e., if they have two distinct sortal concepts corresponding to DUCK and TRUCK, they should expect to see two objects and be surprised (indicated by a longer looking time) to find only one object. Ten-month-old infants perform poorly in this task: they look equally long when seeing one or two objects. In contrast, most 12-month-olds look significantly longer when only one object is present, indicating that they can see the difference between both toys. Xu (2002) argues that this developmental change lies in language acquisition: at 12 months, but not at 10 months, most infants can recognize and use nouns. As nouns provide us with a convenient way to categorize objects, this linguistic capacity might enable infants to discriminate better between different kinds of objects. An alternative, non-linguistic explanation is that 12-month-olds succeed in the test due to an improved ability for *feature placing*. This is the capacity to distinguish features without predicating them to objects (Strawson, 1963). In this case, the older infants could simply have expected to see yellowness (the duck) and redness (the truck) and be surprised to find only yellowness or redness. However, this alternative explanation seems dubious, because other experimental studies show that infants have access to

kind information before they pay attention to features. Indeed, infants and young children experience difficulties with color categorization, leading 12-month-olds, for example, to notice when a bottle is switched for a cup, but not to notice that a blue cup is switched for a red one (Leslie, Xu, Tremoulet, & Scholl, 1998). This strengthens the interpretation of the evidence as an emerging ability to form sortal concepts with the aid of language. In support of her conclusion, Xu (2002) mentions that the success in 12-month-olds is strongly correlated to vocabulary: if an infant knew what the words ‘duck’ and ‘truck’ meant, she had a higher chance of succeeding in the task. In a replication of the experiment, 10-month-olds were given explicit linguistic cues (such as ‘look, it’s a truck’, or ‘look, that’s a duck’). Infants who had failed the experiment previously succeeded when they got these linguistic cues.

Although these additional experiments provide corroborative evidence, they do not unequivocally prove that language lies at the basis of our ability to form sortal concepts. In a replication of Xu and Carey’s (1996) experiment, with an orange carrot and yellow squash used as stimuli, free-ranging rhesus monkeys did as well as 12-month-olds despite their lack of natural language (Uller, Xu, Carey, & Hauser, 1997). The capacity to make sortal concepts has also been demonstrated in several ape species (Mendes, Rakoczy, & Call, 2008). Some variations on Xu and Carey’s (1996) original study were solved successfully by 10-month-olds: Bonatti, Frot, Zangl, and Mehler (2002), for example, showed that they notice the difference between anthropomorphic and zoomorphic puppets. What do these experiments show? Clearly not that language is necessary and sufficient to create sortal concepts, as nonhuman animals are also able to do so. Nor does the coincidence between the utterance of first words at 12 months and success at the task provide persuasive evidence, as 10-month-olds can succeed in versions of the test that are more ecologically salient, like discriminating between humans and nonhumans in the Bonatti et al. (2002) experiment. Perhaps 10-month-olds succeed in the duck and truck test with the linguistic cues because this arouses their interest and attention for the objects.

Another case for linguistic determinism from the perspective of developmental psychology is the emergence of flexible search strategies. Humans use a variety of cues to find their way, and this capacity is often attributed (e.g., Haun, Call, Janzen, & Levinson, 2006) to language. Cheng (1986) observed that rats rely purely on geometric cues when they have to find back the location of a food-item. He let hungry rats explore a room with partially buried bits of food. After the food was fully buried, they were reintroduced. Although the animals were provided with a wealth of nongeometric information (here termed featural cues), such as distinctive odors and relative brightness of the walls, they apparently relied on one clue only, the shape of the room. The rats betrayed their search methods by looking with high frequency for the food at its true location as well as its geometric equivalent, a mistake termed the rotational error. For example, they would search in the two corners that are located to the left of the short walls, which are geometrically indistinguishable, as shown in Fig. 1. In a series of replications of this experiment, Hermer and Spelke (1994) found that two-year-olds make the same rotational error. After having wit-

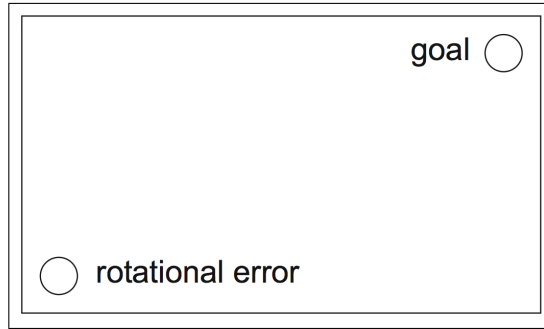


Figure 1: The rotational error: rats and toddlers are as likely to look for a hidden reward in the correct location as in its geometrical equivalent.

nessed how attractive toys were hidden in a room, the toddlers were disoriented and reintroduced: they reliably looked as often in the geometrically appropriate corners as in the true locations. Like the rats, they were utterly unable to orient themselves by use of nongeometric (featural) cues, such as the color of a wall. Between five to seven years of age, children gradually exhibit more flexible reorientation behavior, paying attention to both landmarks and geometric relationships (Hermer-Vazquez et al., 2001). Hermer-Vazquez et al. (2001) ran a multiple regression analysis to examine what changes in cognitive development could best predict success, including rote memory, IQ, visuospatial ability and language comprehension. Only success in the latter, in particular the aptitude to correctly use the words ‘left’ and ‘right’, was significantly correlated with the ability to pay attention to environmental cues. To Hermer-Vazquez et al. (2001, 295) ‘these results strongly suggest that the conjunctive powers of language production allow more flexible performance of these tasks in humans’. However, since these experiments were set in an artificial laboratory context, they might yield an underestimation of the children’s real capacities. In a recent replication (Smith et al., 2008), two-year-olds (who invariably fail the feature condition) were introduced in a park landscape where they witnessed several toys being hidden. After desorientation, the toddlers were reintroduced and their search behavior was tracked using GPS. In this experiment they successfully relied on features of the environment, like trees and shrubs. The language hypothesis is problematic in this respect: why would language enhance flexibility in search behavior in a room, but play no part in a landscape? Several other studies indicate that the switch from a purely geometrical to a more flexible search strategy occurs earlier in development than Hermer-Vazquez et al. (2001) propose, for example at about three years in Haun et al. (2006). Also, the capacity to use both geometry and features of the environment is not restricted to humans: chickens, goldfish and lizards (all non-linguistic species) are as flexible as human adults in their search behavior (see De Cruz, 2009, for a review).

Infancy and early childhood are characterized by a myriad of developments, linguistic as well as non-linguistic. These include changes in brain structure, such

as myelination, growth and subsequent pruning of synaptic connections, next to changes in functional neural connectivity, such as the increasing importance of the frontal cortex in reasoning (Johnson, 2001). Pinpointing language as the causal factor in development remains problematic. It is possible that the burst of synapse formation (building of connections between neurons) in the visual cortex that reaches its peak at 12 months of age improves the ability of infants to visually discriminate between different kinds of objects, as exemplified in the duck and truck test. The fact that this coincides with the acquisition of the first nouns might be due to neural growth processes in language-related brain areas that occur independently of the synapse formation in the visual cortex. The improvements in search strategies between 2 and 7 years of age might similarly be attributed to maturational processes. Navigational capacities continue to improve until well into adulthood (Pine et al., 2002), and these improvements can be correlated to maturational processes in areas in the left temporal and parietal cortex, areas that are not situated in the classical brain-regions associated with language.

3 Comparative linguistics

Since natural languages differ in their structure, one might test linguistic determinism by comparing conceptual thought in speakers of different languages. The Whorfian hypothesis, to date the strongest version of this claim, argues that speakers of different natural languages conceptualize the world differently. Whorf (1956) famously claimed that speakers of Hopi (a Native American language) perceive time and space in a fundamentally different way from speakers of Indo-European languages. However, upon closer scrutiny, Whorf's reasoning turned out to be circular, as his claims were solely based on the grammatical structure of Hopi. Current investigations focus on particular domains of perceived reality—such as color terms, spatial relationships and number words—and investigate whether differences in the way unrelated languages encode these lead to dissimilarities in the way speakers of these languages conceptualize them. Domain-centered approaches are not immune to circularity either, as can be illustrated by the apocryphal case of Inuit words for 'snow'. The myth derives from Boas' (1911) *Handbook of American Indians*, where he observed in passing that Inuit have four unrelated words for snow. This caught the interest of authors like Sapir and Whorf who expanded (apparently without empirical basis) the snow lexicon to 12 words. Gradually, the list expanded to 50 words or more in the academic literature (Martin, 1986). Although the account proved to be fictional, Inuit words for 'snow' illustrate a fundamental problem of domain-centered approaches: does the perception of different kinds of snow (very plausible considering the environment) lead to different words for snow or vice versa?

A domain that received much attention is that of number words, in which natural languages exhibit considerable variation, from completely regular, positional (usually base-10) numerical systems that are potentially infinite (e.g., Chinese, Welsh) to languages with extremely few number words (5 or fewer), such as several Amazo-

nian and Australian Aboriginal languages. We may wonder whether the complexity of number words affects numerical cognition. The ability to reason about number *approximately* is not restricted to humans. It has been attested in many vertebrate species (e.g., dolphins, salamanders) and even in insects (e.g., honeybees). These numerical capacities fall short of the ability to represent natural numbers precisely—animals have a fuzzy, approximate representation of numerosity that grows more and more imprecise as quantities increase. For example, animals can discriminate between 2 and 3 but not between 4 and 6 (Brannon & Terrace, 2002). How do children learn that natural numbers correspond to exact magnitudes? Several developmental psychologists (e.g., Carey, 2004) think that language plays a crucial role: through linguistic experience, young children learn that number words like ‘one’, ‘three’ or ‘sixty-four’ denote exact magnitudes. Indirect support for the hypothesis that language—rather than other developmental traits—guides the acquisition of natural number concepts comes from studies that show that infants have numerical cognition that is very similar to that of animals. Six-month-olds, for example, can see the difference between 6 and 12 dots, but not between 8 and 12, possibly because the ratio difference in the latter is too small (Xu & Spelke, 2000). In several experiments where numerate adults were prevented from counting, their numerical cognition was similar to that of animals and infants. For example, adults who are required to tap 10, 20 or 30 times in quick succession while saying ‘the’ (to eliminate subvocal counting), show a characteristic pattern of increasing error rate with increasing quantity, similar to animals (Cordes, Gelman, & Gallistel, 2001).

Recent studies that examine linguistic determinism focused on two indigenous South American hunter-gatherer societies from the Amazon forest with extremely few number words. The Pirahã (Gordon, 2004) have only three words that consistently denote cardinality, ‘hói’ (about one), ‘hoí’ (a couple) and ‘baásigo’ (lots). These terms are not used as count words, but rather as approximations of perceived magnitude (not just cardinality). For example, the word ‘hói’ is not only used to denote single objects, but also as a synonym for small (as in ‘a small child’). One can ask ‘I want only one/a small (hói) fish’ to denote one fish, but one cannot use this phrase to ask for one very large fish, in which case one would use ‘baásigo’ (Everett, 2005). Gordon (2004) gave Pirahã volunteers a battery of experiments to test numeracy, such as memory for specific numbers of items and the capacity to place objects into a one-to-one correspondence. Their ability to reason about exact magnitudes was severely compromised, especially in numerosities larger than 4. For example, the participants saw how a quantity of nuts were placed in a can, and then being withdrawn one by one. After each withdrawal, the subjects responded as to whether the can still contained nuts or was empty. Once the can contained more than 4 nuts, their responses dropped to chance level. Another experiment involved placing a candy in a box with a specific number of fish painted on it. The box was then hidden, and subsequently two boxes were revealed: the original with the candy, and a new one with a different number of fish painted on the lid. The participants had to point out the box with the candy. Interestingly, the Pirahã showed a striking

similarity to ten-month-olds in a study by Feigenson, Carey, and Hauser (2002): they could discriminate between very small sets such as two and three, but their performance beyond this was not significantly above chance level (Gordon, 2004, 498–499). To Gordon (2004, 498), the study ‘represents a rare and perhaps unique case for strong linguistic determinism’, indicating a causal connection between the sparse number vocabulary and the limited numerical cognition. However, subsequent studies suggest a more nuanced picture. Frank et al. (2008a) showed that although Pirahã do not have a word for ‘one’, they are capable of matching large sets through one-to-one correspondence, which shows an implicit understanding of the concept ONE. The authors nevertheless think that language enhances numerical performance—it is ‘a cognitive technology for keeping track of the cardinality of large sets across time, space, and changes in modality’ (Frank et al., 2008a, 819). This corresponds to a weaker version of linguistic determinism already proposed by Locke (1689, book II, ch. XVI), who described a native American culture that lacked number words above five: ‘Some Americans I have spoken with (who otherwise of quick and rational parts enough) could not, as we do, by any means count to 1000; nor had any distinct idea of that number’. However, they could go beyond five ‘by showing their fingers, and the fingers of others who were present’.

The Mundurukú, a second intensively studied Amazonian culture, have consistent number words up to five that denote approximate rather than exact quantities. In one experiment (Pica, Lemer, Izard, & Dehaene, 2004), Mundurukú participants were asked how many objects they saw. Although their number words showed some consistency across subjects, they were applied in an approximate, rather than a precise fashion. For example, the term ‘pūg pōgbi’ (literally ‘a hand’) was not just used for five items, but also for three, four and six. When the Mundurukú were asked to perform approximate calculations or compare large numerosities in an approximate fashion (e.g., 20 versus 80 dots), their performance was comparable to French, numerate adults, so their knowledge of approximate numerosity is not affected by their limited number vocabulary. The only exact number test the Mundurukú were given was a subtraction task, in which they had to predict the remaining number of seeds in a can after some had been removed. The Mundurukú were unable to predict outcomes of subtractions like $6 - 4 = 2$, even though the remainder was small enough to be named in their number system. However, exact subtraction is not a very good measure of exact numerical cognition, as it is a relatively difficult arithmetical operation, which is only mastered during the first school years, long after schooled children have acquired exact counting.

It is difficult to draw straightforward conclusions from these anthropological studies. It remains unclear whether the absence of language, rather than other factors compromises performance. If language is the only causal factor to account for limited numerical performance, then we might expect that Western adults who are prevented from counting perform in an equally limited way. However, Western college students prevented from subvocal counting still do better than the Pirahã in most numerical tests (Frank, Fedorenko, & Gibson, 2008b). Perhaps cultural factors

unrelated to language explain why both Amazonian cultures have limited numerical cognition. Take the role of finger counting, pervasive in numerate cultures and observed in young Western children who learn to count. Unlike Westerners, Pirahã cannot rely on finger counting, since they do not individuate between their fingers (e.g., they have no names for individual fingers). They have literally no clear notion of how many fingers they have. Only when asked by an insistent linguist do they refer to their fingers collectively as ‘hand sticks’ (Everett, 2005). Possibly, the absence of finger counting can partly explain the absence of natural number concepts in this culture. Although the Mundurukú practice counting on fingers and toes, field observations (Pica, personal communication) indicate that this is effortful and slow, and seldom practiced. Pierre Pica, who made the observations, hypothesizes that this is because Mundurukú extensively use their fingers (gesturing) to complement linguistic expressions—if they have to count objects they cannot gesture at the same time, and thus counting fails.

Number words, like all linguistic expressions, are arbitrary, so their semantic content can shift. Take speakers of Martu Wangka, an Aboriginal Australian language, who started using their approximate number words in an exact sense once monetary economy was introduced. In the 1980s, older speakers still used the terms ‘marakuju’ (about a hand) and ‘marakujarra’ (about two hands) in an approximate fashion. Younger speakers, however, who were more involved in monetary activities such as trade and gambling, started using these terms in a precise way, with ‘marakuju’ denoting precisely five and ‘marakujarra’ exactly ten (Harris, 1982). In this case, the linguistic expression remained identical, but the semantic meaning changed. An increased cultural importance of number, due to an increased participation in the monetary economy can alone explain the change in numerical cognition. In the following chain of causality

lack of commerce, money and other cultural incentives for natural numbers → lack of cultural necessity for number words → limited numerical vocabulary → limited numerical cognition

we can see that it also works well without invoking the third step, limited numerical vocabulary.

Further doubt on the Whorfian interpretation of the Amazonian data is cast by a series of experiments (Butterworth & Reeve, 2008) that probe numerical cognition in Australian Aboriginal children from cultures with few counting words. These children performed tests similar to those in Gordon (2004), such as matching the number of items on their mats with the number of items on the experimenter’s mat, and remembering a specific number of objects. The subjects who only spoke Warlpiri or Anindilyakwa did as well as English-speaking children from these communities. Butterworth and Reeve (2008) argue that the Pirahã failed the tests simply because they did not understand them. One observation in Gordon (2004) supports this interpretation: the Pirahã matched a number of lines to the number of lines drawn by the experimenter. Their performance was accurate until three or four, then

showed a sudden dip at five and six, but afterwards reached fair accuracy. Perhaps the subjects became confused when the number of lines became bigger than the subitizing range (i.e., the number of items one can count at a glance, in human adults at about 3 or 4), but devised a strategy (presumably one-to-one correspondence) for the larger numbers (Decock, 2008).

Studies of cultures with few number words are inconclusive with respect to linguistic determinism. Undoubtedly, having a vocabulary that permits one to conceptualize very large numbers is *helpful* for numerical cognition, a very weak interpretation of the Whorfian hypothesis that sounds uncontroversial. However, there are ways to remember and denote exact numerical quantity that do not rely on language: the use of counting rods or beads are widespread non-linguistic ways to keep track of cardinality. The question whether or not language plays a role in numerical cognition may therefore not have a universal yes or no answer, but may depend on cultural practices in dealing with number. Indeed, a study that measured brain activation during numerical tasks (Tang et al., 2006) showed that native English speakers, who rely heavily on calculations stored in verbal memory, show an increased activation in the perisylvian areas associated with language; by contrast native Chinese speakers, who have learned to calculate with the aid of an abacus (a counting frame with beads), have enhanced activity in the premotor cortex, which is involved in the planning of fine hand movements (in this case, the manipulation of the beads).

4 Why does linguistic determinism remain equivocal?

From the cases presented here, we cannot decide whether language is necessary for the development of sortal concepts, spatial searching strategies or natural number concepts. This might point to a fundamental problem with linguistic determinism as a scientifically testable hypothesis. Empirical tests for linguistic determinism require clear distinctions between conceptual (nonlinguistic) knowledge and non-conceptual linguistic skills. But it is not always clear how these distinctions can be drawn. Linguistic expressions have a semantic content, and it is difficult to assess to what extent this can exist independently from language. Some authors (e.g., Marcus, 2006, 454) argue that language draws upon phylogenetically older systems of conceptual representation: ‘language does indeed borrow [...] cognitive machinery inherited from our non-speaking primate ancestors’. This view is supported by the observation that nonhuman animals can make high-level conceptual distinctions: rhesus monkeys even outperform humans in accuracy and speed when categorizing pictures into food and nonfood items (Fabre-Thorpe et al., 1998). Although cases of people with intact cognition and impaired language or vice versa do exist, there is usually a connection between them: impairments in linguistic skills are often coupled with impairments in one or more conceptual domains. Take patients with brain

damage in the occipital lobe, who lose their ability to name animals and plants *and* to remember semantic facts about them. They answer, for instance, at chance level to questions like ‘do whales have feet?’ (Caramazza & Mahon, 2003). Although such cases can be taken as strong evidence for linguistic determinism (language influencing cognition), they might just as well be evidence of the reverse claim that prelinguistic conceptual capacities influence language. If language critically depends on nonlinguistic conceptual capacities, claims that language influences cognition become tantamount to a tautology.

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