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CONCEPTUAL REVIEW ARTICLE

A Shared Mechanism of Linguistic, Cultural, and Bodily Relativity

Daniel Casasanto
University of Chicago

What's special about the way language influences thought? In some cases, the answer may be: nothing at all. Language influences nonlinguistic cognition via numerous mechanisms. Other forms of experience can also influence our thinking via some of the same mechanisms. This article illustrates how separable streams of linguistic, cultural, and bodily experience can influence the way people think, feel, and make decisions by strengthening some implicit associations in long-term memory while weakening others. As a result, people with different experiences think differently, in predictable ways. Distinct kinds of physical and social experiences can shape our minds via similar processes, suggesting continuity between different facets of experiential relativity: linguistic relativity, cultural relativity, and bodily relativity.

Keywords bodily relativity; cultural relativity; experiential relativity; linguistic relativity; Whorfian hypothesis

Introduction

How does language affect thought? For decades, the question driving linguistic relativity research has been *whether* people's experience using language influences their nonlinguistic thinking. The question of *how* language shapes thinking has taken a back seat. In place of psychological mechanisms, we have had metaphors.[1] One of the most common metaphors can be found in Roger Brown and Eric Lenneberg's (1954) summary of Benjamin Whorf's

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Correspondence concerning this article should be addressed to Daniel Casasanto, Department of Psychology, University of Chicago, 5848 S. University Avenue, Chicago, IL 60637. E-mail: casasanto@alum.mit.edu

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(1956) notion of linguistic relativity. For Whorf, they suggested, “languages are molds into which infant minds are poured” (Brown & Lenneberg, 1954, p. 454). Whether or not Whorf would have agreed with this suggestion, the language-as-mold metaphor is still used frequently more than half a century later.

Yet, the language-as-mold metaphor has entailments that reflect—and may even contribute to—two mistaken beliefs about the ways in which language can influence thought. First, it suggests that language influences cognition at only one point in time: in the moment that the wax of the mind is being poured into the mold of language. Presumably, this moment corresponds to the period of early childhood during which children are becoming competent users of their native languages. Once the wax has cooled, language has done its job, and the mind has been cast permanently in either one form or another. Second, this metaphor suggests that language plays a unique role in shaping thought—that language is *the* mold. I suspect that most researchers would reject the idea that language is the sole shaper of the mind, yet linguistic relativity studies have often focused on relationships between language and thought that are presumed to be privileged, if not exclusive. For example, one of the most productive theories of linguistic relativity in the past two decades, Dan Slobin’s (1996) “thinking for speaking” hypothesis, is predicated on there being “a special kind of thinking that is intimately tied to language” (p. 75).

In this article, I will argue that it is time to break the mold. Language does not necessarily shape thinking permanently, nor at any one point in cognitive development, nor is it necessarily a privileged shaper of thought. There are many aspects of language, many dimensions of thinking (and perceiving, feeling, etc.), and multiple mechanisms by which particular aspects of language can influence particular dimensions of thought. In at least some cases, these mechanisms are not peculiar to language and do not signal any special relationship between language and thought. Rather, language mobilizes ordinary cognitive mechanisms whose effects on people’s thoughts, feelings, and judgments should be uncontroversial. Other kinds of experience, such as nonlinguistic cultural practices and direct bodily interactions with the environment, can mobilize the same cognitive mechanisms and shape our minds in similar ways. In at least some cases, these processes are not active exclusively during childhood; rather, they operate throughout the lifetime, affecting our thinking on various timescales. As evidence for these claims, I will focus on three lines of research that illustrate how (a) language, (b) nonlinguistic cultural practices, and (c) direct bodily experiences can influence thinking in different conceptual domains via a shared mechanism.

Mental Metaphors Are Shaped by Different Physical and Social Experiences

According to theories of metaphorical mental representation, metaphors in language are more than just ways of talking; they are clues to a pervasive way of thinking (Lakoff & Johnson, 1980). On this view, when people use expressions like a *long* vacation, a *high* price, or a *close* resemblance, they are using mental representations of space (i.e., length, height, proximity) to scaffold mental representations in nonspatial conceptual domains (i.e., time, value, similarity). Although initial evidence for metaphor theory was based entirely on descriptive analyses of how people talk, there is now abundant experimental evidence that people also *think* metaphorically—even when they are not using any metaphorical language or using any language at all (for a review, see Casasanto & Bottini, 2014a). That is, people often think in mental metaphors (Casasanto, 2008a).[2] In the examples above and in those I will discuss below, the mental metaphors are constituted by associations in long-term memory between nonlinguistic representations in the source domain of space and nonlinguistic representations in a nonspatial target domain (Lakoff & Johnson, 1980). Both the source and target domains are analog continuums, and when people activate a mental metaphor they construct a point-to-point mapping between the continuums, such that longer in space corresponds to longer in time, higher in space corresponds to higher in value, and so on.

Here I will describe three sets of mental metaphors whose use is conditioned by different streams of physical and social experience. Spatial representations of a particular dimensionality or directionality serve as the metaphorical source domain that structures people's mental representations in the target domains of musical pitch, time, and emotional valence. These target domains are more abstract than the domain of space insomuch as they are impossible to see or touch; in the cases of time and valence, they are impossible to experience through any of the five senses. That is, we can see the spatial length of a rope or the height of a ladder, but we can never see the length of a vacation (i.e., its duration) or the height of a musical note (i.e., its auditory frequency).[3] Spatializing these nonspatial domains in our minds may make our experiences of pitch, time, and valence easier to imagine, compare, or remember. It may be a human universal to conceptualize these domains in terms of space (cf. Eitan & Timmers, 2010; Whorf, 1956), but the particulars of these spatial representations vary across groups of people, according to the particulars of their linguistic, cultural, or bodily experiences. The mechanism underlying all of these effects of experience, I will suggest, is the same: Repeated experiences cause a certain mental metaphor to be activated frequently, strengthening this source–target association in memory at the expense of competing associations.

Spatial Representations of Musical Pitch: A Case Study in Linguistic Relativity

Like many constructs in the cognitive sciences, linguistic relativity may be understood differently by nearly every researcher who studies it. For the purposes of this article, the theory of linguistic relativity holds that certain aspects of people's thinking vary relative to the languages they speak. People who tend to talk differently, using different words or constructions to describe a given domain of experience, come to think about this domain differently as a consequence. A series of experiments I conducted with Sarah Dolscheid and our colleagues at the Max Planck Institute for Psycholinguistics illustrates this process in the domain of musical pitch.

Thinking About Pitch Using Representations of Spatial Height or Thickness

In many languages, pitch is metaphorized in terms of vertical space: High-frequency pitches are high and low-frequency pitches low. But this is not the only possible spatial metaphor for pitch. In other languages like Farsi, Turkish, and Zapotec, high-frequency pitches are thin and low-frequency pitches are thick (Shayan, Ozturk, & Sicoli, 2011). Beyond talking about pitch using spatial words, do people think about pitch using spatial representations? Several studies suggest that speakers of height languages, like English, activate vertical space–pitch mappings when judging pitches (e.g., Pratt, 1930; Roffler & Butler, 1968). In one set of experiments, Dolscheid, Shayan, Majid, and Casasanto (2013) investigated (a) whether people still activate space–pitch associations even when they are not using language and (b) whether speakers of height languages and thickness languages tend to use the same nonlinguistic space–pitch associations, or whether their mental metaphors for pitch are shaped by their experience of using linguistic metaphors.

Like English, Dutch describes pitches as high (*hoog*) or low (*laag*), but in Farsi high pitches are thin (*nāzok*) and low pitches are thick (*koloft*). Dolscheid et al. (2013) tested Dutch and Farsi speakers using a pair of nonlinguistic pitch reproduction tasks in which participants were asked to reproduce the pitches of tones that they heard in the presence of irrelevant spatial information, which consisted of either lines that varied in their height (height interference task) or their thickness (thickness interference task). Dutch speakers' pitch estimates were strongly affected by irrelevant spatial height information. On average, a given tone was sung back higher when it had been accompanied by a line that was high on the computer screen and lower when it had been accompanied by a line that appeared low on the screen. By contrast, lines of various thicknesses had no measurable effect on Dutch participants' pitch estimates. Farsi speakers showed the opposite pattern of results. Lines of varying heights had no measurable effect on Farsi speakers' pitch estimates, but tones accompanied by thin lines were sung back higher, and tones accompanied by thick lines were sung back lower.

Differences in Nonlinguistic Pitch Representations Not Due to Verbal Labeling During the Task

The effects of spatial interference on people's pitch reproduction performance reflected the space–pitch metaphors in their native languages: Dutch speakers could not help incorporating irrelevant height information into their mental representations of pitch (but could ignore thickness), whereas Farsi speakers could not help incorporating irrelevant thickness information into their mental representations of pitch (but could ignore height). This pattern can be explained neither by differences in overall accuracy of pitch reproduction, nor by differences in musical training between groups.

Additionally, this pattern cannot be explained by participants using language covertly during the task, for example, by labeling the pitches they needed to reproduce as high/low or thick/thin. This explanation was ruled out by the experimental design, in which nine different pitches were paired with each of nine different spatial heights or thicknesses. This crossing of all of the levels of pitch and of space meant that variation in each domain was orthogonal to variation in the other: There was no correlation between space and pitch in the stimuli. As such, covertly labeling high pitches as high (or thin) and labeling low pitches as low (or thick) could not produce the observed effects of space on pitch reproduction; on the contrary, labeling pitches using the spatial metaphors in one's native language during the task could only work against the effects we predicted and found.

Rather than an effect of using language online during the task, these experiments show an effect of people's previous experience using either one linguistic metaphor or the other, thereby strengthening either one mental metaphor or the other (i.e., strengthening a nonlinguistic height-pitch or thickness-pitch mapping in memory). To confirm that the observed effects did not depend on participants covertly labeling pitches during the task, Dolscheid et al. (2013) repeated the height interference task in Dutch speakers with the addition of a concurrent verbal suppression task. On each trial of the task, participants had to rehearse a novel string of digits while perceiving and reproducing the pitches. Secondary tasks like this have been used across many experiments to prevent participants from labeling the stimuli (e.g., Winawer, Witthoft, Frank, Wu, & Boroditsky, 2007). As predicted, verbal suppression had no effect on the results of Dolscheid et al.'s pitch reproduction task. Dutch speakers still showed strong height-pitch interference, consistent with an offline effect of participants' previous experience using language on their subsequent nonlinguistic pitch representations (see also Casasanto, 2008b).

Does Using Different Linguistic Metaphors Cause People to Use Different Mental Metaphors?

The results reviewed so far show a correlation between people's linguistic metaphors and their nonlinguistic mental metaphors, but they do not provide any evidence that language *causes* Dutch and Farsi speakers to mentally represent pitch differently. Dolscheid et al. (2013) reasoned that if using thickness-pitch metaphors in language is what causes Farsi speakers to activate thickness–pitch mappings implicitly when reproducing pitches, then training Dutch speakers to use similar thickness–pitch metaphors in language should cause them to reproduce pitches like Farsi speakers. A new sample of Dutch speakers were recruited and assigned to one of two training conditions: Participants in the thickness- training group learned to describe pitches using Farsi-like metaphors (e.g., a tuba sounds *thicker* than a flute), whereas the other half in the height-training group (i.e., the control group) described pitches using standard Dutch metaphors (e.g., a tuba sounds *lower* than a flute). After about 20 minutes of this linguistic training, participants in both groups performed the nonlinguistic thickness interference task described above. Whereas height-trained participants showed no effect of irrelevant thickness information on their pitch estimates, thickness-trained participants showed a thickness interference effect that was statistically indistinguishable from the effect found in native Farsi speakers. Even a brief (but concentrated) dose of thickness metaphors in language was sufficient to influence Dutch speakers' mental metaphors, demonstrating that linguistic experience can cause the differences in nonlinguistic pitch representations found across natural language groups.

When Does Language Shape Space–Pitch Mappings?

The results reviewed up to this point leave open the question: Do space–pitch metaphors in language cause people to develop the corresponding nonlinguistic space–pitch mappings, or does using linguistic metaphors change how likely people are to use a preexisting mental metaphor? To evaluate these possibilities, Dolscheid, Hunnius, Casasanto, and Majid (2014) tested 4-month-old infants using a pair of space–pitch congruity tasks. Infants heard pitches alternately rising and falling while they saw a ball rising and falling on a screen (height congruity task) or a cylinder growing thicker and thinner (thickness congruity task). For half of the trials, changes in pitch and space were congruent with the height–pitch and thickness–pitch mappings encoded in Dutch and Farsi, respectively, and for the other half of the trials they were incongruent with these space–pitch mappings. The data showed that infants looked longer at congruent space–pitch displays than at incongruent displays. This was true both in the height congruity condition, which is consistent with an earlier experiment by Walker et al. (2010), and in the thickness congruity condition. There was no difference in the magnitude of the congruity effect between conditions, which suggests that there was no difference in the strength of the height–pitch and thickness–pitch mappings in the infants' minds.

Four-month-olds are completely unable to produce space–pitch metaphors in language and are also, presumably, unable to understand them. Yet, they are sensitive to two of the space–pitch metaphors that are found in languages like Dutch and Farsi and in their speakers' nonlinguistic pitch representations. These results suggest that people who use different linguistic metaphors for pitch come to think about pitch differently, not because language instills in them one type of spatial mapping over the other, but rather because language strengthens one of their preexisting space–pitch mappings, at the expense of the other.

Hierarchical Construction of Spatial Metaphors for Pitch

How could infants who are sensitive to both height–pitch and thickness–pitch mappings turn into adults who appear to activate only one of these mappings when they represent pitch? This process can be understood in terms of Hierarchical Mental Metaphors Theory (HMMT; Casasanto & Bottini, 2014b). According to this proposal, the implicit, nonlinguistic mental metaphors that people tend to use most often are specific members of a more general family of mental metaphors. The development of language-specific mental metaphors appears to occur over two stages. First, a superordinate family of mappings is established, which in the case of space and pitch includes both the height–pitch and thickness–pitch mappings. These mappings may be constructed, over either ontogenetic or phylogenetic time, on the basis of observable correlations between space and pitch in the natural world. The height–pitch mapping reflects the fact that people involuntarily raise their larynxes, chins, and sometimes other body parts (e.g., eyebrows) when they produce higher pitches and lower them when they produce lower pitches. It also reflects a statistical tendency for higher pitches to originate from higher locations and lower pitches from lower locations (Parise, Knorre, & Ernst, 2014). The thickness–pitch mapping reflects a pervasive correlation between pitches and the size of the objects or creatures that produce them: Consider the different pitches produced by strumming thin versus thick strings on a guitar, banging on a large steel oil drum versus a small steel can, barking by a small dog versus a big dog, and so on. Although Dolscheid et al.'s (2014) data confirm that both the height–pitch and thickness–pitch mappings are present in infants' minds, they leave open the question of exactly how and when these mappings become established initially.

Whatever the ultimate origin of space–pitch mappings in prelinguistic children may be, when children learn metaphors in language, a second process begins. Dolscheid et al.'s (2013) findings in adults suggest that each time people use a linguistic metaphor like "a high pitch" they activate the corresponding mental metaphor, strengthening this mapping at the expense of competing mappings in the same family of space–pitch associations. As a consequence, speakers of height languages like Dutch and English come to rely on vertical spatial schemas to scaffold their pitch representations more strongly than multidimensional spatial schemas, whereas speakers of thickness languages like Farsi come to rely on multidimensional spatial schemas more strongly than vertical spatial schemas.

According to HMMT, the process of strengthening certain mental metaphors via the use of the corresponding linguistic metaphors results in the weakening of other members of the family of mappings (consistent with the dynamics of many memory networks)—but this does not cause these dispreferred mappings to be extinguished. This aspect of the theory may explain the representational flexibility demonstrated by Dolscheid et al.'s (2013) training experiment. Dutch speakers could be induced to use a nonlinguistic thickness–pitch mapping (like Farsi speakers do) after only a brief training intervention because no spatial mappings had to be created or destroyed. Rather, the new pattern of language experience boosted the strength of the thickness–pitch mapping that had presumably been present in the Dutch speakers' minds since infancy, causing them to think about pitch in a way that was not new, just rarely used.

Spatial Representations of Temporal Sequences: A Case Study in Cultural Relativity

The notion of cultural relativity may be even more variably defined than linguistic relativity. This phrase is sometimes synonymous with cultural relativism, the doctrine that it is impossible to define what is *good* or *ethical* except within a given cultural context. This is not what I mean by cultural relativity. Rather, I use the term analogously to the way I use "linguistic relativity." For the purposes of this article, the theory of cultural relativity holds that certain aspects of people's thinking vary relative to the cultural practices they engage in. People's mental representations of temporal sequences provide a testbed for exploring the cultural relativity of mental metaphors.

Spatial metaphors for time are common across languages (Alverson, 1994). In English, time appears to flow along a sagittal (front–back) axis: The future is ahead and the past is behind. No known spoken language uses the lateral (left–right) axis to talk about time conventionally: Monday comes before Tuesday, not to the left of Tuesday (Cienki, 1998). Yet, despite the total absence of left–right metaphors in spoken language, there is strong evidence that people implicitly associate time with left–right space and that the direction in which events flow along people's imaginary lateral timelines varies systematically across cultures. In a seminal study, children and adults were asked to place stickers on a page to indicate where breakfast and dinner should appear relative to the lunch sticker, in the middle of the page. Whereas English speakers placed breakfast on the left and dinner on the right of lunch, Arabic speakers preferred the opposite arrangement (Tversky, Kugelmass, & Winter, 1991). This crosscultural reversal in the lateral space–time mapping has been corroborated by reaction-time tasks comparing English versus Hebrew speakers (e.g., Fuhrman & Boroditsky, 2010; Ouellet, Santiago, Israeli, & Gabay, 2010).

The sagittal mapping of time, enshrined in linguistic metaphors, has been proposed to arise from the canonical experience of moving forward through space (not backward or sideways) due to the construction of our feet, hands, and sensory organs, all of which are directed toward the front of our bodies (Clark, 1973). As we use these bodies to move forward through the world, objects that we encounter in the future lie literally ahead of us, and objects we have already passed lie behind us. Thus, a correlation between anteriority and the future, and between posteriority and the past, is reinforced nearly every time we walk (or run, bike, drive, fly, etc.). But where does the lateral mapping of time come from?

The left–right mapping of temporal sequences has been hypothesized to arise from our experience with the written word. As we read or write, we move our eyes and attention through both space and time, from left to right for some orthographies (e.g., Roman script) and from right to left for others (e.g., Arabic script). In English, for each line of text we read we begin on the left side of a page (at an earlier time) and arrive at the right side (at a later time). Thus, reading English entails a correlation between progress through time (from earlier to later) and progress through space (from left to right). To find out whether experience using one orthography or another is sufficient to determine the direction of the mental timeline, Roberto Bottini and I asked Dutch participants to perform a space–time congruity task on stimuli written in standard (left-to-right) Dutch orthography, mirror-reversed orthography, or orthography that was rotated either 90 degrees upward or downward (Casasanto & Bottini, 2014b). When participants judged temporal phrases written in standard orthography, their reaction times were consistent with a rightward-directed mental timeline: Past-related phrases (e.g., a day earlier) were judged faster with the left hand, and future-related phrases (e.g., a year later) with the right hand. After a few minutes of exposure to mirror-reversed orthography, however, participants showed the opposite pattern of reaction times; their implicit mental timelines were reversed. When standard orthography was rotated 90 degrees upward or downward, participants' mental timelines were rotated accordingly.

Separating Effects of Language and Culture on Space–Time Mappings
These data show that experience reading is sufficient to determine the direction of people's implicit mental timelines, though they do not rule out the possibility that other culture-specific practices (such as gesturing about time or using calendars) could also influence people's lateral representations of time. But why is this an effect of cultural relativity as opposed to linguistic relativity? Language can be considered an aspect of culture, and in many cases it is difficult to disentangle linguistic and nonlinguistic practices. At first glance, reading might appear to be an ambiguous case, because it is a cultural overlay on natural language. Yet, it is notable that reading is extremely recent and rare in human history; although reading may seem integral to language use in our culture, only a tiny fraction of all of the humans who have ever used language have been able to read. More to the point, in Casasanto and Bottini's (2014b) experiments, language was held constant across the orthography conditions. The words and phrases in natural language were invariant; all that changed was the direction and orientation of the orthography in which they appeared. Thus, changes in orthography determined the flow of time in people's minds independent of any changes in the structure or content of language.

Hierarchical Construction of Spatial Metaphors for Temporal Sequence
How could a few minutes of exposure to a new orthography completely reverse people's usual mental timelines, established over a lifetime of reading experience? As in the case of language, space, and pitch, HMMT may explain the flexibility of this culture-dependent mental metaphor. To elaborate, Casasanto and Bottini (2014b) proposed that people's implicit associations between

space and time can be characterized as a set of nested intuitive hypotheses (Goodman, 1955). At the top of the hierarchy is the overhypothesis, which comprises a family of specific hypotheses. In this case, the overhypothesis could be: "Progress through time corresponds to change in position along a linear spatial path." This correspondence could be learned as children observe the relationship between space and time in moving objects, or it could be part of infants' innate core knowledge (Casasanto, 2010; Srinivasan & Carey, 2010). Either way, the overhypothesized association between space and time is presumably universal across cultures, and it should be direction nonspecific: More time passes as moving objects travel farther in any direction.

Once children are exposed to cultural practices with consistent directionality, they accumulate a preponderance of evidence for one specific hypothesis. For Dutch children, reading and writing experience provides evidence for the specific hypothesis, "Progress through time corresponds to rightward change in position along a linear spatial path," strengthening this hypothesis at the expense of its competitors and causing Dutch speakers to use a rightward-directed mental timeline by default. Exposure to a different orthography in the experimental setting increased the weight of evidence for one of the participants' overhypothesized (but culturally dispreferred) space–time mappings, strengthening it to the point that it influenced behavior and transiently weakening their culturally preferred mapping as a consequence.

Spatial Representations of Emotional Valence: A Case Study in Bodily Relativity

Several years ago, I proposed a theory of bodily relativity, by analogy to the theories of linguistic and cultural relativity described above (Casasanto, 2009). By hypothesis, the contents of our minds are constructed, in part, through our physical interactions with the environment. People with different kinds of bodies interact with their environment in systematically different ways. Therefore, certain aspects of their thinking should vary relative to the particulars of their bodies. The spatial mapping of emotional valence has provided one fruitful testbed for this proposal (for reviews, see Casasanto, 2011, 2014).

Across languages and cultures, good things are often associated with the right side of space and bad things with the left. This association is evident in positive and negative idioms like "my right-hand man" and "two left feet." Beyond language, people also conceptualize good and bad in terms of left–right space, but not always in the way linguistic and cultural conventions suggest. Rather, people's implicit associations between space and valence are body specific. When asked to decide which of two products to buy, which of two job applicants to hire, or which of two alien creatures looks more trustworthy, right- and left-handers respond differently. Right-handers tend to prefer the product, person, or creature presented on their right side, whereas left-handers tend to prefer the one on their left (Casasanto, 2009). This pattern persists even when people make judgments orally, without using their hands to respond. Children as young as 5 already make evaluations according to handedness and spatial location, judging animals shown on their dominant side to be nicer and smarter than animals on their nondominant side (Casasanto & Henetz, 2012).

Beyond the laboratory, the association of goodness with the dominant side can be seen in left- and right-handers' spontaneous speech and gestures. In the final debates of the 2004 and 2008 U.S. presidential elections, positive speech was more strongly associated with right-hand gestures and negative speech with left-hand gestures in the two right-handed candidates, George W. Bush and John Kerry, but the opposite association was found in the two left-handed candidates, John McCain and Barack Obama (Casasanto & Jasmin, 2010). In summary, a body-specific mental metaphor links lateral space and emotional valence and influences the way people think and communicate about positive and negative ideas. The observed space–valence mappings cannot be explained by influences of language or culture because, in the case of the good-is-left mapping in left handers, the implicit mental metaphor goes against the explicit good-is-right mapping enshrined in linguistic idioms and other cultural conventions (e.g., raising the right hand to swear to tell the truth).

Experiential Basis of Lateral Space–Valence Mappings

Where do body-specific space–valence mappings come from? All of the results reviewed so far demonstrate correlations, but Casasanto (2009) proposed a causal relationship between the way people use their hands and the way they implicitly spatialize "good" and "bad." In general, greater motor fluency leads to more positive feelings and evaluations: People like things better when those things are easier to interact with (e.g., Ping, Dhillon, & Beilock, 2009). Bodies are lopsided. Most of us have a dominant side and a nondominant side and therefore interact with the physical environment more fluently on one side of space than on the other. As a consequence, right-handers, who interact with their environment more fluently on the right and more clumsily on the left, come to implicitly associate good with right and bad with left, whereas left-handers form the opposite association (Casasanto, 2009).

To test this proposal, Evangelia Chrysikou and I studied how people think about good and bad after their dominant hand has been handicapped, either due to brain injury or to something much less extreme: wearing a bulky ski glove.

In one experiment, right-handed university students performed a motor fluency task, arranging dominoes on a table, while wearing a cumbersome glove on either their left hand (which preserved their natural right-handedness), or on their right hand (which turned them temporarily into left-handers, in the relevant regard). After about 12 minutes of lopsided motor experience, participants removed the glove and performed a test of space–valence associations, which they believed to be unrelated to wearing the bulky ski glove. Participants who had worn the left glove still thought right was good, but participants who had worn the right glove showed the opposite left-is-good bias, like natural lefties do (Casasanto & Chrysikou, 2011).

Hierarchical Construction of Spatial Metaphors for Valence

Even a few minutes of altered motor experience can change people's implicit associations between space and emotional valence, causing a reversal of their usual judgments. HMMT provides a potential explanation of this representational flexibility. In the case of mental metaphors linking lateral space and valence, the overhypothesis may be: "The fluent region of space is good." For right-handers, who act more fluently on the side of their dominant hand, typical motor experience provides a preponderance of evidence for the specific hypothesis that "the right side of space is good," whereas typical motor experience for left-handers increases the strength of the evidence for the hypothesis that "the left side of space is good." In terms of memory networks, this means that either the association between right and good or the association between left and good is strengthened at the expense of the competing association—which is weakened but not lost and can therefore be strengthened again by new patterns of motor experience.

Hierarchical Construction of Language-, Culture-, and Body-Specific Mental Metaphors

The case studies described in this article illustrate ways in which language-, culture-, and body-specific mental metaphors can be constructed; the same mnemonic processes can be driven by different kinds of experience. Early in ontogenetic time (or perhaps over phylogenetic time), families of source–target mappings are constructed, which reflect sets of observable relationships between source and target domains in the natural world. Specific members of these families are then strengthened according to an individual's language-specific, culture-specific, or body-specific experiences. As a result, other mappings in these families are weakened. This process of competition among mappings in long-term memory explains why not all of the mappings within a given family are active at once: for example, why adult Dutch speakers do not typically conceptualize pitch using representations of both height and thickness, even though both mappings appear to be equally active in infants' minds (Dolscheid et al., 2013, 2014).

The hierarchical structuring of mental metaphors in terms of source–target families and their constituent members may also explain how spatial source–target mappings can be fundamental to our conceptions of nonspatial domains, yet also remarkably flexible. It is notable, for example, that about 5 minutes of exposure to mirror-reversed writing did not simply modulate the direction of participants' mental timeline, it completely reversed its direction, as indicated by a reversal of reaction-time congruity effects (Casasanto & Bottini, 2014b). If reaction time effects had been extinguished by exposure to the new orthography, this outcome would have been consistent with the possibility that people could cease to represent time spatially when their preferred mental metaphor was challenged. Instead, the reversal of these effects indicates that participants did not abandon a spatial mapping of time; rather, they rapidly adopted a different mental timeline, consistent with their new orthographic experience.

How are the various members of an overhypothesized family of mappings preserved in long-term memory, even though some of the mappings may never be reinforced explicitly (e.g., through the use of corresponding linguistic metaphors)? Presumably, they are maintained by the recurrence of the same sorts of physical experiences that are ultimately responsible for the family's construction. Even in a language group that uses only height metaphors for pitch in language, physical thickness–pitch relationships can still be observed (e.g., in the sound of thick vs. thin guitar strings). Even in a left-to-right reading culture, it should still be possible to observe moving objects progressing through space and time from right to left (and in all other directions). Even right-handers occasionally experience greater fluency with their left hand or on their left side of space. The preservation of dispreferred mappings explains why these mappings can be adopted so quickly when people are given new patterns of experience.

Conclusion

By seeking to understand common mechanisms of linguistic, cultural, and bodily relativity effects, we can demystify these constructs. In particular, we can move beyond the belief that linguistic relativity effects are necessarily produced by mechanisms that are the special province of language or that they signal a privileged connection between language and thought. Linguistic relativity effects become a species of experiential relativity effects. By seeking to understand experiential relativity, we can better understand the origins of our thoughts, the extent of cognitive diversity, and the dynamism of our mental lives.

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Notes

1 It is somewhat ironic to juxtapose "metaphor" with "mechanism" because arguably the notion of a psychological mechanism is, itself, a metaphor for an invisible mental process. Metaphors like the language-as-mold metaphor are rarely cashed out in any operationalizable psychological mechanisms like attending, encoding, retrieving, categorizing, discriminating, associating, which makes them hard to evaluate.

2 The term "mental metaphor" is used contrastively with "linguistic metaphor," the former designating a mapping between nonlinguistic mental representations, and the latter between linguistic representations. This distinction, which is often blurred by the use of the term "conceptual metaphor" (Lakoff & Johnson, 1980), is particularly important in contexts like the present article where I raise questions like, "Do people who use different linguistic metaphors think in correspondingly different mental metaphors?" and "Do people sometimes think in mental metaphors that are absent from language, or contradict their linguistic metaphors?"

3 A common objection to this claim is that we *can* see the length of a vacation as it stretches across the grid of our wall calendar, and the height of a musical pitch as it is notated on a musical staff. But in these cases, we are not seeing time or pitch at all; rather, we are seeing a spatial representation of time or of pitch—consistent with the theory that we habitually use space to represent time and pitch, both in the mind and on the page.

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