Metaphor and Symbol, 26: 260–271, 2011
Copyright © Taylor & Francis Group, LLC
ISSN: 1092-6488 print / 1532-7868 online
DOI: 10.1080/10926488.2011.609065

Psy gy Press
Taylor & Fr oup

Even Abstract Motion Influences the Understanding of Time

Teenie Matlock

time, as in *"We are approaching the holidays,"* or about time moving relative to them, as in *"The holidays are approaching."*

Talking about time in terms of motion is no accident. Nor is it simply a matter of linguistic convention. Rather, it is motivated by our conceptual experience. There is much evidence to show that spatial and temporal representations are linked in everyday reasoning (e.g., Casasanto & Boroditsky, 2008; Xuan, Zhang, He, & Chen, 2007), even in infants (Lourenco & Longo, 2010; Srinivasan & Carey, 2010). There is also evidence to suggest that the conceptual metaphor *"TIME IS MOTION,"* or more generally, *"TIME IS SPACE,"* is universal (Clark, 1973; Evans, 2004; Kövecses, 2005; Radden, 1997; Traugott, 1978). Moreover, it is well established that people readily think about all sorts of things metaphorically. Metaphor allows them to anchor their understanding of relatively abstract domains, such as mathematics (Lakoff & Núñez, 2001), emotions (Kövecses, 2000), and information spaces (Maglio & Matlock, 1999), in terms of concrete, familiar domains (Gibbs, 1994; Lakoff & Johnson, 1980).

The connection between time and space has been studied extensively in linguistics, psychology, philosophy, and other fields, yet many questions remain about the nature of this connection. On one view, time and space are autonomous conceptual domains that both derive structure from a generalized representational template, one that is perhaps the result of evolutionary recycling (see, for instance, Cantlon, Platt, & Brannon, 2009; Jackendoff, 1983; Pinker, 1997; Walsh, 2003). On another view, the conceptual domain of time achieves much of its meaning and coherence from our basic perceptual, motor, and kinesthetic experiences in the physical world (see Clark, 1973; Gibbs, 1994, 2006; Lakoff & Johnson, 1980, 1999).

The goal of this paper is to extend prior psychological work on how people metaphorically conceptualize time. We focus on how the source domain of motion interacts with the target domain of time. In particular, we examine how the direction of motion shapes temporal reasoning, and the extent to which this effect generalizes. We explore the influence of *abstract motion*, which occurs in counting, reciting the alphabet, and other activities that involve mentally "moving" from symbol to symbol in an ordinal sequence (see Langacker, 1986, 1987). Our studies use an ego-moving time perspective, in which people conceptualize motion through time (e.g., *"We are approaching Thanksgiving"*), and a time-moving perspective, in which people conceptualize time moving relative to themselves (e.g., *"Thanksgiving is approaching"*; see Clark, 1973; Gentner, 2001; McGlone & Harding; 1998; but see also Moore, 2006; Núñez, Motz, & Teuscher, 2006). Here we are especially interested in how abstract motion influences temporal reasoning, and what it means for processing everyday spatial metaphors.

ACTUAL MOTION AND TIME

Many researchers have investigated the metaphoric connection between time and motion. The logic is that if time and motion are conceptually linked, then thought about motion should influence thought about time. In pioneering work, McGlone and Harding (1998) asked participants to read a series of statements about time that were phrased in terms of an ego-moving perspective (e.g., occur or had already occurred. Critically, the last sentence was ambiguous, as in *"The meeting originally scheduled for next Wednesday has been moved forward two days,"* and thus permitted a Monday and a Friday response. The results showed that participants in the ego-moving condition often interpreted "moved forward" in a manner consistent with the ego-moving perspective (i.e., judged the meeting to be on Friday), but participants in the time-moving condition often interpreted it in a manner consistent with the time-moving perspective (i.e., judged the meeting to be on Monday; see also Boroditsky, 2000).

Boroditsky and Ramscar (2002) further explored how motion influences the understanding of time. In several studies, participants answered the question, "Next Wednesday's meeting has been moved forward two days. What day is the meeting now that it has been rescheduled?" (adapted from McGlone & Harding, 1998), after thinking about movement under various circumstances. In one experiment, participants imagined themselves moving toward a stationary object, or they imagined an object moving toward them before answering the ambiguous "move forward" time question. When they had thought about themselves moving, they were more likely to indicate that the meeting would be held on Friday than Monday, but when they had thought about an object moving toward them, the two responses were about equally likely. The results from Boroditsky and Ramscar (2002) showed that different ways of thinking about physical motion can yield different construals of time. (For related work, see Núñez, Motz, & Teuscher, 2006; Teuscher, McQuire, Collins, & Coulson, 2008.)

FICTIVE MOTION AND TIME

Matlock, Ramscar, and Boroditsky (2005) extended earlier findings on the *"TIME IS MOTION"* metaphor by exploring the effect of fictive motion, a non-literal type of motion implied in statements such as *"The road goes through the desert"* and *"The tattoo runs along his spine"* (Matlock, 2004a; 2004b; Langacker, 1987; Matsumoto, 1996; Talmy, 2000). In one experiment, participants read and visually depicted sentences that did or did not include fictive motion (e.g., *"The tattoo runs along his spine"* versus *"The tattoo is next to his spine"*) before answering the "move forward" question. In brief, sentences with fictive motion led to proportionally more Friday than Monday responses, but sentences without fictive motion yielded no reliable differences. (See also Ramscar, Matlock, & Dye, 2010.)

ABSTRACT MOTION AND TIME

So far, there is good evidence to support the idea that thought about motion, including fictive motion, influences tTc[.-1ne-283.s97TD-8le8-41ublzes)-312Tudged numbers, they mentally “move” along the number line.[1] For example, when people generate numbers at random, their eye position predicts what number they have in mind. Leftward shifts often precede smaller numbers, and rightward shifts, larger numbers (Loetscher, Bockisch, & Brugger, 2008; see also Fischer, Castel, Dodd, & Pratt, 2003; Loetscher, Bockisch, Nicholls, & Brugger, 2010; Schwarz & Keus, 2004). These results suggest a strong coupling between external physical space and internal mental space, with eye movements along physical trajectories reflecting abstract motion along the mental number line.[2] Abstract motion can also be construed in terms of movement toward or away from a “zero” reference point, consistent with a left–right orientation (see Dehaene, 1997; Lakoff & Núnez, 2001). On this view, when people “move” in ascending order through a series of numbers (e.g., *2*, *3*, *4*), they “go” forward and away from zero. When they “move” in descending order (e.g., *4*, *3*, *2*), they “go” backward and toward zero.

Especially compelling evidence for abstract motion in numerical processing comes from research on

Downloaded by [Emory University] at 08:51 03 October 2011

narrative about a person doing a countdown, in either ascending or descending order, before an event. In all cases, it was expected that people would "move" forward through time to a greater extent after processing symbols in ascending order than after processing symbols in descending order.

EXPERIMENT 1: NUMBERS AND TIME

How might abstract motion—in this case, "movement" through a sequence of numbers—influence temporal reasoning? Would it be anything like actual motion (Boroditsky & Ramscar, 2002) or fictive motion (Matlock et al., 2005)? Participants completed a task in which they thought about numbers that proceeded in ascending or descending order (either *5* to *17* or *17* to *5*) before answering the ambiguous "move forward" question. In light of the earlier results and given our everyday experience with motion (typically forward, not backward), abstract motion in a canonical direction through numbers (ascending order, away from zero) ought to prompt people to adopt an ego-moving perspective, and yield more Friday responses, than abstract motion in a non-canonical direction (descending order, toward zero).

Method

Eighty-eight Stanford undergraduates participated for partial credit in an introductory psychology course. In this and other experiments reported in this paper, participants completed a survey in a booklet that contained various unrelated tasks, and were randomly assigned to the forward or backward condition. First, participants read, "Fill in the blanks with the missing numbers." Next, they filled in the 11 missing integers between *5* and *17* (forward abstract motion) or between *17* and *5* (backward abstract motion). As reading and writing direction (rightward ver-

Method

Ninety-six Stanford undergraduates volunteered for partial credit in an introductory psychol-

Downloaded by [Emory University] at 08:51 03 October 2011

determine whether the influence of abstract motion on time would generalize to conventionalized situations involving a sequence of symbols in ascending or descending order.

Method

A total of 101 undergraduates at the University of California, Merced, volunteered for extra credit in a psychology or cognitive science course. In the forward condition, participants first read the following passage:

> John is at a school event in the park. He is seated at a table and about to compete in an ice cream eating contest. He is fidgeting and eager to start. He's holding a pint of ice cream with one hand and clutching a spoon with the other. Finally, he hears, "One, two, three, four, five, start!

The last sentence was about a person who called out a countdown that occurred in ascending order. In the backward condition, participants read the same passage, but the last sentence was about a person who called out a countdown in descending order. After reading one of these passages, participants answered the ambiguous "move forward" time question used in the previous experiments.

Results and Discussion of Experiment 3

Six responses were omitted because inappropriate responses were given (e.g., Wednesday, Saturday). This left 95 responses. Of the 46 participants in the forward condition (ascending order), 11 percent gave a Monday response and 89 percent gave a Friday response. Of the 49 participants in the backward condition (descending order), 53 percent provided a Monday response and 47 percent provided a Friday response. A chi-square test of independence showed a reliable difference in the proportion of Monday and Friday responses across the two conditions, $\chi^2(1) = 17.34$, $p < .0001$. Chi-square goodness-of-fit tests showed that the proportion of responses differed reliably from chance in the forward condition, $\chi^2(1) = 28.17$, $p < .0001$, but not in the backward condition, $\chi^2(1) = .18$, $p > .6$.

These results are consistent with those of the first two experiments. They show that even in conventionalized counting situations, in which people are not computing sequences of symbols themselves, ascending order encouraged people to take an ego-moving perspective and "move" through time, but descending order did not.

GENERAL DISCUSSION

Three experiments explored whether and how abstract motion would influence temporal reasoning. Together, the results suggest that abstract motion, "motion" from one symbol to another, (*17 . . . 5* or *P . . . G*) did not. In Experiment 3, similar results obtained when people read a story that included a countdown in ascending or descending order.

These results are consistent with earlier work on time and motion, both actual and fictive (Boroditsky & Ramscar, 2002; Matlock et al., 2005). However, in the current experiments, participants were not primed with information about motion through physical space in any way. They were never asked to imagine, for instance, being pulled in a chair toward a distant object (Boroditsky & Ramscar, 2002). Nor were they primed with fictive motion sentences, non-literal language known to evoke simulated motion (Matlock et al., 2005). Instead, our participants simply thought about numbers or letters in ascending or descending order. In doing so, they may have mentally simulated motion from one symbol to the next, and, at least in the case of forward motion, it was sufficient to lead to more Friday responses when reasoning about time. This would be in line with evidence that sequential processing invokes abstract motion along an internal spatial representation of symbols (e.g., Loetscher et al., 2008, 2010; McCrink et al., 2007).

Given that thinking about numbers or letters in ascending order produced reliable effects on temporal reasoning across the three experiments, why did thinking about numbers or letters in descending order not do the same? One possibility is that our ordinary experiences with motion often occur in a canonical forward direction. In everyday life, we walk through rooms, down stairs, and across streets with our bodies facing forward. We drive cars on roads or ride bicycles on paths facing forward. We also watch others moving forward hundreds of times on any given day. Because forward movement is deeply entrenched in our perceptual experience, it is primary in our conceptual system (Clark, 1973; Johnson, 1987; Lakoff & Johnson, 1999; Radden, 1997, 2006). As such, it is readily and persistently recruited in our understanding of time, often through mental simulation metaphorically construed actions (see Gibbs & Matlock, 2008). In contrast, backward movement is relatively rare, and consequently, its conceptualization may be inconsistent or vague.

Our results, which extend earlier work on motion and time, suggest that even abstract motion can influence the conceptualization of time. These findings have implications for research on temporal reasoning, and provide insights into the sequential processing of numbers and other symbols. On one view, thinking about numbers might simply involve calling up a static representation of a series of numbers on a line. In this case, people would think about numbers as static entities and would not simulate motion from one to the next. On another view, however, thinking about numbers evokes a dynamic representation. In the latter case, people would mentally simulate motion from one number to the next. If number X is at location 1 and number Y is at location 2, people might imagine moving from location 1 to location 2 while counting. These views point to different predictions: A static representation would predict no difference for the ambiguous “move forward” time question (because a static numerical sequence should not prime conceptual “movement” through time), but a dynamic representation would predict differences as a function of direction of movement, with canonical forward movement encouraging an ego-

Based on our results, we conclude that abstract motion, “motion” through non-physical domains, can influence the understanding of time. The work adds new insights to the existing body of work on the conceptual relationship between space and time by showing how even very subtle forms of motion can influence temporal reasoning. Follow-up research might disentangle the front–back and left–right spatial axes in the processing of ordinal sequences, as both types of construal are recruited in the conceptualization of time (Fuhrman & Boroditsky, 2008; Torralbo, Santiago, & Lupiáñez, 2006). It would also be informative to study the effect of abstract motion on the understanding of time in languages other than English, for instance, Aymara (see Núñez & Sweetser, 2006) or Wolof (see Moore, 2006). Nevertheless, at this point, we can say with some degree of confidence that even abstract motion influences the understanding of time.

ACKNOWLEDGEMENTS

The authors thank Lera Boroditsky, Herbert Clark, Michael Spivey, and Rolf Zwaan for enlightening discussions related to this research, as well as Michael Leon, David Sparks, and Elsie Wang for assistance with data collection. They are also grateful to Editor Raymond Gibbs, as well as to Sarah Anderson, Caitlin Fausey, Paul Maglio, Art Markman, Bodo Winter, and others for comments on earlier drafts of this paper. This work began when the authors were conducting research at Stanford University.

REFERENCES

Boroditsky, L. (2000). Metaphoric structuring: Understanding time through spatial metaphors. *Cognition*, *75*, 1–28.

Boroditsky, L. & Ramscar, M. (2002). The roles of body and mind in abstract thought. *Psychological Science*, *13*, 185–188.

Cantlon, J. F., Platt, M. L., & Brannon, E. M. (2009). Beyond the number domain. *Trends in Cognitive Sciences*, *13*, 83–91.

Casarotti, M., Michielin, M., Zorzi, M., & Umiltà, C. (2006). Temporal order judgment reveals how number magnitude affects visuospatial attention. *Cognition*, *102*, 101–117.

Fuhrman, O., & Boroditsky, L. (2010). Cross-cultural differences in mental representations of time: Evidence from an implicit nonlinguistic task. *Cognitive Science*, *34*, 1430–1451.
Gentner, D. (2001). Spatial metaphors in temporal reasoning. In M. Gattis (Ed.), *Spatial schemas and abstract thought* (pp. 203–222). Cambridge, MA: MIT Press.
Gevers, W., Reynvoet, B., & Fias, W. (2003). The mental representation of ordinal sequences is spatially organized. *Cognition*, *87*, B87–B95.
Gibbs, R. W. (1994). *The poetics of mind: figurative thought, language, and understanding*. New York, NY: Cambridge University Press.
Gibbs, R. W. (2006). *Embodiment and cognitive science*. New York, NY: Cambridge University Press.
Gibbs, R. W., & Matlock, T. (2008). Metaphor, imagination and simulation. Psycholinguistic evidence. In R. W. Gibbs Jr., (Ed.), *The Cambridge handbook of metaphor and thought* (pp. 161–176). New York, NY: Cambridge University Press.
Holmes, K. J., & Lourenco, S. F. (in press). Common spatial organization of number and emotional expression: A mental magnitude line. *Brain and Cognition*.
Jackendoff, R. (1983). *Semantics and cognition*. Cambridge, MA: MIT Press.
Johnson, M. (1987). *The body in the mind: The bodily basis of meaning, imagination, and reason*