Research Report

THE ROLES OF BODY AND MIND IN ABSTRACT THOUGHT

Lera Boroditsky[1] and Michael Ramscar[2]

[1]*Massachusetts Institute of Technology and* [2]*University of Edinburgh, Edinburgh, Scotland*

Abstract—*How are people able to think about things they have never seen or touched? We demonstrate that abstract knowledge can be built analogically from more experience-based knowledge. People's understanding of the abstract domain of time, for example, is so intimately dependent on the more experience-based domain of space that when people make an air journey or wait in a lunch line, they also unwittingly (and dramatically) change their thinking about time. Further, our results suggest that it is not sensorimotor spatial experience per se that influences people's thinking about time, but rather people's representations of and thinking about their spatial experience.*

How are people able to think about things they have never seen or touched? Much scientific progress—whether it involves theorizing about invisible forces, studying the behaviors of atoms, or trying to characterize the nature of private mental experience—depends on generating new ways of describing and conceptualizing phenomena that are not perceivable through the senses. In everyday life, too, people face the same problems with abstract notions like time, justice, and love. How do people come to represent and reason about abstract domains despite the dearth of sensory information available about them?

One suggestion is that abstract domains are understood through analogical extensions from richer, more experience-based domains (Boroditsky, 2000, 2001; Clark, 1973; Gentner, Bowdle, Wolff, & Boronat, 2001; Gentner, Imai, & Boroditsky, in press; Gibbs, 1994; Holyoak & Thagard, 1995; Lakoff & Johnson, 1980, 1999). This experience-based structuring view can be formulated in several strengths. A very strong, embodied formulation might be that knowledge of abstract domains is tied directly to the body such that abstract notions are understood directly through image schemas and motor schemas (Lakoff & Johnson, 1999). A milder view might be that abstract knowledge is based on representations of more experience-based domains that are functionally separable from the representations directly involved in sensorimotor experience.

The studies we report in this article show that people's understanding of the abstract domain of time is built on their knowledge and experiences in the more concrete domain of space. In fact, people's representations of time are so intimately dependent on space that when they engage in particular types of everyday spatial activities (e.g., embarking on a train journey or standing in a lunch line), they unwittingly also change how they think about time. Further (and contrary to the very strong embodied view), it appears that abstract thinking is built on representations of more experience-based domains, and not necessarily on the physical experience itself.

Suppose you are told that next Wednesday's meeting has been moved forward 2 days. What day is the meeting, now that it has been rescheduled? The answer to this question depends on how you choose to think about time. If, on the one hand, you think of yourself as moving forward through time (the ego-moving perspective), then moving a meeting "forward" is moving it further in your direction of motion—that is, from Wednesday to Friday. If, on the other hand, you think of time as coming toward you (the time-moving perspective), then moving a meeting "forward" is moving it closer to you—that is, from Wednesday to Monday (Boroditsky, 2000; McGlone & Harding, 1998; McTaggart, 1908). Most people have very strong intuitions about which answer to this question is correct. As we discuss here, however, the question is indeed ambiguous, and individuals' intuitions about the answers can change dramatically depending on context (though their certainty of their answers generally remains untouched). In a neutral context, people are as likely to think of themselves as moving through time as they are to think of time as coming toward them, and so are as likely to say that the meeting has been moved to Friday (the ego-moving answer) as they are to say that it has been moved to Monday (the time-moving answer) (Boroditsky, 2000; McGlone & Harding, 1998).

But where do these representations of time come from? Is thinking about moving through time based on more concrete experiences of moving through space? If so—if representations of time are indeed tied to representations of space—then getting people to think about space in a particular way should also influence how they think about time.

STUDY 1

To investigate the relationship between spatial thinking and people's thinking about time, we asked 239 Stanford undergraduates to fill out a one-page questionnaire that contained a spatial prime followed by the ambiguous question, "Next Wednesday's meeting has been moved forward two days. What day is the meeting now that it has been rescheduled?" The spatial primes (shown in Fig. 1) were designed to get people to think about themselves moving through space in an office chair (see Fig. 1a) or making an office chair come toward them through space (see Fig. 1b). In both cases, participants were asked to imagine how they would "maneuver the chair to the *X*," and to "draw an arrow indicating the path of motion." The left-right orientation of the diagrams was counterbalanced across subjects. Immediately after subjects completed the spatial prime, they were asked the ambiguous "Next Wednesday's meeting . . ." question. We were interested in whether subjects would think differently about time right after imagining themselves as moving through space versus imagining things coming toward them.

As predicted, people used primed spatial information to think about time. Subjects primed to think of objects coming toward them through space were more likely to think of time as coming toward them (67% said Wednesday's meeting had moved to Monday) than they were to think of themselves as moving through time (only 33% said the meeting had moved to Friday). Subjects primed to think of themselves as moving through space showed the opposite pattern (only 43% said Monday, and 57% said Friday), $\chi^2(1, N = 239) = 13.3$, $p < .001$. It appears that people's thinking about time is indeed tied to their spatial thinking. These results raise a further question: Do people unwittingly change their thinking about time during everyday spatial experiences and activities (not just when processing specially designed spatial primes in a laboratory setting)?

Address correspondence to Lera Boroditsky, Department of Brain & Cognitive Science, NE20-456 MIT, 77 Massachusetts Ave., Cambridge, MA 02139; e-mail: lera@mit.edu.

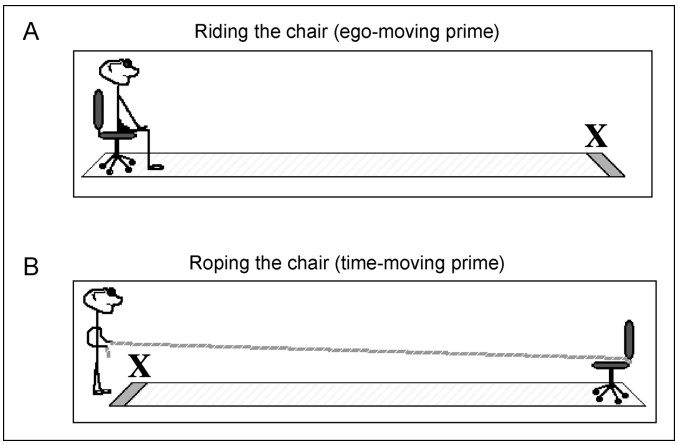

Fig. 1. The ego-moving (a) and time-moving (b) priming materials used in Study 1. The instructions began, "Imagine you are the person in the picture. Notice there is a chair on wheels, and a track." For participants in the ego-moving condition, the instructions continued, "You are sitting in the chair. While sitting in the chair, imagine how you would maneuver the chair to the *X*. Draw an arrow indicating the path of motion." For participants in the time-moving condition, the instructions continued, "You are holding a rope attached to the chair. With the rope, imagine how you would maneuver the chair to the *X*. Draw an arrow indicating the path of motion."

STUDY 2: THE LUNCH LINE

To investigate the relationship between spatial experience and people's thinking about time, we asked 70 people waiting in a lunch line the ambiguous question about Wednesday's meeting. The lunch line was for a café in the basement of Stanford's psychology department. The line is usually about 50 m long, but moves quickly, with a waiting time of about 10 min. After participants answered our ambiguous question, we asked them how long they felt they had waited in line, and also recorded which quartile of the line they were in when interviewed. This second index served as an objective measure of how much forward motion in line they had experienced (with people furthest along in line having experienced the most motion). We were interested in whether the spatial experience of moving forward in a line made people more likely to think of themselves as moving forward in time also (as opposed to thinking of time as coming toward them).

As predicted, the further along in line people were (the more forward spatial motion they had experienced), the more likely they were to think of themselves as moving through time (to say the meeting had been moved to Friday), $r = .33$, $p < .005$ (see Fig. 2). People's estimates of their waiting time were also predictive of their answers to the question about next Wednesday's meeting, $r = .26$, $p < .05$. However, their estimates of their waiting time were less predictive of their answers than was their spatial position in line. When the effect of spatial position was controlled for, people's estimates of their waiting time were no longer predictive of their answers to the ambiguous question about time, $r = .05$, $p = .67$. However, when the effect of people's perceived waiting time was controlled for, spatial position was still predictive of people's answers, $r = .20$, $p = .05$. It appears that spatial position in line (and hence the amount of forward spatial motion that a person had just experienced) was the best predictor of people's thinking about time.

In the next study, we examined whether spatial motion per se is necessary, or whether simply thinking about or anticipating a journey is enough to influence how people think about time.

STUDY 3: THE AIRPORT

To investigate whether spatial thinking is enough to influence people's thinking about time (even in the absence of spatial motion), we asked 333 visitors to San Francisco International Airport the ambiguous question about Wednesday's meeting. After the participants answered, we asked them whether they were waiting for someone to arrive, waiting to depart, or had just flown in.[1] We were interested in two things: (a) whether a lengthy experience of moving through space makes people more likely to take the ego-moving than the time-moving perspective on time, and (b) whether the actual experience of motion is necessary to change one's thinking about time, or if just thinking about motion is enough.

As shown in Figure 3, people who had just flown in were more likely to take the ego-moving perspective on time (to think of themselves as moving through time and to say the meeting was moved to Friday; 76%) than were people who had not yet flown and were waiting to depart (62%), $\chi^2(1, N = 220) = 11.8$, $p < .01$. Further, even people who were waiting to depart were already more likely to think of themselves as moving through time (62%) than were those waiting to pick someone up (51%), $\chi^2(1, N = 217) = 4.3$, $p < .05$.[2] This set of findings suggests that just thinking about spatial motion is sufficient to change one's thinking about time (because people who were only about to depart—who had not yet flown—were already more likely to take the ego-moving perspective than those just waiting to pick someone up). But these findings also raise an interesting question: Why were people who had just flown in more likely to take an ego-moving perspective than people who were only about to depart? Was it because they had spent more time actually moving through space, or was it just because they had had more time to think about it?

STUDY 4: THE TRAIN

To investigate this issue further, we posed the ambiguous question about Wednesday's meeting to 120 passengers on CalTrain (a train line connecting San Francisco and San Jose). All of the passengers were seated at the time that they were approached by the experimenter. After they answered our question, we asked them how long they had been on the train, and how much further they had to go. Participants wrote down their answers (in minutes) on a questionnaire form.

1. Although people who fly on airplanes and people waiting to pick someone up may be two different populations, people who have just flown are likely to be the same population as those about to depart on an airplane because anyone embarking on an airplane journey must both depart and arrive at least once each trip.

2. The group of people waiting to pick someone up is an interesting case. On the one hand, they were waiting for something (or someone) to come to them, and so one might predict a time-moving bias (a bias to say the meeting was moved to Monday). On the other hand, these people had just traveled to the airport and were planning a trip back home, so one might expect an ego-moving bias (a bias to say the meeting was moved to Friday). It is possible that these two opposite biasing factors canceled each other out, producing the nearly even Monday-Friday split we observed.

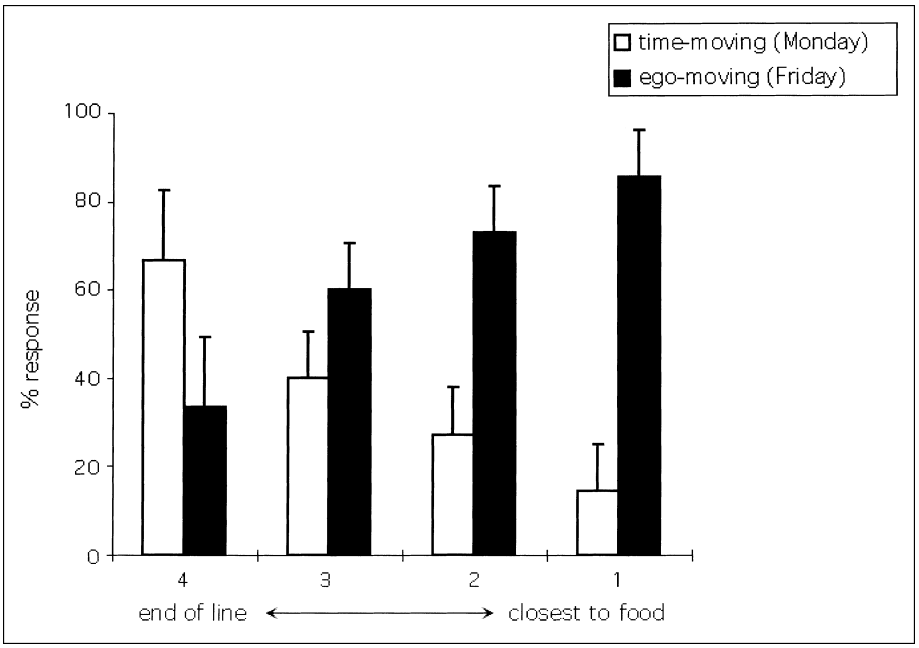

Fig. 2. Results of Study 2, in which 70 people waiting in a lunch line answered the ambiguous time question. The percentage of responses reflecting the ego-moving and time-moving perspectives is plotted as a function of position in line (from the end quartile of the line to the quartile closest to the food).

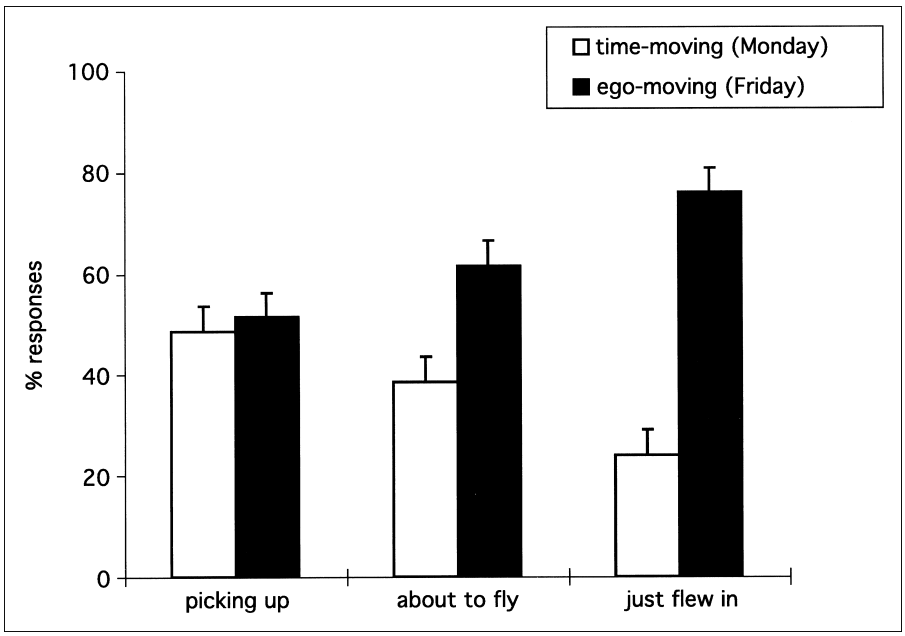

Fig. 3. Results of Study 3, in which 333 people at an airport answered the ambiguous time question. The percentage of responses reflecting the ego-moving and time-moving perspectives is plotted as a function of whether respondents had just flown, were about to depart on an airplane, or were just picking someone up.

We were interested in whether actual motion (simply sitting on a moving train) is sufficient to influence how people think about time, or whether actively thinking about one's journey is necessary in addition to the actual spatial motion. To investigate this, we analyzed whether the responses of the people on the train varied according to whether they had answered our ambiguous time question at the beginning, middle, or end of their journey. People are most likely to be involved in thinking about their journey when they have just boarded the train and when they are getting close to their destination. In the middle of their journey, people tend to relax, read, talk on cell phones, and otherwise mentally disengage from being on the train.

As shown in Figure 4, people's biases for thinking about time mimicked this pattern of engaging and disengaging from spatial thinking. Within 5 min of getting on or getting off the train, people were very likely to take the ego-moving perspective on time (77% and 91%, respectively, said the meeting was moved to Friday). Passengers in the middle of their journey, however, showed only a very slight ego-moving bias (only 55% said the meeting was moved to Friday). We calculated each participant's minimum distance (in minutes) from a trip end point (i.e., either the beginning or end of their trip, whichever was closest). The closer people were to an end point of their trip, the more likely they were to take the ego-moving perspective on time and say that the meeting had been moved to Friday, $r = .23$, $p < .01$.

Once again, it appears that people's thinking about time is tied to their thinking about spatial motion and not necessarily to the experience of motion itself. Although all three groups of passengers were having the same physical experience (all were sitting on a moving train), the two groups that were most likely to be involved in thinking about their journey showed the most change in their thinking about time.

DISCUSSION

Taken together, these studies demonstrate the intimate relationship between abstract thinking and more experience-based forms of knowledge. People's thinking about time is closely linked to their spatial thinking and their spatial experiences. When people engage in particular types of spatial thinking (e.g., thinking about their journey on a train or standing in a lunch line), they also unwittingly and dramatically change how they think about time. Further, and contrary to the very strong, embodied view (that abstract thought is based directly on sensorimotor representations), we found that actual spatial motion is neither necessary (Studies 1 and 3) nor sufficient (Study 4) to influence people's thinking about time. Rather, it is thinking about spatial motion that seems to underlie thinking about time. It appears that thinking about abstract domains is built on representations of more experience-based domains that are functionally separable from representations directly involved in sensorimotor experience itself.

But how do these relationships between abstract and concrete domains come about in the first place? It seems likely that some relationships come from correspondences that can be observed in experience. For example, progression in space and progression in time are often correlated—the longer movements are spatially, the longer the amount of time they are likely to take. These simple correspondences in experience can then be amplified and built on by language. People often use metaphors from more experience-based domains to talk about more abstract domains, and often these metaphors go beyond what can be observed in experience. This means that some abstract knowledge might be constructed and shaped by language. In fact, this turns out to be the case. For example, English and Mandarin speakers use different

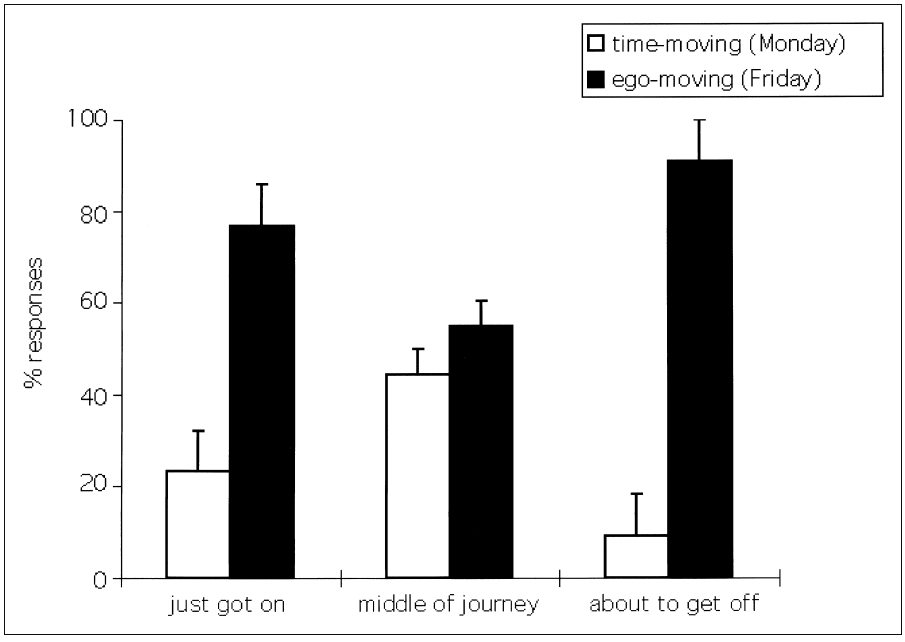

Fig. 4. Results of Study 4, in which 120 passengers on a train answered the ambiguous time question. The percentage of responses reflecting the ego-moving and time-moving perspectives is plotted as a function of point in the journey.

spatial metaphors to talk about time, and this difference in language leads to important differences in the way the two groups think about time (Boroditsky, 2001). It follows that to properly characterize abstract thought, it will be important to look not only at what comes from innate wiring and physical experience, but also at the ways in which languages and cultures have allowed us to go beyond these to make us smart and sophisticated as we are.

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