Abstract motion is no longer abstract

TEENIE MATLOCK*

University of California, Merced

Abstract

Dynamic conceptualization is a fundamental notion in cognitive linguistics. Abstract motion is one type of dynamic conceptualization. It is said to structure descriptions of static scenes such as 'The mountain range goes from Mexico to Canada', and in doing so, invokes a subjective sense of motion or state change. In recent years, a growing body of experimental research supports this claim. However, additional work is needed to understand the dynamics of abstract motion and the extent to which it generalizes. This paper provides some background on abstract motion and reports two new experiments that investigate two unexplored types of abstract motion, including visual paths and pattern paths. Together, the results indicate that abstract motion plays a central role in language use and understanding.

Keywords
abstract motion, dynamic conceptualization, fictive motion, motion verbs, perceptual simulation, path prepositions, spatial language

1. Introduction

Imagine that you're watching a TV show about travel. The camera takes you up and over a mountain range, across a lake, and onto a plateau, where it tracks

---

* Correspondence address: Teenie Matlock, Cognitive Science Program, School of Social Sciences, Humanities and Arts, University of California, Merced, CA 95343, USA. E-mail: tmatlock@ucmerced.edu. Many thanks to collaborators and friends who shared useful insights or provided comments on this research, especially Sarah Anderson, Caitlin Fausey, Paul Maglio, Yo Matsumoto, Daniel Richardson, Michael Spivey, and Leonard Talmy. Thanks also go to Nassreen El-Dahabi and Sarah Matlock for data entry and coding, and to Editor Vyvyan Evans.

Language and Cognition 2–2 (2010), 243–260 1866–9808/10/0002–0243
DOI 10.1515/LANGCOG.2010.010

a herd of mustang charging along a ravine. Bored, you reach out and press the "off" button on the remote control. You stand up, and walk across the room, grab your keys, and step out the door. You run down a flight of stairs, and as you approach the bottom step, you remember the time you tripped and sprained your ankle. You hop into your car and drive to a pizzeria. In this scenario and hundreds like it each and every day, you experience motion by engaging in physical action, watching others moving, or by imagining movement.

This paper examines *abstract motion*, which is believed to underlie spatial descriptions such as *The mountain range goes from Mexico to Canada*. The main questions are: What is abstract motion, and how is it conceptualized? Does it involve dynamic conceptualization? And if so, what does this mean for language representation and processing? Does abstract motion behave like actual motion? To answer these questions, I first provide some background on abstract motion. Second, I discuss two new experiments on unexplored forms of abstract motion, one on visual paths, and the other on pattern paths. Third, I discuss how the results of experimental work on abstract motion support the early claims by cognitive linguists and offer suggestions on future directions of exploration.

1.1. *What is abstract motion and why is it important?*

In everyday conversation, people routinely use language about motion to describe static situations. Perplexing as it may seem, this is common practice when people are describing stationary spatial layouts. In talking about a mountain range, they use descriptions such as *The mountain range goes from Mexico to Canada* or *The mountain range follows the coastline.* In talking about a trail, they use expressions such as *The trail crosses an earthquake fault* or *A trail runs along the coastline*. Even when talking about a tattoo, they use language such as *A tattoo goes down his back* or *The tattoo runs along his spine*. These constructions are ubiquitous in many languages, including English, Finnish, Japanese, Thai, Spanish, and Hindi (for example and discussion, see Huumo 2005; Matsumoto 1996; Rojo and Valenzuela 2003). They feature a subject noun phrase referent that lacks volition (e.g. mountain range, trail, tattoo) and a motion verb that conveys no motion (e.g. go, follow, run)—see Matlock (2004a) for discussion.

In the 1980s, constructions such as *The mountain range goes from Mexico to Canada* were of interest to cognitive linguists because they appealed to the idea that meaning is conceptualization (e.g. Langacker 1987). On this view, dynamic perceptual and cognitive processes were thought to motivate linguistic form. Ronald Langacker and Leonard Talmy in particular argued that these constructions invoked an implicit, fleeting sense of motion even though no motion was explicitly expressed. Langacker called it *abstract motion* (Langacker

1986), and Talmy referred to it as *fictive motion* (Talmy 1996). Yo Matsumoto called this fleeting sense of motion *subjective motion* to emphasize its subjective nature (see Matsumoto 1996). Often, this abstract motion was thought to involve simulated movement along a linearly extended trajector (subject noun phrase referent), such as a mountain range, as in *The mountain range goes from Mexico to Canada*, or along a fence, as in *A fence follows the property line*.[1] Abstract motion was also thought to involve simulated movement from one scan point to another in a series of conceptually linked objects, for instance, houses in *Houses run along Mariposa Creek* and trees in *The pine trees follow the driveway.* It was also thought to invoke mental simulation from one abstract object to another, for instance, from *A* to *B* to *C* when reciting the alphabet, or from *1* to *2* to *3* when counting (see Langacker 1986, 1987, 1999).

The early conceptual work on abstract motion revealed many valuable insights about the semantic structure of linguistic forms common in many languages. Some of the work provided rich taxonomies about types of abstract motion (see Talmy 1996, 2000). Other work was comparative, for instance, contrasting Japanese and English (see Matsumoto 1996). Some work argued that abstract motion was grounded in metaphorical knowledge anchored in motion and space (Lakoff and Turner 1989). And related work argued that the understanding of abstract motion expressions was a product of conceptual blending, by recruiting input from domains associated with actual movement (Fauconnier 1997). The idea of abstract motion, or more generally, of dynamic conceptualization, was viewed as somewhat radical in the 1980s and 1990s. At the time, many language theorists viewed linguistic representations as static constituents that could be concatenated via ordered rules (see Barsalou 2008; Gibbs 2006; Langacker 1987; Lakoff and Johnson 1999; Spivey 2007, for critiques). Nonetheless, the early work on abstract motion successfully laid the theoretical groundwork needed for experimental investigation in the years to come.

2. Prior experiments on abstract motion

Interested in the mental simulation of motion in the realm of both literal and non-literal language use and understanding, I was intrigued by abstract motion. Why would speakers of many languages choose to use motion verbs to describe static spatial scenes, and what does this say about the connection between spatial language and mental imagery? I decided to explore whether people do in fact simulate motion with sentences such as *The mountain range*

1. Note that Talmy has also used the term *virtual motion* to refer to this type of spatial description (Talmy 1983).

goes from Mexico to Canada. With colleagues, I have explored this domain with offline and online tasks that test whether abstract motion expressions, such as *The road goes from Sacramento to Los Angeles* and *A tattoo runs down his back*, do involve a fleeting sense of motion. These studies, many of which are summarized below, explore whether and how people simulate motion when interpreting spatial descriptions that contain (or do not contain) abstract motion.

2.1. *Narrative understanding tasks*

In one set of experiments, I investigated whether abstract motion language understanding includes mentally simulated motion (Matlock 2004b). The reasoning was that if people do in fact experience a fleeting sense of motion when processing sentences such as *The road goes from Sacramento to Los Angeles*, then varying information about space and motion in the immediate linguistic context should influence the way abstract motion is processed. In three experiments, participants read short passages about protagonists traveling through relatively large spatial domains (e.g. desert, valley). At the end of the passage they read an abstract motion target sentence that related to the path along which motion transpired in the earlier part of the passage (e.g. *Road 49 crosses the desert*). Participants had to quickly decide whether the target sentence matched the passage. (There were also filler tasks with target sentences that did not include abstract motion). In one experiment, the protagonist moved through the spatial scene either slowly or quickly (e.g. drove across a desert at 100 miles per hour versus 25 miles per hour). In another, the protagonist traveled a short distance or a long distance (e.g. drove across a desert that was 10 miles wide versus 100 miles wide). And in yet another, the protagonist traveled through a cluttered or an uncluttered terrain (e.g. a desert that was rough and bumpy or smooth and flat). The goal of the experiments was to determine whether varying the information about motion in the passage would influence the time it would take participants to understand and make a decision about target sentences. If people simulate motion with abstract motion, imagining movement that occurs quickly, over a short distance, and over an easy terrain should cause people to read abstract motion target sentences more quickly overall. The results were straightforward and in line with these predictions. People were generally quicker to make a decision about whether the target sentence related to the story when they had read about traveling a short distance (versus long), at a fast rate (versus slow), and over an uncluttered terrain (versus cluttered). Critically, these differences were not just the result of linguistic priming. A set of control studies with spatial sentences without abstract motion (that had been judged as similar in semantic content, such as *Road 49 is in the desert*) showed no difference across conditions in any of the three experiments.

Together, the results of these narrative understanding experiments suggested that even though sentences with abstract motion describe no motion, people appear to simulate motion when interpreting them. These experiments broke new ground in the area of mental simulation and spatial language, especially in the area of figurative language. However, many questions remain around the psychological reality of abstract motion. Does the abstract motion always involve subjective motion along a path or other trajector (e.g. faster or easier movement on a road under certain conditions)? Or might it simply involve linear extension, specifically, of a path, road, or whatever other trajector is being conceptualized? The next set of studies further pursued the understanding of abstract motion using a variety of experimental tasks.

2.2. *Drawing studies*

In another set of experiments, I used drawing tasks to test whether abstract motion would result in spatially extended trajectors in visual depictions of spatial scenes (Matlock 2006). In the first experiment, participants were asked to draw a picture to represent their understanding of various spatial descriptions with or without abstract motion, for instance, *The highway runs along the coast* and *The highway is next to the coast*. (All sentence pairs had been judged to be semantically similar prior to the experiment.) Each trajector was a long, traversable path, such as a highway or a trail. The hypothesis was that people would draw longer trajectors with spatial descriptions that included abstract motion (versus spatial descriptions that did not) because abstract motion construal would encourage linear extension. The results of this experiment showed that participants did in fact draw longer trajectors, such as highways, when they depicted spatial descriptions with abstract motion than when they depicted spatial descriptions without abstract motion.

A second drawing experiment investigated whether abstract motion would encourage participants to extend trajectors that are neither long nor short. In this case, participants were asked to draw an abstract motion sentence with a trajector that could be construed as either long or short, such as *The tattoo runs along his spine*, or *The tattoo is next to his spine*. The results, which were consistent with the first experiment, indicated that participants consistently drew longer trajectors, such as tattoos, when they were depicting spatial descriptions that included abstract motion than when they were depicting spatial descriptions that lacked abstract motion. (See also Matlock 2004a for discussion of Type 1 and Type 2 fictive motion.)

Finally, a third experiment investigated how people would draw lines to represent their understanding of trajectors in sentences with abstract motion that varied only on manner of motion. In English, motion verbs can be used non-literally to describe unusual or salient properties of a spatial scene, for instance, *The road zigzags up the hill* or *The highway races over the railroad tracks.* In the third experiment, participants generally drew longer, straighter, thinner lines with abstract motion sentences that included fast manner verbs (e.g. *race*) than abstract motion sentences that included slow manner verbs (e.g. *crawl*). The results of this experiment suggested that people are more inclined to linearly extend trajectors when abstract motion descriptions include fast manner verbs (versus slow).

Together, the results of these drawing experiments suggest that abstract motion sentences can invoke linear extension of the trajector. These results do not negate the results of the online narrative understanding tasks mentioned above (Matlock 2004b). They simply show that simulated motion is variable and adaptive. Still, more work is needed for a comprehensive understanding of the mechanisms that underlie abstract motion. Another question is whether abstract motion is comparable to actual motion, and if so how.

2.3. *Time and motion surveys*

Boroditsky and Ramscar (2002) showed that the way people conceptualize time is intimately connected to the way they conceptualize space, including the way they imagine physical movement. (For excellent discussion on the metaphorical conceptualization of time in terms of space, see Boroditsky 2000; Clark 1973; Evans 2004; Lakoff and Johnson 1980.) They showed that people's judgments about when a meeting would be held were consistently influenced by the way they had thought about physical space, including the extent to which they were thinking about motion (see McGlone and Harding 1996 for related work). Participants in one of the experiments conducted by Boroditsky and Ramscar (2002) first thought about moving toward an object or about an object moving toward them. Next they were asked to answer the ambiguous time question, *Next Wednesday's meeting has been moved forward two days. What day is the meeting now that it has been rescheduled?* (The question has been called the "ambiguous time question" or the "move forward" time question because people can correctly answer Monday or Friday, depending on how they conceptualize "moved forward"). In general, people were more likely to provide a Friday response after imagining themselves moving toward an object because it encouraged an ego-moving perspective, and more likely to provide a Monday response after imagining the object moving toward them because it encouraged a time-moving perspective. Boroditsky and Ramscar also showed that when people have actively engaged in thought about motion, for instance, when they are getting off a train or beginning a train commute, they were more likely to "move" forward through time and provide a Friday response. (For related work, see Núñez et al. 2006; Teuscher et al. 2008.)

In follow-up experimental work, Boroditsky, Ramscar, and I examined whether abstract motion would have a similar effect on temporal reasoning (Matlock et al. 2005). Our logic was that if thought about abstract motion involves simulated motion, it could have a similar influence on the way people conceptualize time. In the first experiment, some participants read a spatial description that included abstract motion, such as *The bike path runs alongside the creek* or *A tattoo runs along his spine*, and others read a spatial description that did not include abstract motion, such as *The bike path is next to the creek* or *A tattoo is next to his spine*. To make sure participants actively conceptualized the meaning of the sentence, they were asked to draw a picture to convey their understanding. Last, they answered the "move forward" time question used by Boroditsky and Ramscar (2002), *Next Wednesday's meeting has been moved forward two days. What day is the meeting now that it has been rescheduled?* The results showed that participants who read and depicted a sentence with abstract motion were more likely to provide a Friday response (70 percent of the participants in this condition) than a Monday response (30 percent), and that participants who read and depicted a sentence without abstract motion were no more likely to provide a Friday response (51 percent of the participants in this condition) than a Monday response (49 percent). These results showed that engaging in thought about abstract motion can encourage people to take an ego-moving perspective, which in turn, encourages them to "move" forward through time. In a separate analysis of the drawings in the study with colleagues Boroditsky and Ramscar, we found an interesting result (reported in Matlock et al. 2004). We examined when participants depicted actual motion in their pictures, and found that people were more likely to include motion elements, such as a person jogging, a car driving, or a bird flying, when they were depicting sentences that included abstract motion versus sentences that did not. (About 76 percent of all motion elements occurred in depictions of abstract motion).[2] These results were important because they provided further evidence that people naturally think about motion when processing language with abstract motion.

In a second experiment with Boroditsky and Ramscar, I explored whether there would be magnitude effects of abstract motion (Matlock et al. 2005). Participants first read one abstract motion sentence about pine trees that ran along a driveway and then answered the ambiguous time question. The goal

2. In an experiment on how people depict abstract motion, Michelle Greenwood and I found consistent results (Greenwood and Matlock 2009). People drew proportionally more motion elements in depictions of abstract motion expressions with fast manner motion verbs, such as *The road races past the barn*, than abstract motion expressions with slow manner motion verbs, such as *The road crawls past the barn*, or even neutral motion verbs, such as *The road goes past the barn*.

was to ascertain whether extending a series of scan points (in this case, increasing the number of pine trees along a driveway) would lead to greater linear extension in space, and hence, more and more Friday responses. In this case, participants first read about few (four), several (eight), many (20) or very many (over) trees along a driveway. The sentences were *Four pine trees run along the edge of the driveway, Eight pine trees run along the edge of the driveway, Twenty pine trees run along the edge of the driveway,* or *Over eighty pine trees run along the edge of the driveway*. After reading one of these sentences, the participants answered the "move forward" time question, *Next Wednesday's meeting has been moved forward two days. What day is the meeting now that it has been rescheduled?* The overall results showed that participants were more likely to provide a Friday response (61 percent of all responses) than a Monday response (39 percent). Closer analysis, however, showed that the proportion of Friday responses varied according to number of scan points along the driveway. Participants were more likely to provide a Friday response with eight pine trees (80 percent) and 20 pine trees (61 percent), but not with four pine trees (55 percent, not a reliable difference) or over 80 pine trees (50 percent). Hence, the overall results were consistent with the first experiment, but they also indicated that the effect of abstract motion on time could vary depending on number of scan points. A "just right" number of scan points (i.e. one that is easy to conceptualize as a path) appeared to cause people to take an ego-moving perspective and move through time toward Friday. A small number of trees may not have had the same effect because not enough scanning could occur, especially when people drew two trees on either side of the path in their drawings. And an inordinately large number of trees meant too many trees to conceptualize as a path.

In a third experiment with Boroditsky and Ramscar, I investigated direction. We were interested in whether abstract motion that explicitly includes direction would influence how people conceptualize time (Matlock et al. 2005). In particular, we investigated whether people would readily adopt a perspective that is consistent with the self moving toward a temporal landmark (Friday) or a perspective that is consistent with another entity moving toward the self (Monday). Participants in our experiment first read a sentence with abstract motion that implied direction either toward or away from the body, precisely, *The road goes all the way to New York* or *The road comes all the way from New York*. Then they read the "move forward" time question, *Next Wednesday's meeting has been moved forward two days. What day is the meeting now that it has been rescheduled?* The results revealed that more Friday responses (62 percent) than Mondays (38 percent) with the *goes to* sentence but fewer Fridays (32 percent) than Mondays (68 percent) with *comes from* sentence. This suggested that the effect brought on by abstract motion could be attributed to something more than simply a diffuse, undirected sense of motion. Rather, it appeared that direction of abstract motion could also influence the conceptualization of time.[3]

In follow up work with Ramscar and Srinivasan, I explored how direction of numbers (*5, 6, 7, 8, 9* . . . versus *9, 8, 7, 6, 5* . . .) would affect temporal reasoning (Matlock et al. 2005). Thought about numbers is anchored in spatial thought, including direction, and numbers can be conceptualized as objects (Dehaene 1997; Lakoff and Núñez 2000). Once again, we used the "move forward" question about time, *Next Wednesday's meeting has been moved forward two days. What day is the meeting now that it has been rescheduled?* Before answering this question, some participants were given the numbers 5 and 17 with 11 blanks between and asked to fill in the blanks (6, 7, and so on), and others were given the numbers 17 to 5 with 11 blanks between and asked to fill in the numbers. The reasoning behind the tasks was that filling in the blanks in canonical counting direction (forward) would encourage people to take an ego-moving perspective and move forward in time toward a Friday response, and that counting backwards would not. As predicted, people were more likely to provide a Friday response after filling in the blanks from 5 to 17 (75 percent did this), but not more likely to do so after filling in the blanks from 17 to 5 (only 41 percent). We did a second experiment with letters, for instance, *G, H, I, J* . . . and *J, I, H, G* . . . , and found similar results (see Matlock et al. 2005). The results of these two studies showed that abstract motion need not involve physical objects or actual space. Simply thinking about the direction of a series of abstract entities did influence whether people took an ego-moving perspective.

This collection of experiments on temporal reasoning and abstract motion show that abstract motion can influence the understanding of time, to some extent in the same way as actual motion (Boroditsky and Ramscar 2002). Still, we need to know how abstract motion unfolds in real time. Can processing abstract motion bring on an observable physical state change in the body, for instance, different patterns of eye movements, and if so, how?

2.4. *Eye movement studies*

If people simulate motion while interpreting sentences that include abstract motion, then simulated motion may influence how they visually process scenes that contain paths or other linearly extended trajectors. In an offline study by Matlock and Richardson (2004), participants were asked to view schematic drawings of spatial scenes on a computer screen while they passively listened to accompanying descriptions that included abstract motion or sentences that

3. Ramscar et al. (in press) conducted the experiments reported by Matlock et al. (2005) without the drawing task and found similar effects overall. These experiments eliminated the possibility that drawing played a result in the earlier work.

did not include abstract motion. During the task, their eye movements were recorded by a remote eye tracker. This method provides a fine-grain measure of where people are looking as a spoken sentence unfolds over time (for background on eye tracking in language tasks, see Tanenhaus and Spivey-Knowlton 1996, and Henderson and Ferreira 2004). On average, people spent more time viewing the region of the scene that contained relevant trajectors while they were processing sentences with abstract motion versus without abstract motion. For instance, they spent more time viewing the region of the scene that contained a cord when listening to *The cord runs along the wall* than they did when listening to *The cord is on the wall*. In a follow-up study by Richardson and Matlock (2007), participants did the same task but first heard a sentence about the terrain in the scene before hearing the sentence with or without abstract motion and before viewing the scene. In this case, they heard about a cluttered environment or a non-cluttered environment. The result was that terrain information influenced only the sentence with abstract motion. People looked longer at the trajector when they had listened to information about a cluttered terrain.

The results of these eye-tracking experiments suggest that abstract motion in language is capable of causing mental simulation of physical movement along a trajector even though objectively no motion takes place in the scene. This novel use of eye tracking allowed us to discover concrete evidence that linguistically induced mental simulations do indeed exhibit important differences as a result of the figurative use of motion verbs. Importantly, the reason such evidence was so readily forthcoming is because the cognitive processes associated with that linguistically induced mental simulation are so tightly connected to motor processes (especially eye movements) that we could see that simulated motion borne out in the eye-movement patterns themselves. That is, the reason we were able to produce concrete motoric evidence that subtle linguistic manipulations can so radically alter a mental simulation of an event is precisely because language and cognition are embodied (Gibbs 2006; Lakoff and Johnson 1999).

The constellation of experimental research discussed in this section led to new insights on the processing of abstract motion, including its role in language understanding. The experiments suggested that people simulate motion along a path or other linear trajector, or in some cases, imagine linear extension. The work suggests that abstract motion shares some properties with actual motion. It is sufficiently robust to lead people to imagine movement through time in a way that is similar to actual motion.

3. Current experiments on abstract motion

Where does abstract motion go from here? The findings from the experimental work discussed thus far support the idea that people engage in simulated motion or scanning when they are processing sentences with abstract motion. (Leonard Talmy refers to these cases as *coextension path* fictive motion, see Talmy 2000). However, all studies focused on sentences that contained motion verbs. What about other types of abstract motion, in particular, sentences that include path prepositions? Will these give rise to imagined movement or state change? And what about imperfective aspect, which implicitly highlights the ongoing nature of events? Two new experiments investigate other forms of abstract motion: visual paths and pattern paths.

Experiment 1: Visual scan paths and temporal reasoning

In everyday language, we frequently describe where we are and where objects are located relative to ourselves. One way that we do this is by using vision verbs, as in *Thomas looked at deer across the meadow* or *We see Maria getting off the plane*. In such cases, the agent subject (*Thomas, We*) is conceptualized as directing visual attention that "moves" along a path to a reference object (*deer, Maria*) (Talmy 2000). This line of sight forms a visual path that shares many properties with a motion path (see also Slobin 2008).

The first experiment extended my line of research on abstract motion and time to test the effect of visual paths on the understanding of time. Would varying the lengths of visual paths differentially influence the way people conceptualize time, and if so, how? Would increasing the length of a visual path lead to a greater chance of providing a Friday response when posed with the ambiguous "move forward" time question?

A total of 429 University of California, Merced undergraduate students volunteered for extra credit in a cognitive science or psychology course. In this experiment and the other new experiment reported in this paper, participants completed a single page in a booklet that contained various unrelated materials. Each participant in the experiment read one of the following sentences: *I can see Fred across the table*, *I can see Fred across the room*, or *I can see Fred across the field*, descriptive of short, medium, and long viewing distances, respectively. The first person was used to encourage the participants to take a subjective, first person viewpoint. Next they indicated whether the sentence was an acceptable English sentence (manipulation check). And finally, each participant answered the "move forward" time question, *Next Wednesday's meeting has been moved forward two days. What day is the meeting now that it has been rescheduled?*

Of the 138 participants who read the sentence *I can see Fred across the table* (short visual path condition), 53% gave a Friday response (47 percent gave a Monday response) when they answered the ambiguous time question about when the meeting would be held. Of the 137 participants who read *I can see Fred across the room* (medium visual path), 64% provided a Friday response (36 percent gave a Monday response). Of the 154 participants who read *I can*

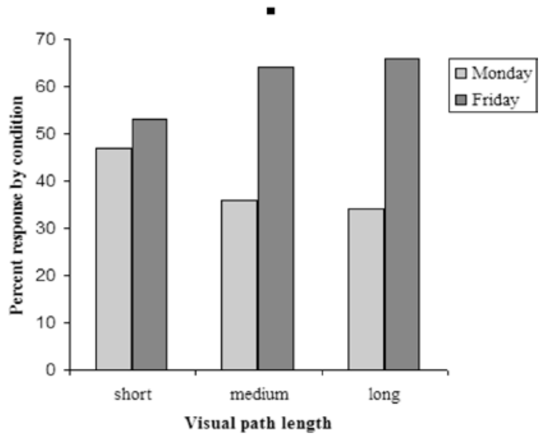

Figure 1. *Experiment 1 results show that length of visual path influenced temporal reasoning.*

see Fred across the field (long visual path), 66% gave a Friday response (34 percent gave a Monday response). A linear-by-linear association chi-square text of significance showed a reliable effect, $\chi^2(1) = 5.32$, $p = 0.02$. As shown in Figure 1, lengthening the visual path increased the likelihood of a Friday response, suggesting that more length meant more simulated action and more ego-movement through time.

The results are informative because they show that visual paths can influence the conceptualization of time in ways that are consistent with abstract motion and actual motion. Imagining directing visual attention at a referent located at close, medium, and long range, can result in increasingly more Friday responses. The results also provide evidence to support the claim that visual paths share many conceptual properties with motion paths (see Slobin 2008; Talmy 2000).

Experiment 2: Aspect and spatial distribution

There is a rapidly expanding body of work in cognitive science to support the idea that simulation is part of everyday reasoning and that it figures into language processing (see Barsalou 2008; Gibbs and Matlock 2008; Pecher and Zwaan 2005). Some of this research argues that imperfective aspect (e.g. *John was walking to work this morning*, *The boys were shooting baskets last night*) is processed differently from perfective aspect (e.g. *John drove to work this morning, The boy shot baskets last night*). Simply stated, imperfective aspect highlights details of the unfolding of situations and perfective aspect, the completion of situations. These differences are known to have implications for several forms of cognition, including memory of events (Magliano and Schleich 2000) and confidence about political attitudes (Fausey and Matlock in press). In my own work, I have argued that people process more action in a given period of time with imperfective aspect than they do with perfective aspect (Matlock in press). Because the imperfective form focuses on the ongoing nature events and draws attention to the details of the situation as it is happening in time, it invites more simulation of action in a given time period than the perfective does. (See also Anderson et al. 2008; Anderson et al. in press; Bergen 2009; Madden and Zwaan 2003; Madden and Therriault 2009.)

A total of 253 University of California undergraduate students participated for extra credit in a cognitive science or psychology course. Each participant read a perfective description, *Bob planted pine trees along his driveway last week* or an imperfective description, *Bob was planting pine trees along his driveway last week*, and specified whether the description was an acceptable English sentence. Next each participant was asked to estimate the length of the driveway. The prediction was that thought about imperfective events along a path should lead to greater linear extension of the path than thought about perfective aspect.

Prior to the analysis, 35 uninformative responses were discarded from the data set. These responses (e.g. "I don't know", "many", and "over 1") amounted to approximately 14% of the data. One additional response was removed because the driveway estimate was unusually long (1,000,000 feet). This left a total of 217 analyzable responses. An ANOVA revealed that participants provided larger driveway estimates after they had read the imperfective description ($M = 178.57$, $SD = 658.93$) than the perfective description ($M = 37.97$, $SD = 56.56$), $F(1, 216) = 5.09$, $p = 0.03$. Note that homogeneity of variance assumptions were violated (common with open-ended questions), so a non-parametric test was also conducted. For this, driveway length estimates were grouped into three categories: short (scores 14 and under), medium (15 to 29), and long scores (30 and above). The driveway length estimates of the 111 people who read the perfective description were 33% short, 32% medium, and 34% long, respectively. The estimates of the 106 people who read the imperfective description were 20% short, 31% medium, and 49% long, respectively. A chi-square test of significance showed a reliable effect, $\chi^2(1) = 6.57$, $p = 0.01$ (linear-by-linear association, two-tailed). As shown in Figure 2, imperfective aspect appears to have pushed people toward longer driveway estimates overall.

The results of the second experiment showed that imperfective aspect leads people to think farther in time and space. These results are consistent with other experiments that show how imperfective aspect focuses on the ongoing nature of events (Anderson et al. 2008, in press; Madden and Zwaan 2003; Matlock in press). What is interesting here, however, is that imperfective aspect appears to create a simulation that involves "going" from one event in time and space to another event in time and space (at least more than perfective aspect). In this way, it is like abstract motion construal, which is inherently

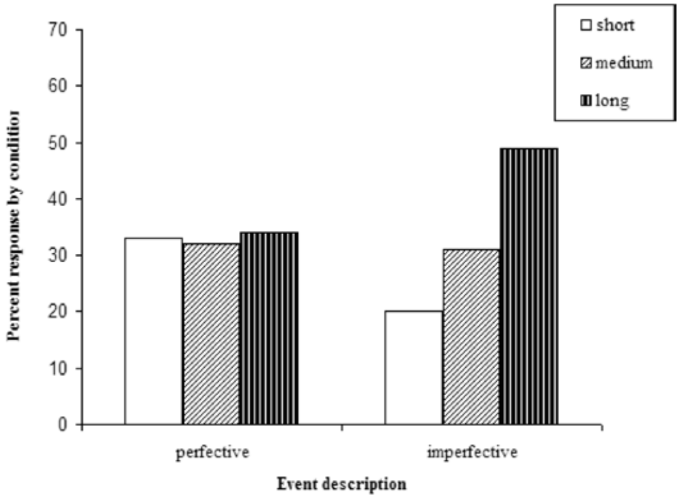

Figure 2. *Experiment 2 results show that imperfective aspect can push people toward greater length estimates.*

imperfective (see Langacker 1987). Support for this interpretation is the rare occurrence of abstract motion with imperfective aspect. Consider the oddity of the following sentence with abstract motion and imperfective aspect: *The mountain range is going from Mexico to Canada*.)

4. Discussion

In this paper, I have provided some background on abstract motion, focusing on cognitive linguists' claim that it invokes a subjective, fleeting sense of motion. I then reviewed recent experimental work on abstract motion, especially work that used reading time, drawings, surveys, and eye-tracking. In all cases, abstract motion appeared to involve dynamic conceptualization, specifically, simulated motion along the trajector or linear extension of the trajector. I then reported results from new offline studies that investigated two other forms of abstract motion. The first experiment tested whether visual scan paths of varied length would differentially influence ego-moving temporal reasoning. Visual paths across larger spatial regions resulted in increasingly more forward "movement" through time. The second experiment investigated whether imperfective aspect versus perfective aspect would differentially influence estimates about the length of an object. Imperfective led to greater linear extension of the object.

In many respects, the notion of abstract motion was ahead of its time when it was proposed by Ronald Langacker and Leonard Talmy in the 1980s. Since then many cognitive scientists have made many discoveries about how the brain processes motion (for excellent review of work on embodied cognition see Barsalou 2008; Gibbs 2006; and Pecher and Zwaan 2005). Such work has demonstrated that people simulate movement not only when they process language, but in all sorts of other situations. They physically simulate actions when they are solving everyday physics problems, and this improves their ability to do so (Schwartz and Black 1999). They mentally simulate locations of actions when imagining spatial scenes (Spivey and Geng 2001). And they also simulate movement when they are engaged in mechanical reasoning (Hegarty 2004). Moreover, when people observe others engaging in action (e.g. grasping), motor areas show patterns of activation that are consistent with self-initiated action (Rizzolatti and Sinigaglia 2008). And last, areas of the brain known to be associated with perceived action are activated from nothing more than the mere hint of motion in a static image (Kourtzi and Kanwisher 2000).

So, at this point, it is reasonable to conclude that abstract motion is less abstract than it once was. Much more is known about processing of perceived and imagined motion, and there is far more data to support the idea that people simulate motion than there was 30 years ago. And more to the point, recent work on abstract motion shows that it is no different. Where do we go from here? It will be informative to design experiments to examine the conceptual structure of the role of abstract motion in processing spatial language in languages other than English. Though some work has been done on abstract motion in other languages, including Hindi (Mishra 2009) and Danish (Wallentin et al. 2005), far more work could be done. It will be useful to conduct further brain imaging work on abstract motion to determine whether areas associated with motion perception will be activated when processing sentences such as *The road goes from Sacramento to Los Angeles.* One early imaging study by Saygin et al. (in press) shows that fictive motion sentences, such as *The highway runs from Modesto to Fresno*, can elicit a small but detectable MT+ response, which is consistent with earlier, behavioral work, including Matlock (2004b). Additional work of this sort will provide even deeper insights into how an abstract motion simulation unfolds in time. Last, naturalistic studies on abstract motion, including joint spatial tasks, will also be valuable to studying how and when people generate expressions with abstract motion in everyday conversation. For now, there are many domains of abstract motion yet to be explored. A long and winding road awaits.

References

Anderson, S., T. Matlock, C. M. Fausey & M. J. Spivey. 2008. On the path to understanding the on-line processing of grammatical aspect. *Proceedings of the 30th annual meeting of the Cognitive Science Society.* 2253–2258.

Anderson, S., T. Matlock & M. J. Spivey. 2010. The role of grammatical aspect in the dynamics of spatial descriptions. *Proceedings of spatial cognition 2010*. Springer Lecture Notes in Computer Science/Lecture Notes in Artificial Intelligence Series.

Barsalou, L. W. 2008. Grounded cognition. *Annual Review of Psychology* 59. 617–645.

Bergen, B. & K. Wheeler. 2010. Grammatical aspect and mental simulation. *Brain and Language*. 150–158.

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

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

Clark, H. H. 1973. Space, time, semantics, and the child. In T. E. Moore (ed.), *Cognitive development and the acquisition of language*. San Diego: Academic Press.

Dehaene, Stanislas. 1997. *The number sense: How the mind creates mathematics*. Oxford University Press.

Evans, V. 2004. *The structure of time: Language, meaning and temporal cognition*. Amsterdam: John Benjamins.

Fauconnier, G. 1997. *Mappings in language and thought*. New York: Cambridge University Press.

Fausey, C. & T. Matlock. 2010. Can grammar influence voting? *Proceedings of the 32nd annual meeting of the Cognitive Science Society*, Portland, Oregon.

Gibbs, R. W. 2006. *Embodiment and cognitive science*. New York: Cambridge University Press.

Gibbs, R. W. & T. Matlock. 2008. Metaphor, imagination, and simulation: Psycholinguistic evidence. In R. W. Gibbs (ed.), *Cambridge handbook of metaphor and thought*, 161–176. New York: Cambridge University Press.

Greenwood, M. & T. Matlock. 2010. That's the way it goes with fictive motion. *Proceedings of the 31st annual conference of the Cognitive Science Society*.

Hegarty, M. 2004. Mechanical reasoning by mental simulation. *Trends in Cognitive Science* 8. 280–285.

Henderson, J. M. & F. Ferreira (eds.). 2004. *The integration of language, vision, and action: Eye movements and the visual world.* New York: Psychology Press.

Huumo, T. 2005. How fictive dynamicity motivates aspect marking: The riddle of the Finnish quasi-resultative construction. *Cognitive Linguistics* 16. 113–144.

Kourtzi, Z. & N. Kanwisher. 2000. Activation in human MT/MST by static images with implied motion. *Journal of Cognitive Neuroscience* 12. 48–55.

Lakoff, G. & M. Johnson. 1980. *Metaphors we live by*. Chicago, IL: Chicago University Press.

Lakoff, G. & M. Johnson. 1999. *Philosophy in the flesh: The embodied mind and its challenge to western thought.* New York: Basic Books.

Lakoff, G. & R. Núñez. 2000. *Where mathematics comes from: How the embodied mind brings mathematics into being.* New York: Basic Books.

Lakoff, G. & M. Turner. 1989. *More than cool reason*. Chicago: The University of Chicago Press.

Langacker, R. W. 1986. Abstract motion. *Proceedings of the 12th annual meeting of the Berkeley Linguistics Society*. 455–471.

Langacker, R. W. 1987. *Foundations of cognitive grammar: Theoretical prerequisites.* Stanford, CA: Stanford University Press.

Langacker, R. W. 1999. *Grammar and conceptualization*. Berlin: Mouton de Gruyter.

Madden, C. J. & R. Zwaan. 2003. How does verb aspect constrain event representations? *Memory and Cognition* 31. 663–672.

Madden, C. J. & D. J. Therriault. 2009. How does verb aspect constrain perceptual representations? *Quarterly Journal of Experimental Psychology* 62. 1294–1302.

Magliano, J. P. & M. C. Schleich. 2000. Verb aspect and situation models. *Discourse Processes* 29. 83–112.

Matlock, T. 2004a. The conceptual motivation of fictive motion. In G. Radden & R. Dirven (eds.), *Motivation in grammar*, 221–248. Amsterdam: John Benjamins.

Matlock, T. 2004b. Fictive motion as cognitive simulation. *Memory and Cognition* 32. 1389–1400.

Matlock, T. 2006. Depicting fictive motion in drawings. In J. Luchenbroers (ed.), *Cognitive linguistics: Investigations across languages, fields, and philosophical boundaries,* 67–85. Amsterdam: John Benjamins.

Matlock, T. In press. The conceptual motivation of aspect. In G. Radden, P. Koch & K.-U. Panther (eds.), *Motivation in grammar and the lexicon: Cognitive, communicative, perceptual and socio-cultural factors.* Amsterdam & Philadelphia: John Benjamins.

Matlock, T., M. Ramscar & L. Boroditsky. 2004. The experiential basis of motion language. In A. Soares da Silva, A. Torres & M. Gonçalves (eds.), *Linguagem, cultura e cognicao: Estudo de linguistica cognitiva,* 43–57. Coimbra: Almedina.

Matlock, T., M. Ramscar & L. Boroditsky. 2005. The experiential link between spatial and temporal language. *Cognitive Science* 29. 655–664.

Matlock, T., M. Ramscar & M. Srinivasan. 2005. Even the most abstract motion influences temporal understanding. *Proceedings of the 27th annual conference of the Cognitive Science Society.* 2527.

Matlock, T. & D. C. Richardson. 2004. Do eye movements go with fictive motion? *Proceedings of the 26th annual conference of the Cognitive Science Society.* 909–914.

Matsumoto, Y. 1996. Subjective motion and English and Japanese verbs*.* *Cognitive Linguistics* 7. 183–226.

McGlone, M. S. & J. L. Harding. 1998. Back (or forward?) to the future: The role of perspective in temporal language comprehension. *Journal of Experimental Psychology: Learning Memory and Cognition* 24(5). 1211–1223.

Mishra, R. 2009. Interaction of language and visual attention: Evidence from production and comprehension. *Progress in Brain Research*. 277–292.

Núñez, R., B. A. Motz & U. Teuscher. 2006. Time after time: The psychological reality of ego- and time-reference-point distinction in metaphorical construals of time. *Metaphor and Symbol* 21. 133–146.

Pecher, D. & R. A. Zwaan (eds.). 2005. *Grounding cognition: The role of perception and action in memory, language, and thinking*. Cambridge, UK: Cambridge University Press.

Ramscar, M., T. Matlock & M. Dye. In press. Running down the clock: The role of expectation in our understanding of time and motion. *Language and Cognitive Processes*.

Richardson, D. C. & Matlock, T. 2005. The integration of figurative language and static depictions: An eye movement study of fictive motion. *Cognition* 102. 129–138.

Rizzolatti, G. & C. Sinigaglia. 2008. *Mirrors in the brain: How our minds share actions, emotions, and experience.* Oxford: Oxford University Press.

Rojo, A. & J. Valenzuela. 2003. Fictive motion in English and Spanish. *International Journal of English Studies* 3. 123–150.

Saygin, A., S. McCullough, M. Alač & K. Emmorey. In press. Modulation of BOLD response in motion-sensitive lateral temporal cortex by real and fictive motion sentences. *Journal of Cognitive Neuroscience*.

Schwartz, D. L. & T. Black. 1999. Inferences through imagined actions: Knowing by simulated doing. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 25. 116–136.

Slobin, D. I. 2008. Relations between paths of motion and paths of vision: A crosslinguistic and developmental exploration. In V. C. Mueller Gathercole (ed.), *Routes to language: Studies in Honor of Melissa Bowerman*, 197–221. Mahwah, NJ: Lawrence Erlbaum Associates.

Spivey, M. J. 2007. *Continuity of mind*. New York: Oxford University Press.

Spivey, M. & J. Geng. 2001. Oculomotor mechanisms activated by imagery and memory: Eye movements to absent objects. *Psychological Research* 65. 235–241.

Talmy, L. 1983. How language structures space. In H. Pick & L. P. Acredolo (eds.), *Spatial orientation: Theory, research, and application*, 225–282. New York: Plenum Press.

Talmy, L. 1996. Fictive motion in language and "ception". In P. Bloom, M. A. Peterson, L. Nadel & M. F. Garrett (eds.), *Language and space*, 211–276. Cambridge, MA: MIT Press.

Talmy, L. 2000. *Toward a cognitive semantics, volume I: Conceptual structuring systems*. Cambridge: MIT Press.

Tanenhaus, M. K. & M. J. Spivey-Knowlton. 1996. Eye-tracking. Special issue: A guide to spoken word recognition paradigms. *Language and Cognitive Processes* 11. 583–588.

Teuscher, U., M. McQuire, J. Collins & S. Coulson. 2005. Congruity effects in time and space: Behavioral and ERP measures. *Cognitive Science* 32. 563–578.

Wallentin, M., T. E. Lund, S. Østergaard, L. Østergaard & A. Roepstorff. 2005. Motion verb sentences activate left posterior middle temporal cortex despite static context. *NeuroReport* 16. 649–652.