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Spatial metaphors in language and mind

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People use space to talk about myriad non-spatial domains of knowledge: Prices can be *high* or *low*; vacations can be *long* or *short*; relationships can be *close* or *distant.* According to nearly two decades of psychological studies, spatial metaphors are not just linguistic conventions; beyond using space to talk about non-spatial concepts, people use space to think about them. Yet, the spatial metaphors in people's minds are not necessarily reflected in their language. This chapter reviews evidence for both convergence and divergence between the ways people use space to talk about abstract ideas like *time* and *goodness* and the ways they use space to think about them, and explores how diverse spatial mappings emerge from language, culture, the body, and the world.

1. Overview: Relationships between linguistic metaphors and mental metaphors

How do we think about abstract entities like *time* and *virtue*, which have no physical properties we can perceive with the senses or act upon with the muscles? Metaphors in language provide clues. As Benjamin Whorf noted, "we can hardly refer to the simplest non-spatial situation without constant resort to [spatial] metaphors" (Whorf, 1939 / 2000, pp. 146). Space provides a basis for talking about countless non-spatial domains of knowledge (Lakoff & Johnson, 1980): Friendships can be *close* or *distant*; insights can be *deep* or *shallow*; scientific advances can be *small* or *great.* This chapter considers the question: Do people think about non-spatial domains the same way they talk about them, using the spatial representations suggested by their linguistic metaphors?[1]

1.1 Conceptual Metaphor Theory and its fundamental assumption

An influential theory of metaphors in language and mind was predicated on the answer to this question being: *Yes*, people conceptualize things the way they talk about them. The linguist George Lakoff and the philosopher Mark Johnson believed that metaphors in language reveal the structure of the concepts they name. According to their Conceptual Metaphor Theory (CMT; Lakoff & Johnson, 1980, 1999), linguistic metaphors correspond to *conceptual metaphors*: unconscious associations in long-term memory between nonlinguistic representations in *source domains* (e.g., space) and *target domains* (e.g., emotion). Source domains are posited to provide conceptual

[1] I thank an anonymous reviewer for asking: How does this question relate to Lakoff's (1993) Invariance Principle? The Invariance Principle is an attempt answer the question: How are source domains related to target domains? By contrast, the question that motivates this chapter is: How are people's linguistic metaphors (i.e., source-target mappings in language) related to their mental metaphors (i.e., non-linguistic source-target mappings that people use unconsciously for thinking)? The claim advanced in this chapter is that mental metaphors often differ from linguistic metaphors; in such cases, mental metaphors cannot be predicted on the basis of patterns in language but can be predicted and explained on the basis of other regularities in people's physical and social experience.

structure to target domains, which are typically more abstract (i.e., impossible to see or touch) or abstruse (i.e., hard to understand) compared to their sources. The expression "her spirits were soaring", for example, suggests that the speaker is using the source domain of movement in space to conceptualize the target domain of positive mood. Lakoff and Johnson (1980) introduced the convention of notating conceptual metaphors as SOURCE IS TARGET (e.g., UPWARD IS POSITIVE MOOD). According to Lakoff and Johnson (1980, 1999), conceptual structure can be inferred from conventional metaphors in language because metaphors in language correspond to metaphors in thought: I will call this claim *the correspondence assumption*.

Conceptual metaphor theorists have identified diverse source domains such as temperature (e.g., a *warm* reception), color, (e.g., feeling *blue*), and taste (e.g., a *sweet* deal). Following Whorf's (1939 / 2000) observation, however, space appears to be the most productive source domain. Spatial continuums such as *up-down, high-low, big-small*, *tall-short, deep-shallow, wide-narrow, left-right,* etc. provide linguistic scaffolding (and by hypothesis conceptual scaffolding) to many non-spatial domains, leading the psychologist Dedre Gentner and colleagues (2001) to suggest that space is the "universal donor" of concrete structure to relatively abstract concepts.

The most common method of research in the tradition of Conceptual Metaphor Theory has been the identification of families of linguistic expressions that putatively correspond to families of conceptual metaphors. For example, in addition to expressions suggesting that UP IS POSITIVE MOOD, related expressions suggest that DOWN IS NEGATIVE MOOD (e.g., sinking into depression). For the CMT theorist, the goal of this linguistic analysis is the discovery of conceptual structure. According to Lakoff (1993), "the locus of metaphor is not in language at all, but in the way we conceptualize one mental domain in terms of another" (pg. 203).

Yet, there are two limitations to the method of analyzing metaphors in language to discover metaphors in thought. First, this method relies on the correspondence assumption but does not test it. How can we tell whether people are really thinking the way that they talk? Second, Lakoff and Johnson (1999) posit that the source-target mappings revealed by linguistic conventions are a subset of the source-target mappings in our conceptual system. How can we discover whether people think using conceptual metaphors that are absent from language?

1.2 Studies validating and violating CMT's fundamental assumption

Building on decades of linguistic analyses, a body of psychological studies testing CMT and other CMT-inspired theories has emerged in the early 21st century. This chapter will first review some of the studies that have validated the correspondence assumption, and then describe studies that have challenged it.

For clarity, this chapter will use the term *linguistic metaphor* to refer to metaphors in language and *mental metaphor* to refer to non-linguistic source-target mappings (Casasanto, 2008a). In principle, the term *conceptual metaphor* refers to non-linguistic source-target mappings (Lakoff & Johnson, 1980). In practice, however, this term gets applied frequently both to metaphors in language and to non-linguistic conceptual mappings, complicating any discussion that requires a separation of linguistic and conceptual levels of mental representation. This separation is necessary to make sense of the experimental data on mental metaphors that have accumulated, and the theoretical picture that is emerging. Section 2 discusses evidence for mental metaphors that correspond closely to linguistic metaphors. Section 2.1 shows that, beyond a correspondence between language and thought, linguistic metaphors can shape the mental metaphors that people rely on for thinking. Section 3, by contrast, illustrates mental metaphors that do not correspond to any conventional linguistic metaphors. Some of these mental metaphors are absent from language, and others directly contradict conventional linguistic expressions. These mental metaphors correspond to non-linguistic cultural conventions (Section 3.1), cultural attitudes (Section 3.2), or patterns of direct bodily experience that are shared by some members of a speech community but not others (Section 3.3). The chapter then details a mechanism by which both universality and variability arise in mental metaphors (Section 4) and offers conclusions to guide future research on metaphors in language and thought (Section 5).

2. Linguistic metaphors can reflect mental metaphors

Metaphors in language often correspond to mental metaphors, as revealed by the psychological studies reviewed in this section. A challenge in designing experimental tests of mental metaphors is the requirement to avoid logical circularity by testing mental metaphors *without* using linguistic metaphors in the test. One of the first studies to succeed in avoiding this source of circularity tested the mental metaphor GOOD IS UP (Meier & Robinson, 2004). Participants saw words with positive emotional valence (e.g., *hero*) or negative valence (e.g., *liar*) presented at the top or bottom of a computer screen. Participants were faster to evaluate the valence of the words when their spatial positions on the screen were congruent with their valence (positive = top; negative = bottom) than when their positions were incongruent with their valence.

Subsequent studies have shown that activating the GOOD IS UP metaphor in people's minds without using words can change their thoughts. In one experiment, participants were randomly assigned to move marbles from a higher box to a lower box, continually, while responding to prompts to retell autobiographical memories (Casasanto & Dijkstra, 2010). The prompts were designed to be neutral in emotional valence (e.g., *Tell me about something that happened last Summer*), so participants could choose to retell either a positive or a negative memory. Participants chose to retell more positive memories while they were moving marbles upward and more negative memories while they were moving them downward; activating the UP IS GOOD mapping implicitly, via upward motor actions, caused people to think more positive thoughts whereas activating the DOWN IS BAD mapping caused them to think more negative thoughts.

Another study harnessed these space-valence mappings to improve (or inhibit) learning. Dutch participants studied flashcards to learn words in an 'alien language' (Casasanto & de Bruin, 2019). Each card had a nonce word on one side and a real word on the other. The real words had either strong positive or negative valence (e.g., paradise, torture). Participants were instructed to think about the valence of each word, and then to place the flashcard on either a high shelf or a low shelf, according to either a GOOD IS UP / BAD IS DOWN mapping or the opposite BAD IS UP / GOOD IS DOWN mapping. In the instructions that participants received, both of these mappings were motivated by idioms (in Dutch) linking space with positive or negative ideas. Idioms instantiating the GOOD IS UP / BAD IS DOWN mapping are common in Dutch, as in many other languages (e.g., *in de zevende hemel zijn*, *tr.*, 'to be in seventh heaven'; *je down voelen*, *tr.,* 'feeling down'). Perhaps surprisingly, there are also some idioms that link positive ideas with low locations and negative ideas with high locations (e.g., *met beide benen op de grond staan*, *tr.* 'to have both feet on the ground'; *het hoog in de bol hebben*, *tr.,* 'having it high in the head', meaning 'being arrogant').[2] Results showed that participants who

[2] Arguably, these idioms are *not* exceptions to the GOOD IS UP mapping because the target domain being spatialized is not emotional valence. In the idiom *to have both feet on the ground* the target domain is stability, or soundness of judgments (STABLE IS DOWN; SENSIBLE IS DOWN); in the idiom *having it high in the head* the target domain is arrogance (ARROGANT IS UP). Spatial mappings of some positive and negative ideas may

placed the flashcards on the shelves according to the GOOD IS UP / BAD IS DOWN mapping learned the meanings of the 'alien words' better than those who placed the cards according to the opposite space-valence mapping, and also better than participants in a baseline condition (placing all cards on the table). Placing flashcards in locations congruent with the GOOD IS UP / BAD IS DOWN mapping improved learning and placing them in locations that were incongruent with this mapping impaired learning. Together, the marble-moving (Casasanto & Dijkstra, 2010) and flashcard (Casasanto & de Bruin, 2019) studies show that the GOOD IS UP / BAD IS DOWN mapping can be activated non-linguistically, via motor actions, and that activating this mental metaphor can change how well people learn and what they choose to remember.

The GOOD IS UP mapping is one of the most thoroughly researched mental metaphors that corresponds to a family of linguistic metaphors. Others that have been validated experimentally include SIMILARITY IS PROXIMITY: Participants judged the meanings of words and the functions of objects to be more similar when the stimuli were presented closer together on a computer screen (Casasanto, 2008a; see also Winter & Matlock, 2013). POWERFUL IS UP: Participants judged words for powerful people (e.g., *king*) faster when they were presented at the top of a computer screen and words for powerless people (e.g., *slave*) faster at the bottom of the screen, even when the emotional valence of the words was controlled (Schubert, 2005; see also Zanolie et al., 2012). NUMEROUS IS UP: Participants were faster to judge higher numbers (i.e., greater cardinalities) by making upward eye movements and to judge lower numbers by making downward eye movements (Schwarz & Keus, 2004). Likewise, when asked to generate

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appear paradoxical, but the paradox is typically easy to resolve by homing in on the relevant target domain. The function of these 'paradoxical' idioms in Casasanto and de Bruin's (2019) experiment was not to suggest that the vertical space-valence mapping can be inverted (cf., Wnuk & Ito, 2021) but rather to convince participants that it was sensible to place positive words on the low shelf and negative words on the high shelf.

random numbers, participants tended to make spontaneous upward eye movements before producing higher numbers and spontaneous downward eye movements before producing lower numbers, demonstrating how automatically people activate the vertical space-number mapping (Loetscher et al., 2010). Together, these studies and others like them provide strong, varied, and replicable evidence that people use mental metaphors routinely, spatializing abstract concepts like valence, similarity, power, and number in their minds in ways that correspond to spatial metaphors in language.

2.1 Linguistic metaphors can influence which mental metaphors people use

Where do our mental metaphors come from? According to Lakoff and Johnson (1999), source-target mappings arise from unavoidable patterns of interacting with the physical environment. If so, then assuming all people share the same physical world, it follows that our mental metaphors should be universal. Yet, across different languages, the same target domain may be spatialized differently in conventional metaphors. Do people who use different linguistic metaphors also use correspondingly different mental metaphors? If so, do the mental metaphors we rely on depend on our language's repertoire of linguistic metaphors?

This question can be stated more broadly: Do the languages we speak shape the way we think? As such, the relationship between linguistic metaphors and mental metaphors provides a testbed for the linguistic relativity hypothesis (Whorf, 1939 / 2000). In order to avoid circularity, and thus to construct a valid test of the hypothesis that language shapes thinking, it is necessary to probe people's mental metaphors without using language in the test. Casasanto and Boroditsky (2008) developed a non-linguistic psychophysical task to test whether English speakers think about *duration* the way they talk about it, using the source domain of spatial extent. Psychophysics, one of the oldest branches of experimental psychology, evaluates the sensory impressions that stimuli make on organisms (in this case, humans): How large, how loud, how bright (etc.) did the stimulus appear? Casasanto and Boroditsky's (2008) task tested participants' estimates of stimuli that varied orthogonally in spatial length and temporal duration. There was no correlation between the length and duration of the stimuli, but there was a strong correlation in participant's *estimates* of the stimuli. Stimuli that extended farther in space were judged to take longer in time. By contrast, stimuli that lasted longer in time were *not* judged to extend significantly farther in space. Participants' estimates of space and time were entirely nonlinguistic: They clicked a mouse to indicate the starting and ending points of a spatial or temporal interval. Yet, this asymmetry between the effect of time on space estimation and the effect of space on time estimation was predicted on the basis of an asymmetry in metaphorical language: People use spatial words to talk about time (e.g., a *long* vacation) much more often than they use temporal words to talk about space. These results support the inference that people think about temporal duration the same way they talk about it, using spatial length. They also raise a further question: If people have an alternative way of talking about duration, do they also have an alternative way of thinking about it?

In English, it is hard to avoid using spatial-length terms to talk about duration. Try replacing the word "long" in the phrase "a *long* vacation" with a non-spatial equivalent: A *lengthy* vacation? *Extended*? *Protracted*? All such words denote spatial extent, currently or historically. Perhaps surprisingly, some languages rarely use DURATION IS LENGTH metaphors. In Greek, for example, rather than using 1-dimensional spatial length, the most common metaphors for duration use the source domain of 3-dimensional spatial volume: Rather than saying, "a *long* night," Greek speakers would most naturally say "a big night (i.e., mia *megali* nychta, [μία *μεγάλη* νύχτα]; Casasanto, 2008b). To test whether people who habitually use different spatial metaphors for time also use correspondingly different nonlinguistic spatial representations, Casasanto and colleagues gave native Greek and English speakers a pair of nonlinguistic psychophysical tasks (Casasanto, et al., 2004; Casasanto, 2008b). Participants used mouse clicks to estimate the duration of temporal intervals in the presence of irrelevant 1-dimensional spatial information (lines growing to different lengths) or 3-dimensional spatial information (schematically drawn containers filling with different amounts of water). English speakers' duration estimates were more strongly influenced by 1-dimensional spatial information than by 3-dimensional spatial information, consistent with their greater reliance on 1-dimensional spatial metaphors for duration in language; Greek speakers showed the opposite pattern of spatial interference in their duration estimates, consistent with their greater reliance on 3-dimensional spatial metaphors for duration in language. This pattern of results has been extended to speakers of other DURATION IS LENGTH languages (e.g., Indonesian, Swedish) and to another DURATION IS VOLUME language (e.g., Spanish; Casasanto et al., 2004; Bylund & Athanasopoulos, 2017).

On the basis of the relationship between temporal metaphors in language and thought found in the study described above, it is tempting to conclude that speaking English or Greek caused people to conceptualize duration using 1-dimensional or 3-dimensional space, respectively. Yet, studies that test speakers of different languages are only capable of establishing language-thought correlations. A further study tested whether speakers using 1-dimensional or 3-dimensional spatial metaphors in language could cause people to use the corresponding spatial schemas in their nonlinguistic representations of time. Native English speakers were randomly assigned to one of two language training conditions, completing sentences about the durations of events using either length or volume metaphors. After this concentrated experience of using one kind of metaphor or the other, all participants performed the nonlinguistic filling-containers task (Casasanto, 2008b). Participants who had used standard English length metaphors for duration showed no significant effect of 3-dimensional volume on their duration estimates; by contrast, participants who had used Greek-like volume metaphors showed a significant effect of irrelevant volume information on time estimation, like native Greek speakers. These training results confirm that experience using different space-time metaphors in language can cause people to use correspondingly different nonlinguistic mental representations.

Another set of studies yielded an analogous set of results regarding spatial metaphors for musical pitch in language and thought. In many languages, pitch is metaphorized in terms of vertical space: High-frequency pitches are *high* and low-frequency pitches are *low*. In other languages like Farsi and Turkish however, high-frequency pitches are *thin* and low-frequency pitches are *thick* (Shayan et al., 2011). Dolscheid et al. (2013) investigated whether speakers of a PITCH IS HEIGHT language (Dutch) and a PITCH IS THICKNESS language (Farsi) tend to use the corresponding nonlinguistic space-pitch associations, and whether their mental metaphors for pitch are shaped by their experience of using linguistic metaphors.

Dutch and Farsi speakers performed a pair of nonlinguistic pitch reproduction tasks in which they were asked to reproduce the pitches of tones that they heard in the presence of irrelevant spatial information: 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 significant effect on Dutch participants' pitch estimates. Farsi speakers showed the opposite pattern of results. Lines of varying heights had no significant 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. Each group incorporated into their nonlinguistic pitch estimates the kind of spatial information (height or thickness) suggested by their space-pitch metaphors in language.

This pattern cannot be explained by differences in overall accuracy of pitch reproduction, or in differences in musical training between groups. Importantly, this pattern also cannot be explained by participants using language covertly, during the task (e.g., labeling the pitches they needed to reproduce as "high/low" or "thick/thin." This explanation was ruled out by the experimental design, in which 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. Explanations based on labeling the stimuli during the task were further ruled out by a study in which Dutch speakers performed the height interference task while performing a concurrent verbal suppression task; preventing participants from subvocally labeling the pitch stimuli did not reduce the effect of irrelevant height information on their pitch estimates (Dolscehied et al., 2013).

A further study tested whether using different space-pitch metaphors in language can change people's nonlinguistic representations of pitch. Dolscheid et al. (2013) reasoned that if using PITCH IS THICKNESS metaphors in language causes Farsi speakers to activate thickness-pitch mappings implicitly when reproducing pitches, then exposing Dutch speakers to similar metaphors in language should cause them to reproduce pitches like Farsi speakers. A new sample of Dutch speakers were 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 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, providing an in-principle demonstration that linguistic experience can cause the differences in nonlinguistic pitch representations found across natural language groups.

Together, these studies of duration estimation (Casasanto, 2008b) and pitch estimation (Dolscheid et al., 2013) provide evidence that metaphors in language can not only reflect underlying mental metaphors, but can also determine which spatial source domains people are likely to use to scaffold their nonlinguistic mental representations.[3]

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[3] I thank an anonymous reviewer for raising the question: In what sense are the target domains in these examples more abstract than the source domains? Time is a parade case of an abstract concept insomuch as it is impossible to see it, touch it, or experience it directly through the senses. The difference in abstractness that is typically found between space and time can be illustrated by the following pair of sentences: (a) They moved the truck forward two meters; (b) They moved the meeting forward two hours. The truck in sentence (a) is a physical object that can travel through space, and whose motion we might see, hear, or feel. By contrast, in sentence (b) there is no way to experience the meeting's 'motion' through time via the senses (Casasanto & Boroditsky, 2008). "Seeing time" as an appointment moved across days on a calendar, or as the hands sweeping across the face of a clock would not constitute an exception, since such cultural artifacts are *spatial* representations of time: What we can see is a *spatial location* on a calendar, or a *spatial position* on a clock face; we're not seeing time per se. In the case of pitch, the

3. Mental metaphors that diverge from language.

On the basis of the preceding sections, it may appear that spatial metaphors in language and thought are linked inextricably, and that the correspondence assumption is generally supported. However, it is now clear that this is not always the case, according to more than a decade of research on the metaphoric representations of the target domains of *time* and *emotional valence*. Rather than reflecting patterns in language, implicit spatial metaphors may reflect people's experience with cultural artifacts (Section 3.1), cultural attitudes (Section 3.2), or with the way they use their bodies to perform everyday actions (Section 3.3).

3.1 Mental metaphors can depend on cultural artifacts and practices

One of the most discussed set of metaphors in the history of cognitive linguistics concerns the mapping of temporal succession to the sagittal (front-back) axis of space: The future is *ahead* and the past is *behind* (Clark, 1973; Lakoff & Johnson, 1999). On the basis of the frequent, highly systematic metaphors that link time with sagittal space in English and many other languages (Alverson, 1994), it is natural to infer that people conceptualize time as unfolding along a sagittal *mental timeline* (MTL): Accordingly, there is experimental evidence that at least some people *do* conceptualize future events as ahead of them and past events as behind them, at least some of the time (e.g., Miles et al., 2010). Yet, there is also a large body of evidence showing that people conceptualize temporal sequences in ways that are absent from conventional spoken metaphors, and even contradictory to them.

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target domain is, indeed, available to sensory perception but only via audition. Space is more concrete insomuch as it can often be experienced not only via audition but also through sight, touch, and sometimes even smell.

Although no attested spoken language has metaphors linking time to the lateral (left-right) axis, a large body of experimental evidence suggests that people often conceptualize time laterally, implicitly using a *mental timeline* analogous to written timelines in Western cultures, with earlier times on the left and later times to the right. For decades, a lateral mapping of time in both language and thought was expressly denied by psychologists (e.g., Clark, 1973) and linguists (e.g., Radden, 2004), but its existence is now supported by experimental results from dozens of experiments using diagram tasks (Tversky, et al., 1991), reaction time tasks (e.g., Torralbo et al., 2006; Weger & Pratt, 2008), and studies of spontaneous gesture (Casasanto & Jasmin, 2012; Cienki, 1998; Cooperrider & Nuñez, 2009).

Where does the lateral mental timeline come from? A clue comes from cross-cultural experiments. Participants who habitually read languages that are written from left to right such as English (Weger & Pratt, 2008) and Spanish (Santiago et al., 2007) implicitly use a left-to-right mental timeline. Participants who habitually read languages that are written from right to left such as Arabic (Tversky et al., 1991) and Hebrew (Fuhrman & Boroditsky, 2010; Ouellet et al., 2010) implicitly use a right-to-left mental timeline.

How could the direction of reading and writing determine the direction of the mental timeline? Cultural artifacts and practices provide correlations between space and time in people's everyday experiences. These correlations are evident in explicit representations of time, such as monthly calendars that place the earliest days of the week on the left and the latest days on the right. The same correlations can be found, however, in cultural artifacts and practices that do not explicitly represent time, including written text (about any topic). For Western languages like English, readers and writers begin each new line of text on the left, at an earlier moment, and progress gradually across the page arriving on the right, at a later moment. Thus, reading and writing English reinforces a correlation of earlier times with the left and later times with the right, whereas reading or writing a right-to-left script reinforces the opposite space-time correlation.

Beyond showing covariation between writing systems and mental timelines across cultures, experimental interventions show that exposure to one script or another can play a causal role in directing the MTL. When Westerners were exposed to mirror-reversed writing in a laboratory training experiment, their usual left-to-right MTLs were reversed (presumably temporarily), like habitual users' of right-to-left writing systems. When participants were trained to read a top-to-bottom or bottom-to-top script, their mental timelines followed the correlations between space and time induced by the act of reading upward or downward (Casasanto & Bottini, 2014; Pitt & Casasanto, 2020). These studies used reaction time tasks that did not require participants to spatialize time explicitly, therefore they revealed the mental timelines that participants were activating unconsciously as they judged temporal sentences (e.g., a month later, a decade earlier).

Even brief exposure to a new writing system is sufficient to determine the direction of the lateral (or vertical) mental timeline. Notably, people's implicit mental timelines can vary independent of the space-time metaphors present in their spoken languages, and of other aspects of the body and the natural environment that are all held constant across different conditions of these laboratory training experiments. Engaging in the cultural practice of reading (which is a recent overlay on humans' innate capacity for language) and interacting with cultural artifacts like books and computer screens can determine which mental metaphors people use to represent time.

3.2 Mental metaphors can depend on cultural attitudes

Mental timelines on the lateral and vertical axis are clearly absent from English, and many other languages.[4] When speakers use sagittal expressions for time, are they activating the source domain of sagittal space? Not necessarily. English speakers have been found to gesture according to a lateral mental timeline even when they are using sagittal spoken metaphors (e.g., gesturing *leftward*, not backward when using the word "back" to refer to the past; Casasanto & Jasmin, 2012). In addition to studies showing that people often use a lateral timeline, other studies show that even when they are conceptualizing time along a sagittal axis their mental metaphors may be at odds with conventional linguistic metaphors.

A serendipitous finding in speakers of Arabic led to a new hypothesis about how space-time mappings are instantiated in individuals' minds and entrenched in our cultures. As part of a broader study of space-time mappings, speakers of Spanish and of Darija (a Moroccan dialect of Arabic) performed a diagram task adapted from Casasanto (2009, Experiment 1); de la Fuente et al., 2014). Participants saw a cartoon head, viewed from above, with one box directly ahead of him and another box behind him. They read that yesterday this character (named Juan or Mohammed) went to visit a friend who liked plants, and tomorrow he would be going to visit a friend who likes animals (or vice versa, depending on the version of the task the participant received). Participants were asked to write the initial letter of the word for "plant" in the box that corresponded to past events and the initial letter of "animal" in the box that corresponded to future events (or vice versa).

[4] According to Lakoff & Johnson (1980), English metaphors like "*up*coming events" suggest that English uses a vertical time mapping. Arguably, however, such linguistic expressions have been analyzed incorrectly: *Up* in this temporal context uses the source domain of sagittal space, not vertical space. Sagittal *up* is evident in purely spatial language as well: If we ask a driver to "pull *up* to the curb" we expect the car to move ahead, not to levitate (Casasanto, 2016). Ultimately, temporal uses of "up" in English may be analyzed most accurately as participating in the mental metaphor Completion of an Action Is Spatial Approximation to a Physical Goal (e.g., "let's finish *up*"); if so, then the spatial direction of "up" may be determined by whatever spatial axis the conceptualizer is using to think about time at that moment, and whichever direction corresponds to future events in their current mental model of time.

The order of mention of the plants and animals was counterbalanced, as were their pairings with "yesterday" and "tomorrow." The results were clear: Most of the Spaniards placed the future event in the box ahead of the character and the past event in the box behind him. By contrast, most of the Moroccans showed the opposite pattern, placing the past event in the box ahead of the character and the future event in the box behind him.

Why did Moroccan Darija speakers conceptualize the past as in front of them and the future behind them? The answer cannot be found in their linguistic metaphors which consistently associate the future with *ahead* (e.g., *masiro chababi ila l amam*, *tr.* "young people have the future in front") and the past with *behind* (e.g., *ayyamo l majdi dallat warae*, *tr.* "glorious days were left behind"; de la Fuente et al., 2014). The motivation for the FUTURE IS AHEAD / PAST IS BEHIND mapping in spoken language is a space-time correlation that emerges from our experience of walking along spatial paths. Given that our feet, hands, and sensory organs are oriented toward the front of our bodies, people ordinarily walk *forward* (or run, drive, ride, ski, etc.), not backward or sideways like a crab. As we move forward, points in time that we will come to in the future lie ahead of us in space, and points in time that we have already experienced lie behind us in space (Clark, 1973; Lakoff & Johnson, 1999). There is no reason to suspect that Moroccans' experience of locomotion differs from other people's.

In the absence of any clear linguistic or body-based motivation for the Moroccan participants' observed space-time mapping, de la Fuente and colleagues (2014) turned to aspects of Moroccan culture. Compared to many Europeans and Americans, Moroccans tend to focus more on past times and older generations, they are more observant of ancient rituals, and they place more value on tradition (Mateo, 2010). Spaniards, by contrast, appear to focus on the future, valuing economic development, globalization, and technological progress. Could this cross-cultural difference in attitudes toward the past and future be responsible for the observed difference in the spatial mapping of time?

De la Fuente et al., (2014) hypothesized that people who "focus" on the past metaphorically (i.e., who devote attention to it) should tend to place the past in front of them, in the location where they could focus on the past literally with their eyes if past events were physical objects that could be seen. This proposal relies on the blending of two more basic mental metaphors. First, people conceptualize events in time (from a single action to an era) as if they were objects in space. Arguably, this EVENTS ARE OBJECTS mapping underlies temporal expressions like "our meeting is *on* Tuesday" and "let's *push* our meeting *back*"; only physical objects can be literally placed on surfaces or moved through space. Second, people conceptualize abstract attention as focused visual perception (ATTENDING IS LOOKING). Metaphorically, we can "look" at things via focused mental effort that we could never perceive with the eyes (e.g., let's *look at* the root causes of this issue).

De la Fuente et al. (2014) reasoned that the end of the temporal continuum one tends to conceptualize as *in front* in one's implicit spatial model of time is determined by one's attentional focus on either the past or the future. Therefore, people should tend to conceptualize the future as in front of them to the extent that their culture (or subculture) encourages them to be future-focused, and should conceptualize the past as in front of them to the extent that their culture encourages them to be past-focused. We called this the Temporal Focus Hypothesis (de la Fuente et al., 2014).

Further experiments in Spaniards and Moroccans supported the Temporal Focus Hypothesis. Spaniards and Moroccans completed a temporal focus questionnaire designed to probe their attitudes about the past and future (de la Fuente et al., 2014, Studies 2, 4). Moroccans showed greater agreement with past-focused statements than Spaniards (e.g., “young people must preserve the traditions”), whereas Spaniards showed greater agreement with future-focused statements than Moroccans (e.g., “technological and economic advances are good for society”). Participants’ responses on this questionnaire were a significant predictor of their responses on the Juan/Mohammed diagram task, demonstrating a correlation between people’s culture-specific attitudes toward time and their tendency to place the past or future ahead of them spatially in their mental models of time.

To test for a causal role of temporal focus in determining how people spatialize time, de la Fuente and colleagues (2014) asked Spaniards to perform a writing exercise designed to manipulate their temporal focus. About half of the participants were assigned to write about personal experiences they’d had in the past, and the other half to write about experiences they expected to have in the future, temporarily focusing their attention on one pole of the past-future continuum or the other. Immediately after completing the writing exercise, participants performed the temporal diagram task, indicating where in space a character (viewed from above) would place events in his past and his future (fig. 1). We hypothesized that focusing someone’s attention on one pole of past-future continuum could cause them to place that pole in front of them in their mental model of time. In support of this hypothesis, participants who had been assigned to write about the future showed a strong bias to locate the future ahead, but this tendency was extinguished in participants who had been assigned to write about the past: Compared with the future-trained participants, a significantly greater proportion of past-trained participants placed the past in front, like Moroccans. Given that participants were randomly assigned to be “treated” with the past-focus exercise or the future-focus exercise, these results provide evidence that temporal focus can play a causal role in determining how people spatialize the past and future in their minds. Furthermore, these results show that people's implicit spatialization of time can vary independent of any variation in space-time metaphors in language.

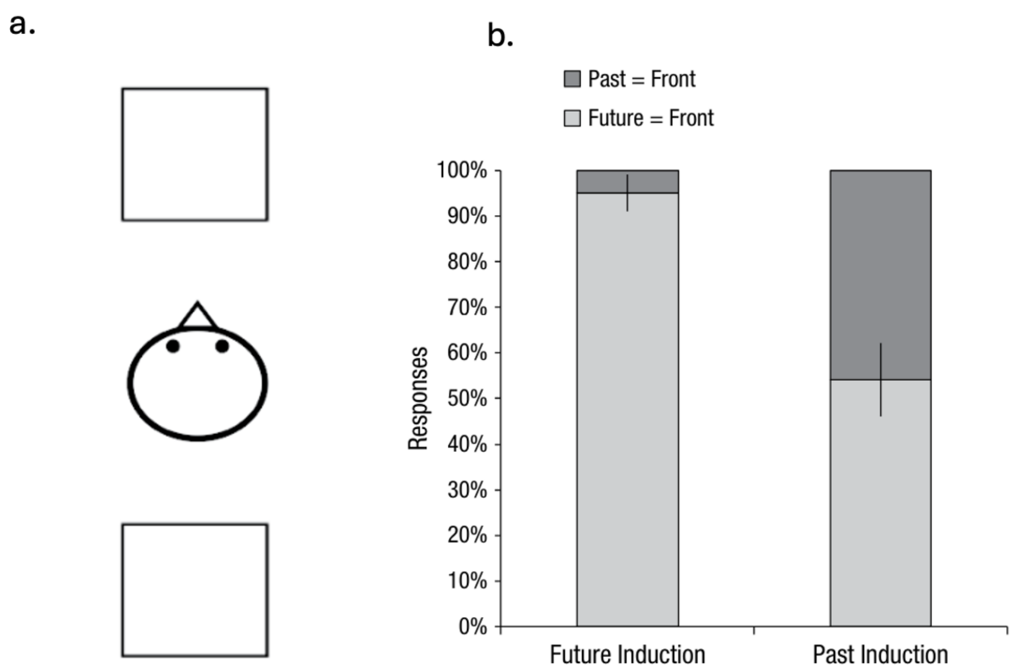

Figure 1. 1a. (left) Diagram used by de al Fuente et al. (2014) to assess whether experimental participants conceptualized the past as in front of the experiencer or behind him. 1b. (right) Results showing that participants who were experimentally induced to focus their attention on the future tended to place the future in front, whereas this tendency was significantly reduced in participants who were induced to focus their attention on the past (even though all participants were members of a future-focused culture). Figures are reproduced from de la Fuente et al. (2014).

The motivation for the Moroccans' past-in-front mapping that de la Fuente and colleagues (2014) proposed is different from the motivation Núñez and Sweetser (2006) proposed for the Aymara, who are believed to place the past in front because the past is known (i.e., seen) and the future unknown (i.e., unseen). Placing what is known in front of us is not the same as placing what we focus on in front of us: The future can be placed in front because we focus our attention on it, even though it cannot be known. The past- and future-focus training task described above, which changed the Spanish participants' likelihood of placing the future in front, presumably did *not* change the extent to which they could know the future. Rather, the writing exercise changed participants' temporal focus, making them more likely to place either the knowable past or the unknowable future in front of them.

In the decade since the Temporal Focus Hypothesis was proposed it has been tested in dozens of cultures and subcultures (for a review see Callizo-Romero et al., 2020). Groups of people across four continents have been found to differ in their temporal focus, and to differ correspondingly in their tendency to place the past or the future in front of them in their mental model of time. Within cultures, individuals have been found to vary in their temporal focus and their spatialization of time according to situational factors. For example, pregnant women (i.e., women who are "expecting" a life-changing future event) showed stronger future focus than non-pregnant women in a control group and showed a correspondingly stronger tendency to place the future ahead of them (Li & Cao, 2018). Likewise, individuals who exhibit higher levels of the personality trait *conscientiousness*, which is correlated with future focus, were more likely than their less conscientious counterparts to place the future ahead (Li & Cao, 2019).

Together, these studies show that cultural attitudes about the past and future determine how people spatialize time in their minds. Temporal focus can cause people's sagittal mappings of time to vary independent of their linguistic metaphors and their body-based habits of locomotion. The training study reviewed above (de la Fuente et al., 2014, Study 5), and other studies that show situation-based changes in temporal focus can induce corresponding changes in space-time mappings, indicating that at any moment, people's implicit sagittal mapping of past and future may diverge from the mapping enshrined in the way they walk and talk.

3.3 Mental metaphors can depend on body-specific motor experience

The preceding sections illustrate how language (Section 2.1), cultural practices (Section 3.1), and cultural attitudes (Section 3.2) can shape our mental metaphors. Yet, according to the dominant belief among Conceptual Metaphor theorists, our mental metaphors arise inevitably from "going about the world constantly moving and perceiving" (Lakoff & Johnson, 1999, pg. 57). Is there any evidence that mental metaphors depend on our direct perceptual or motor interactions with the environment? Although the idea that metaphors have sensorimotor determinants is widely accepted, there is surprisingly little evidence to support it (for a discussion see Casasanto, 2014). This section reviews what is, to date, the *only* mental metaphor that has been demonstrated to have a bodily origin.

Section 2, above, described evidence for the GOOD IS UP metaphor, in language and thought. In addition to this link between emotional valence and vertical space, language also suggests a link between valence and lateral space. Across many languages, good things are associated with the right and bad things with the left (e.g., my *right-hand* man; the *right* answer vs. *sinister* intent; two *left* feet). These patterns in language are reinforced by non-linguistic cultural conventions. In Western cultures, these customs include shaking hands with the right hand, and raising the right hand to swear an oath. In other cultures, they include prohibitions against pointing or eating with the left hand, which is reserved for dirty jobs (Kita & Essegby 2001).

Unconsciously, 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* (Casasanto, 2011): Right-handers associate good with right, but left-handers associate good with left, implicitly, in spite of conventions in language and culture. 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 honest, right- and left-handers respond differently. Right-handers tend to prefer the product, person, or creature presented on their right side but 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 five years old 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 non-dominant side (Casasanto & Henetz, 2012). Reaction time tasks show that the body-specific association between valence and space is activated highly automatically. When judging the valence of words or faces, right- and left-handers are faster to classify stimuli as positive when responding with their dominant hand, and faster to classify them as negative when responding with their non-dominant hand (de la Vega et al., 2012; de la Vega, et al., 2013; Kong, 2013).

Beyond the laboratory, the association of good 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 US 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, John

Kerry), but the opposite association was found in the two left-handed candidates (John McCain, Barack Obama; Casasanto & Jasmin, 2010). In a simulated election, left-handers were 15 percentage points more likely to vote for a candidate whose name appeared on the left of the ballot, compared to right-handers, suggesting that this implicit mental metaphor may have measurable real-world consequences (Kim, Krosnick, & Casasanto, 2015).

Where does this mental metaphor come from? If the experimental record only provided evidence for a GOOD IS RIGHT mapping, it would be plausible to suggest a role for language in constructing it. But the GOOD IS LEFT mapping in left handers cannot be explained by linguistic metaphors or idioms which consistently associate *bad* with left, in English and many other languages. Rather, mental metaphors linking valence with left-right space are shaped by the experience of using our hands to interact with the physical environment. 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 and more clumsily on the other. In general, greater motor fluency leads to more positive feelings and evaluations: People like things better when they are easier to interact with (Ping, Dhillon, & Beilock, 2009). Casasanto (2009) posited that body-specific space-valence associations arise as consequence of asymmetries in our motor experience driving asymmetric associations between fluency and space. 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.

To test this proposal, Casasanto and Chrysikou (2011) 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 on one hand or the other. One experiment tested space–valence mappings in stroke patients with hemiparesis (weakness or paralysis) on either their right or left side following damage to the opposite hemisphere of the brain. The patients, who had all been right-handed prior to brain injury, performed a task known to reveal body-specific space–valence associations in healthy participants. Patients who lost the use of their left hand after a stroke showed the usual GOOD IS RIGHT pattern. By contrast, patients who had lost the use of their right hand showed a GOOD IS LEFT pattern, like natural left-handers. A similar reversal was found in healthy university students who performed a motor-fluency task 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 (i.e., they could act more fluently with their left hand than their right). 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. Participants who had worn the left glove still thought *right* was good, but participants who had worn the right glove showed the opposite GOOD IS LEFT bias, like natural lefties (Casasanto & Chrysikou, 2011).

Together, these studies uncovered a mental metaphor linking positive and negative valence with the right and left sides of space (a mapping that had been expressly denied by researchers for decades (e.g., Clark, 1973), and which may have remained hidden in part because studies that could have revealed it did not distinguish data from right- and left-handers). The GOOD IS LEFT mapping in the minds of left-handers, and in right-handers whose usual motor asymmetries have been changed, stands in contradiction to the relevant linguistic and cultural conventions. Ironically, by contradicting patterns in metaphorical language, the GOOD IS LEFT mapping provides the first clear evidence for a long-held tenet of Conceptual Metaphor Theory (Lakoff & Johnson, 1999): that mental metaphors can arise from bodily interactions with the physical environment.

4. Hierarchical structuring of spatial metaphors

The mental metaphors people use to represent nonspatial domains like time, pitch, and emotional valence vary systematically across individuals and groups. This variation challenges some core tenets of Conceptual Metaphor theory: (i.) that the basic metaphors in our minds are “universal” because they are based on “universal early experiences” (Lakoff & Johnson, 1999, pg. 46), and (ii.) that they are “fixed conceptual mappings” (ibid., pg. 149) implemented in “permanent neural connections” (ibid., pg. 46). Contrary to the claim that mental metaphors are “universal,” the studies reviewed here show that they can vary systematically on the basis of people’s languages (e.g., Dolscheid et al., 2013), cultures (e.g., de la Fuente et al., 2014), or bodies (e.g., Casasanto & Chrysikou, 2011). Contrary to the claim that mental metaphors are “fixed,” laboratory training studies reviewed above show that even deeply entrenched mental metaphors can change in a matter of minutes when people are exposed to new patterns of linguistic, cultural, or bodily experience (e.g., Casasanto & Bottini, 2014; Casasanto & Chrysikou, 2011; Dolscheid et al., 2014). How can mental metaphors be grounded in universals of experience if they vary across people? How can they be fundamental to our conceptualizations of target domains if they can change in a matter of minutes?

Hierarchical Mental Metaphors Theory (HMMT; Casasanto & , 2014; Casasanto, 2017) provides a potential resolution to these paradoxes. On this proposal, the mental metaphors that people use at any moment are the result of two processes, that occur over different time courses. The first process results in a *superordinate family of source-target mappings*, which typically reflects source-target correlations in the natural world. These correlations could be learned from early experiences with source and target domains, as Lakoff and Johnson (1999) suggest.

Alternatively, they could be part of infants' innate "core knowledge" (Srinivasan & Carey 2010): Cross-domain relationships such as DURATION IS DISTANCE and SIMILARITY IS PROXIMITY are survival-relevant, and could plausibly become encoded in the human genome. Whether learned or innate, each superordinate family of mental metaphors constitutes a set of mappings that can be used for scaffolding target-domain thinking and can be encoded in linguistic and cultural conventions.

For a given target domain, children acquire (or manifest) a superordinate family of source-target mappings early in life. To the extent that source-target relationships in the natural world are found universally, superordinate families of mental metaphors should be universal. For example, people experience a correlation between space and time in their observation of moving objects, universally. Seeing an object progress through a succession of points in space is necessarily correlated with progress through a succession of 'points' in time, providing an experiential basis for the mental timeline.[5] Importantly, this correlation obtains no matter what direction an object is moving. Since we see objects moving along various trajectories, people's everyday experience provides the basis for a family of timelines extending in many different orientations and directions (Casasanto & Bottini, 2014; Figure 2a. bottom row), yielding a mental metaphor that encompasses spatial mappings of time along multiple trajectories which can be stated as LATER IN TIME IS FARTHER IN SPACE (Figure 2a-b, top rows).

Once a superordinate family of mappings has been constructed, a second process begins that determines which *specific source-target mappings* among a superordinate family of mappings become activated the most automatically. Due to the specifics of an individual's experiences with the physical and social world, certain mappings within a family may tend to get activated more

[5] Like seeing a moving object, moving our attention through a succession of points in space along a stationary surface also correlates with moving through a succession of point in time (e.g., while reading a line of text).

frequently than others. For example, Western reading and writing conventions cause the mapping LATER IS RIGHTWARD to be activated frequently – presumably more frequently than other mappings in the superordinate family, since this mapping is reinforced with every line of text we read (see Section 3.1). Activating a source-target mapping frequently should strengthen it while also weakening the less-frequently-activated source-target mappings in a family, as a consequence.[6] As a result, Westerners who use left-to-right writing systems activate the LATER IS RIGHTWARD mapping automatically when thinking about temporal sequences (Figure 2b., bottom row), whereas Hebrew or Arabic speakers who use right-to-left writing systems rely on the LATER IS LEFTWARD mapping by default (Tversky et al., 1991).

HMMT makes some novel predictions that have been tested experimentally. For example, if a group of people have been exposed to a set of source-target correlations in the natural world, giving rise to a superordinate family of mappings – but they have not been exposed to the kinds of experiences that cause one of the subordinate mappings to become strengthened relative to its 'siblings' – then these people should use the sibling mappings non-differentially. This prediction was borne out in a study testing mental timelines in the Tsimané people of Bolivia (Pitt et al., 2021). The Tsimané are an indigenous Amazonian people whose cultural experience does not typically include the artifacts and practices that condition industrialized cultures' mental timelines (e.g., extensive reading and writing, or using calendars and graphs). When asked to arrange pictures in temporal order (e.g., an unripe banana, a ripe banana, an overripe banana) Tsimané participants frequently created systematic linear mappings of time, much like Westerners. Unlike Westerners, however, the Tsimané participants did not show any preferred direction for their linear

[6] The idea that frequently activated source-target mappings become strengthened at the expense of less-frequently-activated mappings is consistent with the dynamics of competing associations in long-term memory (Anderson et al., 2000),

space-time mappings. For example, when prompted to arrange the pictures on a lateral (left-right) axis, Tsimané participants produced about equal numbers of left-to-right and right-to-left mappings. A similar pattern was found when Tsimané participants were asked to show temporal relationships on a vertical (up-down) or sagittal (front-back) axis. The Tsimané participants' space-time mappings, which are linear but direction-agnostic, are consistent with the superordinate-level mapping LATER IN TIME IS FARTHER IN SPACE; a mapping that can only be revealed in Westerners through laboratory training experiments that manipulate the frequency of specific subordinate mappings (e.g., LATER IS LEFTWARD; Bottini & Casasanto, 2014).

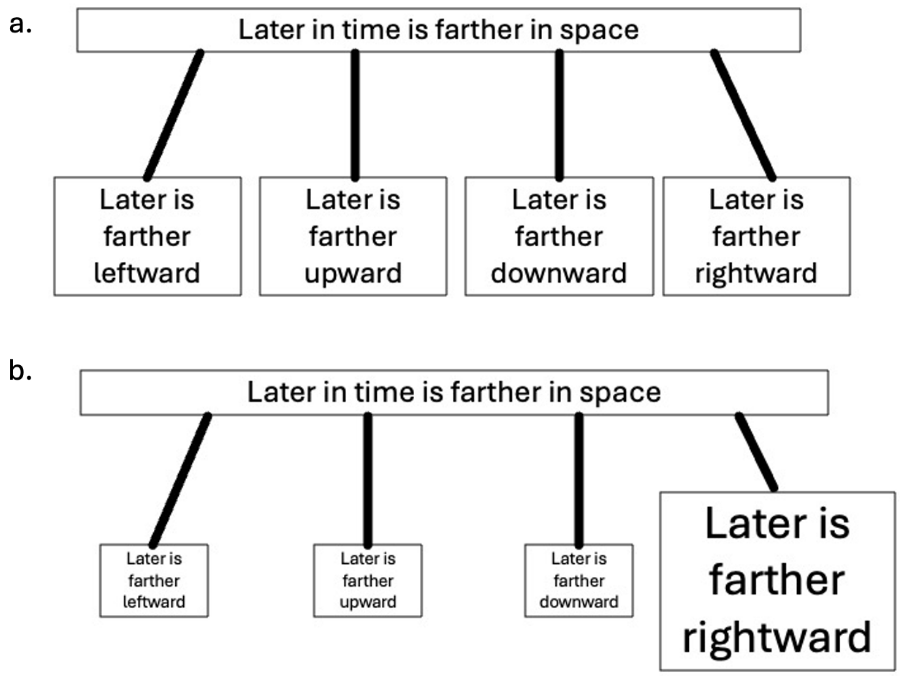

Figure 2. Hierarchical structure of the mental timeline, at earlier (2a.) and later (2b.) stages of cognitive development. The top rows in 2a. and 2b. name a superordinate family of space-time mappings; the bottom rows in 2a. and 2b. show examples of specific subordinate 'sibling' mappings within the family. The size of the boxes in each bottom row indicates the relative strengths of the sibling mappings. 2a. (top) shows the relationships among sibling mappings early in cognitive development, based on people's experience with space-time correlations in the natural world; boxes are drawn equal in size for simplicity, even though the natural world could in principle provide more evidence for some subordinate mappings than for others. 2b. (bottom) shows the relationships among sibling mappings later in cognitive development, after Westerners have frequent experience with cultural artifacts (e.g., calendars, graphs, timelines) and practices (e.g., reading, writing) that strengthen an association in long-term memory between later times and rightward space.

The process of strengthening and weakening specific mappings within superordinate families of mappings posited by HMMT can account for some otherwise mysterious properties of mental metaphors. First, this model can potentially explain how mental metaphors can be grounded in universal source-target relationships in the natural world, and yet also be variable across individuals and groups. Even if superordinate families are universal, the specific mappings that get used most frequently or automatically can vary according to distinctive patterns of linguistic, cultural, or bodily experience. Second, HMMT can potentially explain how entrenched mappings can change rapidly in response to new patterns of experience. In the training studies reviewed above (Sections 3.1-3.3), participants were induced to use "new" mappings that differed from — and in some cases directly contradicted — the mappings they ordinarily used, after only brief experimental interventions. This rapid change was possible because the "new" mappings introduced during the experiment were not really new; rather, they were members of the same superordinate family as the mappings participants normally used, and could therefore become strengthened through repeated use to the point that they were (at least temporarily) stronger than the mappings that participants ordinarily used.[7]

5. Conclusions

Half a century ago, researchers began the project of elucidating the metaphorical structure of human concepts (Gruber, 1965; Clark, 1973; Jackendoff, 1983; Lakoff & Johnson, 1980), and a consensus emerged that space may be the most productive source domain for structuring non-

[7] HMMT concerns universals and variability within basic mental metaphors; this theory should not be confused with the "inheritance hierarchies" that Lakoff (1993) proposed to explain how complex metaphors (like love is a journey, a career is a journey, a life is a journey, etc.) are constructed and related.

spatial concepts (Whorf, 1939/2000; Gentner et al., 2001). For several decades, this project consisted in analyzing metaphors in language in order to generate inferences about nonlinguistic thinking. In the 21st century, experimental methods have been developed that allow researchers to evaluate non-linguistic source-target relationships more directly; the results have been surprising, in many ways. Overall, the central claim of Conceptual Metaphor Theory (Lakoff & Johnson, 1980) has been validated to a remarkable extent: People use source domains to conceptualize target domains. In particular, we use the source domain of space to scaffold myriad non-spatial concepts. Yet, the source-target relationships suggested by metaphors in language represent only a subset of the source-target relationships that people use for thinking. Some mental metaphors reflect mappings that are found in speakers' linguistic metaphors; other mental metaphors, however, are absent from language; still others directly contradict the source-target mappings found in language. While supporting the central claim of Conceptual Metaphor Theory, these mental metaphors challenge the assumption underlying most linguistic analyses of metaphorical language: Metaphors in language may not correspond to metaphors in thought.

Considering the spatial metaphors in people's minds to be constructed hierarchically can help to explain how they can be universal at one level of description, reflecting correlations in the natural world, but also variable at another level of description, reflecting people's language-specific, culture-specific, or body-specific experiences.

Many questions about the construction of mental metaphors remain for ongoing research. For example:

1. Are superordinate families of source-target mappings created over evolutionary time or developmental time? The fact that superordinate families typically reflect source-target

relationships in the natural world is consistent with the families emerging on either of these timescales.

2. This chapter gives examples of mental metaphors for which the specific mapping that individuals use by default is conditioned by *either* linguistic experience (e.g., Dolscheid et al., 2014), non-linguistic cultural experience (Casasanto & Bottini, 2014), or direct bodily experience (Casasanto & Chrysikou, 2011). How do linguistic, cultural, and bodily experiences combine to shape the spatial metaphors that scaffold our thinking?

3. Correlations in our experience of source domains and target domains are responsible for the construction of mental metaphors at both the superordinate and subordinate levels of organization. Yet, a key property of mental metaphors is their asymmetry: We use source domains to think about target domains, more than vice versa (Casasanto & Boroditsky, 2008; Lakoff & Johnson, 1980). How do asymmetric source-target mappings in our minds arise from the inherently symmetric relationship of *correlation* in our experience of the world?

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