

# How Languages Construct Time

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## Summary

How do people construct their mental representations of time? I focus on work examining the role that spatial metaphors and basic spatial representations play in constructing representations of time across languages. The results reveal that the metaphors we use to talk about time have both immediate and long-term consequences for how we conceptualize and reason about this fundamental domain of experience. How people conceptualize time appears to depend on how the languages they speak tend to talk about time, the current linguistic context (what language is being spoken), and also on the particular metaphors being used to talk about time in the moment. Further, people who conceptualize space differently also conceptualize time differently suggesting that people co-opt representations of the physical world (e.g., space) in order to mentally represent more abstract or intangible entities (e.g., time). Taken all together these findings show that conceptions of even such fundamental domains as time differ dramatically across cultures and groups. The results reveal some of the mechanisms through which languages and cultures help construct our basic notions of time.

One of the great mysteries of the mind is how we are able to think about things we can never see or touch. How do we come to represent and reason about abstract domains like time, justice, or ideas? All of our experience of the world is physical, accomplished through sensory perception and motor action. And yet our internal mental lives go far beyond those things observable through physical experience; we invent sophisticated notions of number and time, we theorize about atoms and invisible forces, and we worry about love, justice, ideas, goals, and principles. The ability to cognitively transcend the physical is one of the very hallmarks of human intelligence. So how is it possible that physical organisms who collect photons through their eyes, respond to physical pressure in their ears, and bend their knees and flex their toes in just the right amount to defy gravity are able to invent and

reason about the unperceivable and abstract? The mystery of abstract thought has vexed scholars from Plato to Darwin.

One proposed solution to this mystery is that representations of the abstract might be constructed through analogical extensions from more experience-based domains (e.g., [3,5]). That is, in order to construct mental representations of abstract or intangible entities, we co-opt the representations we have developed for more tangible and concrete domains. In this paper I will focus on the domain of time and the role that representations of space play in constructing representations of time.

Time is a topic of central interest in our culture. The word “time” is the most frequent noun in the English language, with other temporal words like “day” and “year” also ranking in the top 10 [1,2]. Time is ubiquitous yet ephemeral. It forms the very fabric of our experience, and yet it is unperceivable: we cannot see, touch, or smell time. So how do we mentally represent and organize this fundamental domain of experience?

To represent time, people around the world rely on space. We spatialize time in cultural artifacts like graphs, time-lines, orthography, clocks, sundials, hourglasses, and calendars; we gesture temporal relations, and rely heavily on spatial words (e.g., forward, back, long, short) to talk about the order and duration of events (e.g., [3–5]). People’s private mental representations of time also appear to be based in space; irrelevant spatial information readily affects people’s judgments of temporal order and duration [6–11], and people seem to implicitly and automatically generate spatial representations when thinking about time [12–18].

However, the particular ways that time is spatialized differ across languages and cultures. Research done around the world has uncovered dramatic variability in representations of time across cultures and groups. Several aspects of linguistic, cultural, and personal experience appear to shape people’s temporal reasoning:

1. The pattern of spatial metaphors that people use to talk about time [19–24];
2. The set of spatial representations and reference frames that are available for co-opting for thinking about time (either in the linguistic or cultural environment more generally, or in the immediate context more specifically) [6–10];
3. Organizational patterns in cultural artifacts (e.g., writing direction) [15,25–27];
4. Aspects of cultural or individual disposition, age and experience [28–30].

In the following sections, I focus on work revealing the role that spatial metaphors and basic spatial representations play in constructing representations of time across languages. Languages around the world rely on spatial terms to talk about time. In some cases, it is difficult or impossible to talk about time without invoking spatial language. However, languages differ in the spatial terms that are most commonly used to talk about time. For example, depending on the language we are speaking, we might talk about the future as if it lies ahead of us (in English), behind us (in Aymara), or below us (in Mandarin Chinese). Do such differences in metaphors matter for how people mentally organize the domain of time?

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## THE AXES OF TIME

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One prominent example of how spatiotemporal metaphors shape temporal thinking comes from comparisons of English and Mandarin. Mandarin speakers are more likely to

talk about time using vertical metaphors than are English speakers [31–33]. Are Mandarin speakers also more likely to think about time vertically than are English speakers?

To test this, Boroditsky [20] compared English and Mandarin speakers' representations of time. In the studies, English and Mandarin speakers made temporal judgments following horizontal or vertical spatial primes. Participants' response times to the target questions about time following either the horizontal or vertical primes were the measure of interest. The results revealed a behavioral pattern consistent with the linguistic observation: Mandarin speakers appeared more likely to think about time vertically than did English speakers. Beyond comparing English and Mandarin speakers, the studies also compared the results of Mandarin speakers who had learned English at different stages of life, and further compared the results of English speakers tested with and without training to talk about time vertically. In each case, more experience with talking about time vertically lead to more vertical representations of time.

Results using this paradigm have been challenged (see [34–36]), but more recent work using a variety of methods has confirmed these cross-linguistic differences [22,26,37,38]. For example, when native English and native Mandarin speakers were asked to spatially arrange temporal sequences shown in pictures, Mandarin speakers arranged the pictures in vertical arrays 30% of the time (18–39% depending on group), whereas English speakers never did so [26]. In a 3D variant of this task, Boroditsky [39] asked English and Mandarin speakers to arrange time by pointing in 3D space around them. Mandarin speakers (tested in Mandarin) arranged time on the vertical axis 43.6% of the time, whereas English speakers did so only 2.5% of the time. Further, the studies found that the more proficient the participants were in Mandarin, the more likely they were to arrange time vertically. Mandarin–English (ME) bilinguals who were tested in Mandarin were more likely to arrange time vertically when they were tested in Mandarin as opposed to in English.

Lai and Boroditsky [24] examined whether metaphor use plays a causal in-the-moment role in how people construct representations of time. The results revealed that Mandarin speakers are more likely to construct front–back representations of time when understanding front–back metaphors, and more likely to construct vertical representations of time when understanding vertical metaphors. It appears that Mandarin speakers flexibly reorganize time along the front–back or up–down axis depending on whether they are processing front–back or up–down metaphors for time.

Finally, several studies have used a non-linguistic implicit space–time association task to measure how English and Mandarin speakers spatialize time [22,23,38]. The studies consistently find differences between the two language groups along the vertical axis. Mandarin speakers show an implicit vertical pattern of space–time association consistent with vertical space–time metaphors in Mandarin, with earlier events above and later events below. English speakers do not show evidence of this vertical space–time association. The findings are consistent with other work showing that experience with speaking Mandarin [22], and processing vertical time metaphors in particular [20,24] helps create and maintain Mandarin speakers' representations of time on the vertical axis. These results reveal that people automatically instantiate spatial representations of time that are consistent with the set of spatiotemporal metaphors in their linguistic environment, even in nonlinguistic tasks.

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## MOTION IN TIME

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Linguistic analyses have suggested that Mandarin relies more heavily on time-moving (as opposed to ego-moving) metaphors than does English. That is, in Mandarin, metaphors that suppose an observer moving along a stationary timeline are less likely than those that suppose a stationary observer and a moving time-line. Do these differences in metaphors predict differences in thinking about time between English and Mandarin speakers?

Lai and Boroditsky [24] measured the relative cognitive salience of ego-moving and time-moving conceptualizations in three groups with different histories of linguistic experience with time metaphors: English monolinguals, Mandarin monolinguals, and ME bilinguals. The results revealed that English and Mandarin monolinguals indeed tend to take different perspectives on time, with Mandarin speakers more likely to take the time-moving perspective (consistent with the linguistic analyses of metaphor use in the two languages). Further, ME bilinguals differ from both groups of monolinguals. When understanding time metaphors in English, ME bilinguals are more likely to adopt the time-moving perspective than are English monolinguals. Interestingly, when understanding time metaphors in Mandarin, ME bilinguals are less likely to adopt the time-moving perspective than are Mandarin monolinguals. That is, for bilinguals there are influences of both their first language on conceptualizing time in their second language, and of their second language on conceptualizing time in their first language.

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## REVERSING THE DIRECTION OF TIME

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So far we have discussed whether time can be laid out on different axes, and whether it is perceived as moving or stationary. What about the direction of time within an axis? A number of studies have found striking reversals in the direction of time between cultural groups.

One factor that affects the perceived direction of time is writing direction. People who read text arranged from left to right, tend to lay out time as proceeding from left to right, and people who read text arranged from right to left (e.g., Arabic, Hebrew) arrange time from right to left. This reversal has been documented in picture arrangement tasks [15,25], in patterns of elicited gestures or points around the body [15], in implicit non-linguistic spatial association tasks [15] and in auditory tasks [27].

Patterns in spatio-temporal metaphors have also revealed striking reversals of the direction of time. For example, in languages like English and Spanish spatial metaphors put the past behind the observer (e.g., the worst is already behind us) and the future in front (e.g., the best is still ahead of us). In Aymara, this pattern is reversed and the future is said to be behind the observer while the past is in front [19]. This pattern in metaphors is reflected in patterns in spontaneous co-speech gesture. When talking about the past, the Aymara gesture in front of them, and when talking about the future, they gesture behind them, a striking reversal from the patterns observed with speakers of English or Spanish (e.g., [19]).

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## DURATION

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Beyond event ordering, interesting cross-linguistic differences have been observed in a separate aspect of time: representations of duration. English speakers talk about duration more often in terms of linear distance (e.g., a long time), whereas Greek speakers talk about duration more often in terms of amount (e.g., *poli ora*, tr. “much time”). To determine whether this difference in language corresponds to a difference in thinking, Casasanto *et al.* [40] compared Greek and English speakers’ ability to estimate duration in the presence of distracting information about distance or amount, using simple duration reproduction tasks with non-linguistic stimuli and responses. Participants’ non-linguistic duration estimates varied as predicted by the space–time metaphors in their native languages: English speakers’ duration estimates were more influenced by irrelevant distance information, and Greek speakers’ by irrelevant amount information. Next, English speakers were trained to use Greek-like metaphors for duration (e.g., a week is more than a day), which resulted in Greek-like performance on a non-linguistic duration estimation task. These findings demonstrate that (a) people who talk about time differently also think about it differently, and (b) language not only reflects the structure of our non-linguistic mental representations, it can also shape those representations in fundamental ways that can be observed even in low-level perceptuo-motor tasks.

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## REPRESENTATIONS OF TIME IN ABSOLUTE SPACE

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Because people tend to recruit spatial representations to think about time, representations of time also differ depending on what spatial representations are most cognitively available to co-opt for time (either in the immediate environment or in the culture more generally) [6,7,9,10,41].

One such demonstration comes from spatial representations of time in a remote Australian aboriginal community of Pormpuraaw. Unlike English, the Pormpuraaw languages do not routinely use relative spatial terms like left and right, and instead rely on absolute direction terms (e.g., North/South/East/West), saying things like “move your cup over to the NNW a little bit” or “the boy standing to the South of Mary is my brother” [42–45]. Members of such linguistic communities must always stay oriented, just in order to be able to speak the language properly. In Kuuk Thaayorre (one of the languages included in this study), to say hello, one says “where are you going?” an appropriate response being “a long way to the SSW.” That is, if you do not know which way is which, you literally cannot get past hello. Previous work has documented that speakers of such languages do indeed stay oriented, show precision in spontaneous co-speech gesture, and exhibit remarkable skill in dead reckoning [46–50]. How might members of such speech communities think about time?

To find out, Boroditsky and Gaby [41] gave participants sets of pictures that showed some kind of temporal progression (e.g., a man aging, or a crocodile growing, or a banana being eaten) (see Fig. 20.1). Their job was to arrange the shuffled photos on the ground to



**FIGURE 20.1** Example of a picture series participants were asked to arrange.

show the correct temporal order. Each participant was tested in two separate sittings, each time facing in a different cardinal direction. If you ask English speakers to do this, they will arrange the cards so that time proceeds from left to right. Hebrew speakers will tend to lay out the cards from right to left, showing that writing direction in a language plays a role. So what about folks like the Kuuk Thaayorre, who do not use words like “left” and “right”? What will they do?

The Kuuk Thaayorre did not arrange the cards more often from left to right than from right to left, nor more toward or away from the body. However, their arrangements were not random: there was a beautiful pattern, just a different one from that of English speakers. Instead of arranging time from left to right, they arranged it from east to west. That is, when they were seated facing south, the cards went left to right. When they faced north, the cards went from right to left. When they faced east, the cards came toward the body, and so on. This was true even though we never told any of our subjects which direction they faced. The Kuuk Thaayorre not only knew that already, but they also spontaneously used this spatial orientation to construct their representations of time.

This example illustrates that cross-cultural differences in thought can be more than a matter of style or preference. Pormpuraawans think about time in ways that other groups cannot (because they lack the necessary spatial knowledge). Many Americans simply could not lay out time in absolute coordinates even if they wanted to, because they lack the basic spatial knowledge necessary to do so (see [41]): two-thirds of the American sample could not reliably point to the compass directions even though they were tested outside on a sunny day in a familiar environment); and even those Americans who could have in principle done it, would be highly unlikely to spontaneously think to do it that way. This example reveals that speakers of different languages can arrive at qualitatively different ways of constructing even such fundamental domains of experience as space and time (in this case, representations that operate in entirely independent coordinate frames).

## SUMMARY

Across the studies cited here, people in different cultures or groups have been shown to differ in whether they think of time as stationary or moving, limited or open-ended, as distance or quantity, horizontal or vertical, oriented from left to right, right to left, front to back,

back to front, or in cardinal space (e.g., East to West). The findings reviewed in the first four sections above demonstrate that the metaphors we use to talk about time (and other cultural factors) have both immediate and long-term consequences for how we conceptualize and reason about this fundamental domain of experience. How people conceptualize time appears to depend on how the languages they speak tend to talk about time, the current linguistic context (what language is being spoken), and also on the particular metaphors being used to talk about time in the moment. Further, the findings reviewed in the fifth section (*Representations of Time in Absolute Space*) demonstrate that people co-opt representations of the physical world (e.g., space) in order to mentally represent more abstract or intangible entities (e.g., time). It appears that differences in basic spatial representations may have far-reaching consequences in many other knowledge domains in the cognitive system. Taken all together these findings show that conceptions of even such fundamental domains as time differ dramatically across cultures and groups and reveal some of the mechanisms through which languages and cultures help construct our basic notions of time.

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