Advanced Review

Linguistic relativity

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The central question in research on linguistic relativity, or the Whorfian hypothesis, is whether people who speak different languages think differently. The recent resurgence of research on this question can be attributed, in part, to new insights about the ways in which language might impact thought. We identify seven categories of hypotheses about the possible effects of language on thought across a wide range of domains, including motion, color, spatial relations, number, and false belief understanding. While we do not find support for the idea that language determines the basic categories of thought or that it overwrites preexisting conceptual distinctions, we do find support for the proposal that language can make some distinctions difficult to avoid, as well as for the proposal that language can augment certain types of thinking. Further, we highlight recent evidence suggesting that language may induce a relatively schematic mode of thinking. Although the literature on linguistic relativity remains contentious, there is growing support for the view that language has a profound effect on thought.
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INTRODUCTION

Folk psychology tells us that human cognition depends on language, and further, that this dependency creates differences in thought across language communities. Although often mistaken, folk psychology appears to be at least partially correct in this case. In academic circles, such intuitions are referred to as linguistic relativity, the Whorfian hypothesis, or the Sapir–Whorf hypothesis. Linguistic relativity comprises three main ideas.[1–3] First, it assumes that languages can differ significantly in the meanings of their words and syntactic constructions—an assumption that is strongly supported by linguistic, anthropological, and psychological studies of word and phrasal meaning across languages.[3–5] Second, the proposal holds that the semantics of a language can affect the way in which its speakers perceive and conceptualize the world, and in the extreme, completely shape thought, a position known as *linguistic determinism*. Finally, given that language can affect thinking, linguistic relativity holds that speakers of different languages think differently.

In the early 1990s, linguistic relativity was all but given up for dead, especially after it was realized that the proposal, as it was often understood, gave rise to several logical paradoxes.[6] However, a recent resurgence of research in this area has uncovered subtle and intriguing interactions between language and thought, leading to a number of more nuanced versions of the proposal.

LINGUISTIC RELATIVITY AND ITS MANIFESTATIONS

It has often been claimed that linguistic relativity is a weaker form of linguistic determinism. But the strong–weak distinction oversimplifies the more complicated picture that is emerging in recent research on the relationship between language and thought. Linguistic relativity can now be said to comprise a 'family' of related proposals that do not necessarily fall along a single strong-to-weak continuum. In this article, we examine the arguments and evidence for several branches of the 'family tree' shown in Figure 1. Our overall conclusion will be that the proposals we call *language as language-of-thought* and *linguistic determinism* can be rejected on both theoretical and empirical grounds, but that recent findings support a range of alternative ways in which language might have significant effects on thought, leading to possible differences in thought across language communities.

Language as Language-of-Thought

Language surely affects thought if the units of thought are words from natural language. This

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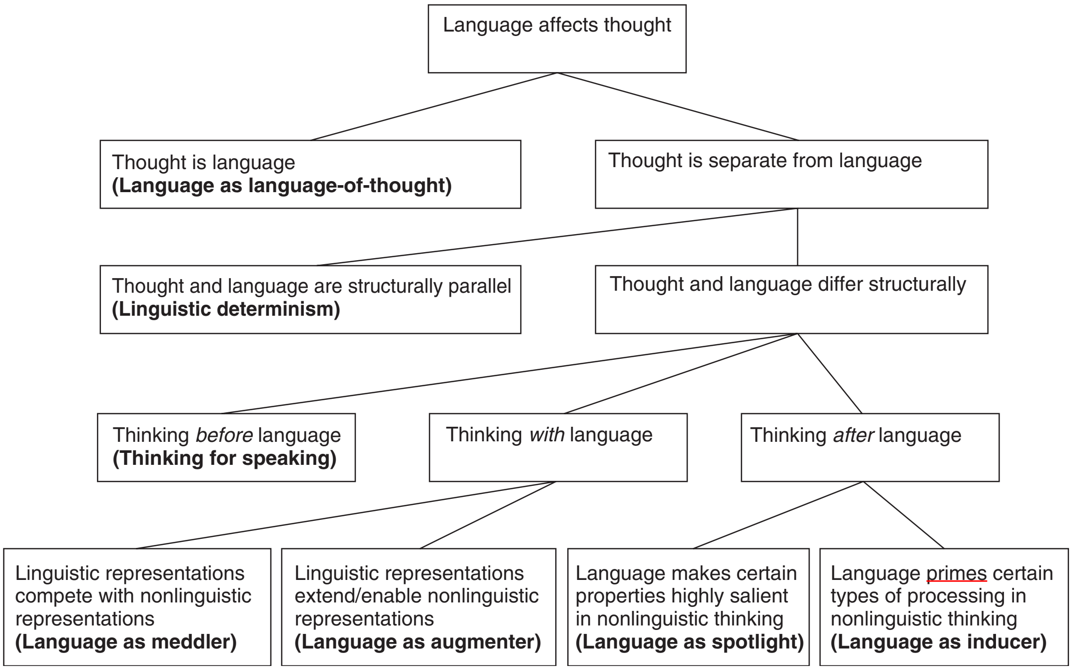

FIGURE 1 | Classes and subclasses of hypotheses on how language might affect thought.

version of how language influences thinking has been advanced by a number of theorists, including Plato, '[T]he soul when thinking appears to me to be just talking...'[7] (p. 252), and Kant, 'Thinking is speaking to ourselves'[8] (p. 278). Max Müller perhaps stated the position most directly when he asserted, 'Language is identical with thought'[9] (p. ii). In psychology, the conflation of language with thought is exemplified by the views of behaviorist John Watson, who proposed that thought should be equated with the production of (subvocal) speech.[10]

Clearly, this version of the language–thought interface cannot be right.[6,11,12] As argued by Pinker,[6] people can have thoughts that are difficult to express, but this would never be the case if thoughts were represented entirely in natural language. People can also understand linguistic expressions that are ambiguous, such as *Kids make nutritious snacks,* but their very ability to recognize this ambiguity implies a finer level of representation than that encoded in the meanings of words.[6] If people thought entirely in words, words expressing new concepts could never be coined because there would be no way of imagining their meanings. Further, research indicates that infants and nonhuman primates are capable of relatively sophisticated forms of thinking, even in the absence of language.[13–20] These arguments point to a medium of thought for categorization, reasoning, and memory—conceptual representations, or *mentalese*—that is independent of the kinds of representations used to specify the meanings of words and constructions in language (see Refs 6,11,12,21).

Linguistic Determinism

The concept of linguistic relativity was championed in the 1950s by the amateur linguist Benjamin Lee Whorf.[22] Whorf argued for what has come to be known as linguistic determinism, the view that language determines the basic categories of thought and that, as a consequence, speakers of different languages think differently.[a] In linguistic determinism, the shaping role of language is held to be so strong that it can even overwrite pre-existing perceptual and conceptual capabilities,[23] in a manner analogous to the way infants lose the ability to notice phonetic distinctions absent in their native language.[24] Linguistic determinism differs from *language as language-of-thought* in that it separates language from the conceptual system.[25,26] While this distinction represents an important advance over the previous proposal, linguistic determinism can still be rejected because it makes untenable predictions about the relationship between language, thought, and the world.

Linguistic determinism holds that differences in language cause differences in thought. This view implies a relatively tight connection between language and thought and a loose connection between thought and the world (see the left side of Figure 2). This

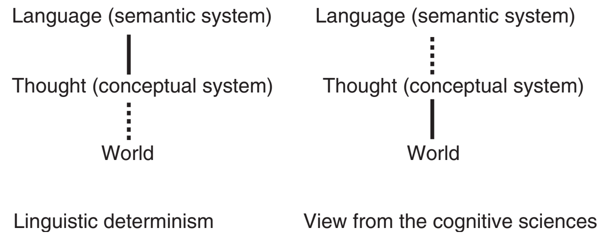

FIGURE 2 | In linguistic determinism, the relationship between language and thought is tight, while the relationship between thought and the world is loose. Research in the cognitive sciences suggests the opposite pattern: a loose relationship between language and thought, and a relatively tight relationship between thought and the world.

pattern of relationships is expected because thought is held to be determined by language, not the world.

Research from the cognitive sciences suggests a different pattern of relationships, namely that the connection between thought and the world is tighter than the connection between thought and language[12,27–30] (see the right side of Figure 2), especially in the case of nominal concepts.[31,32] Evidence for a loose connection between language and thought comes from cross-linguistic studies showing that differences in word meanings across languages are greater than differences in the underlying concepts. For example, as shown by Malt et al.,[33] speakers of English, Spanish, and Chinese diverged significantly when labeling pictures of common storage containers but performed comparably when making similarity judgments about the same containers. A similar pattern of results was observed in an experiment comparing French-speaking and Dutch-speaking Belgians.[34] The two groups of Belgians resembled each other in their similarity judgments for storage containers but diverged in their naming patterns, despite sharing essentially the same culture. This kind of disconnect between language and thought has been observed in other domains as well. For example, Munnich et al.[35] found that Korean and English speakers' memory for spatial locations was far more similar than their naming patterns, and Gennari et al.[36] observed that English and Spanish speakers' memory for motion events was more similar in comparison to how they named such events (see also Ref 37).

The lack of alignment between language and thought raises severe problems for linguistic determinism, but these problems do not imply that language cannot have an effect on thought. Indeed, it is because language and the conceptual system differ that we might expect a tension between them, driving each system to exert an influence on the other.

THINKING *BEFORE* LANGUAGE

One type of thinking that might be influenced by language is the thinking that occurs immediately prior to using language—that is, the thought processes associated with producing speech. Such an influence might be expected to produce differences in thought across languages because languages differ with respect to the aspects of experience to which their users must attend. In English, for example, but not in Indonesian or Mandarin, verbs must specify tense, so presumably English speakers must attend to when an event occurred. In Turkish, descriptions of past events must indicate whether they were witnessed or nonwitnessed.[38]

Thinking for Speaking

In using language, then, speakers must engage in a special kind of mental activity—attending to certain aspects of experience—that Slobin[38,39] has called *thinking for speaking*. Thinking for speaking has been observed in people's attentional patterns and memory for motion events.[36,40] The effect stems from the well-known phenomenon that certain languages (e.g., English, German, Russian, Chinese) tend to encode manner in the main verb (e.g., *jog*, *roll*, *march*) and path in a variety of other linguistic structures, while other languages (e.g., Greek, Spanish, French, Japanese) do just the opposite. In a study by Papafragou et al.,[40] eye-movement patterns of native speakers of English and Greek were monitored as they watched motion events. When participants were instructed to watch the events in preparation for describing them verbally, Greek speakers were much more likely than English speakers to focus on path over manner. When participants simply watched the motion events freely, however, the eye-movement patterns were largely the same for the two language groups (except at the very end of the events; see the section '*Motion*' under *Language as Meddler* below). In similar research by Gennari et al.,[36] similarity ratings for motion events by English and Spanish speakers conformed to language-specific patterns when they were instructed to verbally describe the events, but not when there was no verbal encoding.

THINKING *WITH* LANGUAGE

In thinking for speaking, the effect of language on thought occurs immediately before the production of language. However, much recent research points to another kind of effect of language on thought, namely, one in which processes associated with language are activated along with nonlinguistic processes. Thus, in this kind of effect, thinking occurs *with* language. One of the hallmarks of this kind of language effect is that it can be eliminated by having people engage in a verbal interference task—that is, a secondary task that recruits verbal processing. There appear to be two general classes of this kind of language effect.

Language as Meddler

In one class, the effects of language occur from the spontaneous recruitment of linguistic codes in tandem with nonlinguistic codes. Linguistic codes, in effect, meddle with nonlinguistic codes in the process of making a decision. When the linguistic and nonlinguistic codes are consistent with each other, speed and accuracy are facilitated, but when they conflict, speed and accuracy may be compromised.[41]

Motion

An effect of linguistic meddling is suggested by Papafragou et al.'s[40] study, described in the previous section. The eye-movement patterns of the English and Greek speakers differed not only in the linguistic condition, but also in the non-linguistic condition, at the very end of the animations. Participants shifted their attention to aspects of the scenes not typically encoded in verbs in their language, perhaps, as suggested by Papafragou et al., to compensate for relatively greater early attention to typically encoded aspects. Thus, at the end of the animations, English speakers attended preferentially to path (from an earlier relative preference for manner) and Greek speakers attended equally to both manner and path (from an earlier preference for path). Papafragou et al. speculated that these cross-linguistic differences reflected different approaches to the linguistic coding of the scene in memory. Importantly, these attentional differences do not constitute a type of thinking for speaking because the very point of the nonlinguistic condition was to examine what people would do when they were not asked to put the scenes into words. Instead, these differences exemplify an effect of language on thought that occurred from the unprompted, spontaneous generation of linguistic codes, which consequently meddled with how participants attended to the scenes. Greek speakers also had poorer memory for the events than English speakers, a difference the authors attribute to processing costs associated with trying to attend to both manner and path. But once again, the effect on memory was not due to any promptings from the experimenter or to task demands, but rather, apparently, from the spontaneous generation of linguistic codes.

Color

The color domain has been of central interest in research on the relationship between language and thought. In the 1970s, such research cast a pall over the possibility that language might influence thought with the findings that inventories of color terms shared significant commonalities across languages[42] and that any linguistic differences did not correspond to differences in categorization behavior.[43]

Several recent studies indicate, however, that language may have an influence on color cognition. Work with the Berinmo, a small tribe in New Guinea whose language has 5 basic color terms (compared to 11 in English), is a case in point. Controlling for a confound in previous research,[44] Roberson and colleagues found that the Berinmo's recognition memory was better for the focal colors of their own language than for those of English.[44–47] In a similar line of research, Winawer et al.[41] found that an obligatory color distinction in Russian between *siniy* (dark blue) and *goluboy* (light blue) led to differences in color discrimination. Russian speakers, but not English speakers, performed faster on a matching task when the colors belonged to different linguistic categories than when they belonged to the same category. Moreover, these cross-linguistic differences disappeared under conditions of verbal interference. A similar effect was found for English by Gilbert et al.;[48] participants were faster to locate a target when its linguistic category differed from that of the surrounding distractors (e.g., a green among blues), and slower when the target and distractors shared the same linguistic category (e.g., a green among other shades of green), but only when the target was presented in the right visual field. This lateralization effect was presumably due to the fact that presentation in the right visual field entails that the stimulus will initially be processed in the left hemisphere, the side of the brain where language processing typically occurs. Further, as in the study by Winawer et al., the effect was eliminated by a verbal interference task.

The findings described above suggest that language can meddle with cognition via the interaction of perceptual and linguistic codes.[41,47,49] The results do not imply a change to the underlying perceptual machinery or memory representations because the effects of language on cognition were disrupted by verbal interference tasks (but see Ref 50). It should be noted that, the effects in these studies cannot be attributed to task demands. Some linguistic relativity experiments have used tasks with questions for which there were no objectively correct answers; under these conditions, participants might use linguistic codes to choose between two alternatives because they have no other basis for making a decision.[11,28,36] However, the color tasks described above all had objectively correct answers. Despite the fact that language was not needed to solve these tasks, linguistic codes were generated nonetheless.

Language as Augmenter

In the case of language as meddler, a decision can be made on the basis of either linguistic or nonlinguistic representations. In certain cases, however, linguistic representations may combine with nonlinguistic representations to enable people to perform tasks that could not be completed with either type of representation alone. In such cases, as argued by Gentner[51,52] and Frank et al.,[53] language may augment thought by offering new conceptual tools. This idea can be illustrated by problems like the one in Figure 3. If the first gear in Figure 3 turns clockwise, in which direction will the last gear turn? This problem could be solved by mental simulation; that is, by imagining the first gear turning to the right, then the second gear turning to the left, and so on.[54] Alternatively, people might notice that each successive gear turns in the opposite direction from the previous one and generate the parity rule that 'odd and even gears turn in different directions'.[55] This rule, which may depend on linguistic coding, can then be applied more quickly than the laborious process of mentally rotating each gear. In problems like this one, the constant meddling of language may pay off because it gives rise to a new way of representing the problem, allowing for quicker and more accurate answers.

Number

A similar kind of re-representation seems to occur in the domain of number. There appear to be three main systems for representing numerical quantities. One of these systems involves a fast 'subitizing' procedure that allows everyone from infants to adults to recognize small numbers of items (≤ 4) automatically without having to count.[56] A second system allows animals, infants, and adults to discriminate larger quantities, but only approximately, such as the rough amount of sand in a bucket or fish in a net.[57,58] These two systems are thought to be innate. The third system allows for the specification of exact quantities, such as the quantity 31. An exact number system must be explicitly learned, and several sources of evidence suggest that this third system depends on language. In a study by Dehaene et al.,[59] Russian–English bilinguals were trained on exact and approximate number addition in either Russian or English. After training, performance on the exact addition problems was faster in the trained language than in the untrained language, suggesting that the results of training were stored in a language-specific format. Performance on the estimation problems, in contrast, was unaffected by the language of training, suggesting the use of mental codes that were independent of language. A functional magnetic resonance imaging (fMRI) study supported these results by showing that the exact number task recruited neural networks typically associated with language processing, whereas the estimation task recruited areas in both parietal lobes not typically associated with language processing.

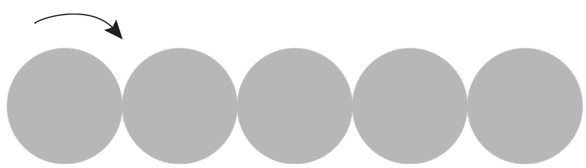

FIGURE 3 | Series of gears in which the first turns clockwise. In which direction will the last gear turn?

While the results from Dehaene et al.[59] suggest an effect of language on cognition, they do not demonstrate linguistic relativity. Exact number calculation was no better or worse in Russian or English. To make the case for an effect of linguistic relativity per se, it needs to be shown that the effects differ across languages. Such evidence has recently been found in work on languages with so-called *one-two-many* number systems. Number words in Pirahã, a language spoken by a small tribe in Brazilian Amazonia, map only roughly onto the quantities 'one' and 'two'. As observed by Frank et al.,[53] the Pirahã's word for one, *hói* (falling tone), may be used to described as many as 6 items, the word for two, *hoí* (rising tone), as many as 4–10 items, and the word for many, *baagi*, between 7 and 10 items. Effectively, then, Pirahã lacks words for exact quantities.

Gordon[25,60] investigated the potential consequences of this absence of number words on tasks requiring exact quantities. In one such task, Pirahã speakers were asked to line up batteries on a table across from a set of nuts arranged in a line. In a more difficult version of this task, they were asked to match the items along an axis orthogonal to the one used by the experimenter. The main result was that the Pirahã were unable to perform the task accurately, but their responses were not random: as the number of items increased, the Pirahã tended to put out more items, though rarely the exact number. The results suggest that the Pirahã tried to solve the task using an approximate number system. Gordon's findings align well with Dehaene et al.'s[59] study in indicating that exact magnitude calculation requires language. The most critical findings in Gordon's study were replicated in a set of studies by Frank et al.,[53] who conclude, like Gordon,[25,60] that the Pirahã's conceptual gaps were due to gaps in their language.

An important question raised by Gordon's and Frank et al.'s findings concerns the exact way in which language might impact number cognition. Pinker and Jackendoff[61] and Bloom[62] have suggested that children may learn the number system by co-opting the mental machinery of language used for iterative and recursive processing. Concepts like five and six, and odd and even, depend on a system of generative rules to give them meaning. The fact that exact number is learned much later than language, and is effectively unique to humans, supports the view that language might be used to reason about numbers. Among other capacities, language may support the formation of rules, and perhaps even more importantly, the embedding of rules within other rules.

False Belief Understanding

This type of language effect is potentially significant because rule embedding appears to be essential in a number of domains, including, for example, the representation of false beliefs.[63–65] An especially compelling case for the role of language in false belief understanding has recently been made with Nicaraguan adults who learned Nicaraguan Sign Language (NSL).[64] NSL first appeared in 1970 with the creation of special-education schools. The first cohort learned an early form of the language, which was elaborated by the second cohort. Although the language skills of these two groups differed, the sociocultural history of the two groups was essentially the same: both attended the same schools for the same number of years, had the same teachers, and had comparable social networks. Pyers and Senghas[64] found that the second cohort knew significantly more mental state signs (e.g., *think*, *know*) than the first cohort, indicating a more developed lexicon for this domain. False belief understanding was measured using a low-verbal task in which participants were shown a sequence of picture cards and asked to choose the last card to complete a story. The surprising finding was that false belief understanding was significantly stronger in the younger second cohort signers than in the older first cohort signers. As emphasized by Pyers and Senghas, the participants in the two groups were comparable, except in their language ability, suggesting that the difference in false belief understanding was due to language. Following de Villiers and de Villiers,[63] Pyers and Senghas suggest that the capacity to represent false beliefs may depend, at least in part, on people's ability to represent embedded propositional structures, as when people say *I know that she thinks X, but what is actually true is Y*. The development of false belief understanding may be rooted in more fundamental executive functioning abilities (e.g., dimension switching),[66] which undergo marked developmental change during the preschool years.[67–69] Interestingly, children's performance on dimension-switching tasks (e.g., sorting first by shape, then by color) improves substantially when language is used to highlight the conflicting dimensions.[68,69] As with false belief understanding, language may improve performance by enabling children to represent embedded rule structures—in this case, the higher-order rules that govern when each individual sorting rule should be applied.[70]

Spatial Analogies

If language aids in the formation of embedded knowledge structures, it is likely to have a significant role in many other cognitive activities. As argued by Gentner,[51,52] hierarchically structured relational knowledge allows people to discover abstract commonalities that can lead to more explicit and uniform units of thought. In a spatial analogy study, Loewenstein and Gentner[71] had 3.5-year-old children watch as a star was placed behind a card on the top, middle, or bottom shelf of a small shelving unit. They were then asked to find the star in an almost identical shelving unit nearby. Children's performance on the task improved if, during the hiding event, the experimenter indicated the star's location using relational words such as *on, under*, *top*, or *bottom*. The results suggest that relational language helped the children align the two sets of spatial relations.

Category Learning

Beyond supporting the representation of embedded rule structures and relational knowledge, language may extend nonlinguistic cognition in several other ways. As suggested by Waxman and Markow,[72] language may serve as an invitation to form new categories (see also Ref 73). It may also facilitate category learning. This type of influence was demonstrated in a set of studies by Lupyan et al.,[74] in which participants learned to distinguish between approachable and nonapproachable alien creatures. These categories could be learned on the basis of visual information alone, so learning labels for the categories was not necessary for completing the task. Nevertheless, category learning was much faster when it was accompanied by auditory or written labels than not. In a subsequent work, Lupyan[75] has shown that categories learned with labels are more resistant to interference from novel stimuli and more flexible in their ability to incorporate new members.

THINKING *AFTER* LANGUAGE

The effects of linguistic meddling and augmenting occur when thought and language work in tandem—that is, when thinking recruits linguistic representations online. Yet another major way in which language might affect thought is as an influence *after* the use of language. The long-term use of a language may direct habitual attention to specific properties of the world, even in nonlinguistic contexts. At a more general level, language use may also induce a given mode of processing, which may persist even as people engage in other nonlinguistic tasks. Unlike the effects described in the previous section, these effects of 'thinking after language' should be less attenuated by verbal interference tasks, since they occur after language is no longer in use, rather than involving the recruitment of linguistic codes during processing.

Language as Spotlight

After exposure to words and constructions that highlight specific properties, attention may linger on those properties. In effect, language may act as a spotlight, making certain aspects of the world more salient than others.

Grammatical Gender

Work by Boroditsky and colleagues demonstrates how such effects might occur as a result of exposure to grammatical gender.[76] Grammatical gender is a feature of nouns in many languages (English being a notable exception), whereby all nouns are assigned a gender. In both German and Italian, for example, the words for 'hammer', 'spoon', and 'screwdriver' are masculine, while the words for 'fork', 'bottle', and 'scissors' are feminine.[77] Languages often conflict in their assignment of grammatical gender. For example, the word for 'key' is masculine in German and feminine in Spanish, while the word for 'bridge' is feminine in German and masculine in Spanish.[76] This cross-linguistic variability suggests that grammatical gender is not determined by the correlational structure of the world, but rather, in large part, by factors that are specific to particular languages. Given that the categories of masculine and feminine are language-specific, it can then be asked whether these language-imposed categories have consequences for the kinds of properties people attend to when thinking about objects. Boroditsky and her colleagues found support for this possibility. In particular, they found that Spanish and German speakers' ability to learn associations between proper and common nouns (e.g., *Tom* and *apple*) was disrupted when the grammatical gender of the common noun differed from the biological gender of the proper noun's referent. They also demonstrated that attention to different aspects of an object could be manipulated experimentally by having English speakers learn a novel language with grammatical gender and that the effects of grammatical gender extended to people's judgments about the similarity of unlabeled pictures. Interestingly, these effects persisted even when people were engaged in a verbal interference task, suggesting that the results were not due to the online recruitment of language, but rather to attentional biases acquired through the frequent, habitual use of language.

Spatial Frames of Reference

Another way in which language might affect how people attend to the world is to promote a particular framework for conceptualizing space. Much research supports the proposal that representations of space utilize one of three possible frames of reference.[5,78–84] An absolute (or geocentric) frame of reference involves a coordinate system in which the main axes are placed within the larger environment (e.g., a house facing east). An intrinsic (or object-centric) frame of reference places the axes in objects (e.g., the front of a car). Finally, a relative (or egocentric) frame of reference defines the axes with respect to the viewer's own body (e.g., the comb to my left). Findings from several sources indicate that all three frames of reference are available to humans across cultures.[78–81] Levinson and his colleagues have argued, however, that there are cross-cultural differences in people's preference and proficiency with these frames of reference, and further, that these biases stem from linguistic differences.[5,78,79,82] As documented by Majid et al.,[5] languages vary in the frequency with which they encode the three frames of reference. In English, the dominant spatial frames are the relative and intrinsic, whereas in Tzeltal, a Mayan language spoken in Mexico, the dominant frames are the absolute and intrinsic. Levinson and his colleagues speculate that, over development, these arguably innate concepts become progressively re-represented to match the structures used in the learner's language. Levinson[82] conducted one of the earliest tests of this hypothesis with speakers of Dutch and Tzeltal. Participants were shown three objects organized in a row; then they were rotated 180° and instructed to 'remake the array just as it was'. As predicted, the Dutch speakers arranged the items according to an egocentric frame of reference, while the Tzeltal speakers appeared to use an absolute frame (see also Ref 79).

These findings are consistent with the possibility that the regular use of language can lead people to prefer one construal of the world over others. It should be emphasized that Levinson et al.'s findings do not imply that people are unable to use frames of reference that are not regularly encoded in their language. Indeed, as demonstrated by Li et al.,[84] Tzeltal speakers can, in fact, use their non-dominant frame of reference, the egocentric frame, without any apparent difficulty. Still to be determined is whether, at the time of encoding, participants in Levinson et al.'s experiments used language to help encode the spatial relations. If so, the results from these experiments might be better classified as a type of thinking *with* language, in which language acts as a meddler or augmenter.

Spatial Relations

The idea that language might lead people to focus on certain aspects of experience at the exclusion of others has also been examined with respect to the encoding of local spatial relations. As documented by Bowerman,[85] the encoding of spatial relations varies greatly across languages. For example, verbs of placement in Korean distinguish between tight and loose fit and ignore the distinction between containment (e.g., 'put in') and support (e.g., 'put on'), while the converse is true for English prepositions.[86–89] Work with infants suggests an ability to distinguish tight from loose fit as early as 5 months (Refs 14,87,88 but see Ref 90). However, Choi[88] has found that by 3 years of age, sensitivity to the distinction between tight and loose fit diminishes greatly in English-speaking children. Similarly, McDonough et al.[87] found that whereas Korean-speaking adults remained sensitive to the distinction between tight and loose fit, English-speaking adults were relatively insensitive to this distinction. Importantly, the results from Choi and McDonough et al. involved preferential-looking paradigms, so they do not indicate that English-speaking 3-year-olds and adults are unable to perceive or conceptualize the distinction between tight and loose fit, only that they are not biased to focus on this dimension.[14] Together, the findings on local spatial relations suggest that early on, infants are sensitive to a wide range of spatial distinctions, but that over development, they may develop biases toward certain distinctions, specifically those encoded in their language, over others. However, the findings do not imply that people lose the fundamental ability to perceive spatial distinctions not regularly made in their language.

Objects and Substances

One final area in which language might bias people to attend to particular aspects of experience is with respect to the distinction between objects and substances. Languages differ in how they partition the world into discrete objects (books, flowers) and unbounded continuous masses (rice, sand). In English, names for objects typically imply individuation. For example, when referring to multiple chairs in a room, we must use the plural marker. In languages like Japanese and Yucatec Maya, such markers are usually not needed; it is as if the noun for chair means 'chair stuff'.[27,91,92]

Several studies have investigated whether this difference in how objects are linguistically individuated might have an impact on thought. In categorizing objects, speakers of languages like English might be biased to focus on shape, since objects can be individuated on the basis of shape. In contrast, speakers of languages like Japanese and Yucatec Maya might be biased to attend to material, since their nouns do not explicitly individuate objects. These predictions were borne out in several studies in which people were asked to determine whether a particular entity (e.g., a ceramic lemon squeezer) was more similar to another entity that shared its shape (e.g., a wooden lemon squeezer) or its material (e.g., bits of ceramic), as indexed by novel noun generalization or explicit similarity judgments. For example, Imai et al.[92,93] and Lucy and Gaskins[91] found that English-speaking children and adults tended to choose according to shape, while Japanese and Yucatec Maya children and adults tended to choose according to material. Recent work by Li et al.[94] replicated these findings with speakers of Japanese, Mandarin, and English. However, this same research showed that such cross-linguistic differences did not prevent speakers of languages like Japanese from being able to think about fixed regular-shaped objects as individuated entities. As in the case of spatial frames of reference and spatial relations, language may lead people to spontaneously focus on certain aspects of experience, but it does not appear to rigidly prevent people from considering aspects of experience not encoded in their language.

LANGUAGE AS INDUCER

When language acts as a spotlight, certain aspects of the world are highlighted, in particular, those that are encoded in the meanings of specific words and constructions. However, there is another, perhaps more general way in which language might affect thought: specifically, language may prime a particular mode of processing that continues to be engaged even after language is no longer in use. This possibility was supported in a recent set of studies on the simulation of motion in static scenes. In a replication of Freyd et al.,[95] Holmes and Wolff[96] found that when an object supporting another object was suddenly removed (e.g., a pedestal beneath a potted plant disappeared), people appeared to simulate the effect of gravity on the unsupported object, as evidenced by their insensitivity to downward changes in the position of the unsupported object. Holmes and Wolff also observed that this mental simulation of gravity was much more likely to occur when participants were presented with schematic line drawings of a scene, as opposed to photorealistic images. However, when participants were instructed to write a verbal description of the photorealistic images, the simulation of gravity subsequently occurred for these stimuli as well. Further, there was a positive correlation between the proportion of relational terms (e.g., verbs and prepositions) participants used in their descriptions and the magnitude of the simulation effect. Interestingly, this influence of language was found to be scene-independent: relational language promoted mental simulation even when people described a completely different scene than the one on which they were tested. The results suggest that language, and relational language in particular, can induce people to conceptualize experience in a relatively schematic manner, a mode of processing effective in facilitating mental simulation.

CONCLUSION

Our survey of the field suggests that at least two versions of the Whorfian hypothesis can be dismissed, namely those based on language as language-of-thought and linguistic determinism. On the other hand, five other versions of the Whorfian hypothesis have garnered empirical support: those in which thinking occurs before language use (*thinking for speaking*), those in which linguistic and nonlinguistic codes compete with each other (*language as meddler*) or in which linguistic codes extend nonlinguistic thinking (*language as augmenter*), and those in which thinking is directed toward properties highlighted by language (*language as spotlight*) or in which language engages a schematic mode of processing (*language as inducer*). Our conclusions are based, in part, on several recurring findings in the field. First, we did not find empirical support for the view that language determines the basic categories of thought or that it 'closes doors'. Once people are able to make a particular conceptual distinction, this ability is retained, even if it is not explicitly encoded in one's language. For example, English speakers retain the ability to distinguish tight and loose fit, even though this distinction is not encoded in their spatial preposition system.[14] There is evidence, however, that while language may not close doors, it may fling others wide open. For example, language makes certain distinctions difficult to avoid when it meddles in the process of color discrimination[47] or renders one way of construing space more natural than another.[82] Lastly, language can sometimes build new doors. For example, language may underlie our ability to represent exact numbers[25,53,60] and entertain false beliefs.[64] Thus, language may not replace, but instead may put in place, representational systems that make certain kinds of thinking possible. Although the mechanism differs from that which Whorf originally proposed, current research suggests that language can still have a powerful influence on thought.

NOTE

[a]It should be noted that Whorf only argued for linguistic determinism in a portion of his writings. In other parts, he seemed to be arguing for the idea that language can act as a meddler or spotlight.

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