Figurative language processing: Fictive motion and the visual world

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Abstract

This chapter is concerned with visual processing in the context of figurative language. Included is background on research that has used the visual world paradigm to study the processing of fictive motion sentences. These sentences, which are ubiquitous in everyday language, include a motion verb but describe no motion (e.g., "A road goes through the desert", "The cord runs along the wall"). Also included is discussion of emerging concepts that form novel hypotheses for how figurative language is processed. This chapter grounds fictive motion processing in interactive dynamical systems and takes figurative language in a new direction.

1. Introduction

Figurative language is pervasive. We read it in poems, such as “O my love’s like the melody that's sweetly played in tune,” in Robert Burns’s “Red, Red Rose”. We hear it in song lyrics, such as “Despite all my rage, I’m still just a rat in a cage,” in Smashing Pumpkins’ “The World is a Vampire”. We read it in newspaper headlines, such as *Newsweek*’s “Obama is trailing with older voters,” prior to the 2008 presidential election. Most of all, we use it in everyday conversations, in expressions such as “I’m feeling down today,” “Business is picking up,” or “Don’t get ahead of yourself.” In this chapter, we discuss figurative language in light of eyetracking research and argue that it is understood via simulations grounded in perceptual experience. We focus on fictive motion expressions, such as *A road goes through the desert* and *The cord runs along the wall*. These sentences are figurative because they include motion verbs but convey no actual physical movement.

We begin with background on the semantics of figurative language. We then provide a summary of recent experiments on fictive motion processing, including eyetracking experiments. We next discuss figurative language in light of the visual-world paradigm, and how ideal this approach is for pinpointing the nature of distributed simulations that drive the use and understanding of figurative language. We close by discussing implications of work on eyetracking and figurative language, and consider new and promising avenues of exploration.

2. Figurative language

Until recently, the term *figurative language* was often used to characterize expressions that substantially differ from everyday literal linguistic forms. Figurative expressions were viewed as statements that were embellished by metaphor, simile, metonymy, and other tropes to make a message more entertaining or captivating. As such, they were thought to have little consequence on processing or to be irrelevant to a rational view of the mind (Pollio, Smith & Pollio, 1990; Grice, 1975; Searle, 1979). Over the past 50 years, many lively debates have emerged around figurative language, including its place in everyday language. Lakoff and Johnson (1980) challenged the idea that metaphor or other forms of figurative language are special by showing how they structure much of everyday language and thought. On this view, it is no accident that people say things like "I'm *headed* for a nervous breakdown" or "This relationship has *hit* a deadend," because people often think of emotions, romance, work, and all sorts of things in terms of motion. Rumelhart (1979) and Gibbs (1994) also challenged the strong dichotomy that once existed between figurative and literal by showing that it is often unclear what counts as literal and what counts as figurative. For example, few English speakers would consciously interpret a statement such as "Bob is in a meeting" as figurative because there is no literal containment (compare to "Bob is in his car or Bob is in his swimming pool"), even if the meeting is conducted by phone (for additional discussion on the gradation between literal and metaphorical, see Coulson & Matlock, 2001). Even though much debate remains about how figurative language is interpreted (e.g., mapping from a source domain to target domain in the case of basic conceptual metaphor), it is now generally agreed that figurative language is part of everyday language, and that as such, it is no more difficult to process than literal language (see Gibbs 1994; Katz, Cacciari, Gibbs, & Turner, 1998; Lakoff, 1987; Lakoff & Turner, 1989).

Everyday language is replete with non-literal spatial descriptions, such as "A road *runs* through the forest", "The trail *goes* across campus," "A fence *follows* the coastline," or "A cord *runs* from the bedroom to the kitchen". These figurative expressions contain a motion verb, but the implied meaning is of static spatial descriptions. The subject noun phrase referent of each sentence is an object or set of objects that is inherently static and linearly extended in space. In some cases, this subject noun phrase referent can be a single object that is associated with motion activities. For instance, cars, trucks, and other vehicles are known to move along roads, and pedestrians and bicyclists are known to move along trails. In other cases, the subject noun phrase referent is a single elongated object not associated with motion. We do not ordinarily think of movement along a fence or cord. In still other cases, it is a series of objects not associated with motion, for instance, pines trees or lamps along driveways, or windows along walls (see Matlock 2004a, for discussion). Fictive motion sentences are found in informal and formal registers and occur in many languages of the world, including Japanese (Matsumoto, 1997), Thai (Takahashi, 2000), Spanish (Rojo & Valenzuela, 2003), Hindi (Mishra & Singh, 2010), and Finnish (Huumo, 2005). In all cases, the only motion experienced is a fleeting subjective sense of motion or state change by the person producing or comprehending the sentence (see Matlock 2010; Matsumoto, 1997; Talmy, 1996, 2000).

At the lexical level of language comprehension lies a crucial debate on discerning figurative versus literal. A dictionary-like definition view of meaning representations in the mind leads to positing that there must be several entries in one's mental lexicon, with one or more being concrete and the rest being figurative uses that one could reference when needed. On this view, one would reference the literal meaning first, and then non-literal meaning would be referenced only when the literal meaning mismatches with context (Giora, 1999). This emphasis on context-selectivity seems to imply a clear divide between literal and figurative language, as well as having a process that operates by logically and clearly ruling out a literal meaning before a non-literal meaning can be activated (Sperber & Wilson, 1995). Indeed, sometimes literal and figurative meanings appear to be simulated or imaged differently, where literal meanings exhibit more well-formed and detailed visual components (Bergen, Lindsay, Matlock & Narayanan, 2007). But the explanation for this phenomenon, as we will see, does not rely on multiple stages, or positing different mechanisms for literal and figurative meanings. Rather a probabilistic activation account in which embodied features are simply less active and cohesive is supported by many experimental results.

Recent empirical evidence on figurative language has come to show that figurative meanings may be directly accessed, based on similar reading times for figurative and literal sentences (Ortony et al., 1978; Inhoff, 1984; Gibbs, 1986). But novel idioms and metaphors still appear to show a bias toward interpreting the meaning firstly as literal for at least a very brief time period, if even for a few hundred milliseconds (e.g., Blasko & Connine, 1993; see also Cacciari & Tabossi, 1988). Fictive motion and the visual world paradigm provide a fertile garden in which to grow our current understanding of figurative language issues and debates because they can provide insight into the real-time temporal dynamics of incremental language comprehension. Here we argue that literal meaning is a distributed representation where rapid sensory uptake and contextually-driven learning create an interactive human-environment coupling appropriate to extremely fast interpretation of learned figures of speech, as well as interpretation of novel phrases.

The time course of simulating this motion is during the processing of the sentence itself. Thus, measures that sample at the endpoint of a sentence (i.e., total reading times, forced-choice responses) do not address a brief moment in time during which a concrete meaning may be activated. It also may not be sensitive enough to pick up on the gradations between a supposed purely literal statement and a purely figurative one. Rather, overlapping features, and thus overlapping neural activation patterns may result in comprehension and behaviors that also overlap with one another. This theory is compatible with the processing of fictive motion, where evidence clearly shows some simulation of motion, but where participants in these studies are not consciously aware of having processed a static description differently from the fictive motion scenarios. As such, it is very likely this simulation of motion is *not* a rich 3D model of actual motion, but rather subtle activation of action events, *not* requiring any use of mental imagery.

3. Processing fictive motion expressions

In recent years, the processing of fictive motion sentences has been investigated using various methods, including narrative understanding, drawing studies, surveys, and eye-tracking tasks. These studies have investigated the connection between thought about actual motion and thought about figurative motion, and ultimately, how an apt interpretation is realized. Central issues have been how people process these sentences, which are somewhat abstract (motion verb but no motion is realized), and what it reveals about creating figurative meaning on the fly.

Narrative understanding tasks

One set of experiments investigated whether fictive motion language understanding includes mentally simulated motion (Matlock 2004b). The logic was that if people experience a fleeting sense of motion while processing sentences such as *The road goes from Sacramento to Los Angeles*, then varying information about space and motion in the immediate linguistic context ought to affect fictive motion processing. In three experiments, participants read passages about travel through particular spatial domains (e.g., desert, valley). After each they read a fictive motion target sentence that related to the path along which motion transpired earlier in the passage (e.g., "Road 49 crosses the desert"). Participants made a timed decision about whether the target sentence matched the passage. In one experiment, a protagonist was described as moving through the spatial scene 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 or long distance (e.g., 10 miles versus 100 miles). In still another experiment, the protagonist traveled through a cluttered or uncluttered terrain (e.g., bumpy or smooth). The aim of these experiments was to ascertain whether varying motion information in the passage would influence time taken to read and make a decision about fictive motion target sentences. If people simulate motion similarly to how real paths are traversed, short distances and easy terrain should cause people to read abstract motion target sentences more quickly overall. The results were consistent with the predictions. People were quicker to decide 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, control studies ruled out the possibility that these differences were the result of linguistic priming.

Together, the results of these experiments provided evidence to support the idea that people experience a fleeting sense of motion or state change while interpreting fictive motion. These results are very similar to mental rotation and imagery studies, where the degree of rotation or imagined distance on a map are directly proportional to the amount of time taken to respond (e.g. Shepard & Metzler, 1971; Hochberg & Gellman, 1977). Likewise, a mental simulation corresponds to characteristics such as distance traveled, taking less time to make a decision when the distance traveled is shorter. Further work was needed to understand the nature of this kind of motion simulation. One question is whether fictive motion is subjectively experienced motion that transpires along some portion of a trajector (subject noun referent, such as a *road* in *The road goes along the coastline*, see Langacker, 1987), or conversely, whether it involves linearly extending the object itself.

Drawing studies

Drawing experiments were also conducted to test how people would visually depict spatial descriptions with and without fictive motion (Matlock 2006). In the first experiment, participants drew a picture to represent their understanding of sentences such as "The highway runs along the coast" or "The highway is next to the coast". In both conditions, trajectors were always a long, traversable path (e.g., highway, trail). As predicted, people drew longer paths when sketching pictures of fictive motion descriptions. A second drawing experiment investigated how participants would depict trajectors that are not necessarily long. In this case, participants drew a fictive motion sentence with a trajector that could be construed as either long or short, such as a tattoo in a depiction of "The tattoo runs along his spine" or "The tattoo is next to his spine". These results also showed longer trajectors in depictions of spatial descriptions with fictive motion. (See also Matlock 2004a, for discussion of Type 1 and Type 2 fictive motion.) A third experiment explored how people would draw lines to represent their understanding of trajectors in sentences with fictive motion that varied in terms of manner of motion. (In English, motion verbs can be used non-literally to describe unusual or salient properties of a shape or form in a spatial scene, for instance, "The road zigzags up the hill" or "The highway races over the railroad tracks") Participants in this third experiment drew longer, straighter, and thinner lines with fictive motion sentences that described fast manner verbs (e.g., *race*) versus slow manner verbs (e.g., *crawl*).

The drawing experiments demonstrated how fictive motion sentences can invoke linear extension of the trajector and not the object itself. These results are consistent with the narrative understanding results (Matlock 2004b), because they show that simulated motion has some of the properties of actual motion, where actual motion is influenced by things like the kind of terrain being traversed. Still, more work is needed for a comprehensive understanding of the mechanisms that underlie fictive motion, and a closer look at how time is related to spatial displacements was clearly warranted.

Time and motion surveys

Boroditsky and Ramscar (2002) conducted several experiments to support the claim that thoughts about time, a relatively abstract concept, are closely connected to thoughts about space and motion. (see also Boroditsky, 2000; Clark, 1973; Evans, 2004; Lakoff & Johnson, 1980) They showed that people's judgments about when a meeting would be held are uniformly influenced by how they conceptualize motion (see also McGlone & Harding, 1998). Participants in one experiment first thought about moving toward an object or an object moving toward them, and later answered this ambiguous question about a meeting: "Next Wednesday's meeting has been moved forward two days. What day is the meeting now that it has been rescheduled?" The question is ambiguous because Monday and Friday are both correct depending on how *moved forward* is conceptualized. People were more likely to provide a Friday response after imagining moving toward an object because it encouraged an ego-moving perspective. Comparatively, they were more likely to provide a Monday response after imagining the object moving toward them, because it encouraged a time-moving perspective (see also Núñez, Motz, & Teuscher, 2006; Teuscher, McQuire, Collins, & Coulson 2008).

In follow-up work, Matlock, Ramscar, and Boroditsky (2005) examined whether fictive motion would have a similar effect on temporal reasoning. The reasoning was that if thought about fictive motion includes simulating motion, this should extend the temporal window within the conceptualization of the sentence. In the first experiment, some participants read a spatial description that did or did not include fictive motion, such as "The bike path runs alongside the creek or The bike path is next to the creek*". Participants were instructed to draw a picture to convey their understanding (to make sure they were paying attention and engaged in the task). Next, they answered the ambiguous *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 fictive motion were more likely to provide a Friday response (70 percent of participants in this condition) than a Monday response (30 percent), and that participants who read and depicted a sentence with no fictive motion were no more likely to provide a Friday response (51 percent of participants in this condition) than a Monday response (49 percent). In a separate analysis of the drawings, it was observed that participants were also 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 fictive motion versus sentences that did not. Approximately 76 percent of all motion elements appeared in depictions of fictive motion (see Matlock, Ramscar, & Boroditsky 2004). These results lent further evidence to support the findings that people naturally think about motion, a durative and concrete event, when processing fictive motion. However, this is not to say fictive motion would be different from descriptions from actual motion like "John walked to the store to buy a loaf of brea*d*". In fact, the simulation of motion in a more abstract sense may be very similar, but further comparative work is needed to determine how discriminable they are.

A second experiment by Matlock, Ramscar, and Boroditsky (2005) explored magnitude effects of fictive motion. Participants read one fictive motion sentence about pine trees that ran along a driveway and then answered the ambiguous time question. The aim of the study was to ascertain whether extending a series of scan points (in this case, increasing the amount of pine trees along a driveway) would results in greater linear extension, and hence, more and more Friday responses. Participants 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". Next, they answered the *forward* time question, "Next Wednesday's meeting has been moved forward two days. What day is the meeting now that it has been rescheduled?" Participants were more likely to say Friday (61 percent of all responses) than Monday (39 percent), but closer analysis 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). So, although the overall results were consistent with the first experiment, they showed that the effect of fictive motion on time varied depending on number of scan points. An intermediate number yielded an easy to conceptualize path and appeared to drive an ego-moving perspective, moving through time toward Friday. Few trees did not have the same effect because not enough scanning could occur, and an inordinately large number of trees meant too many trees to conceptualize as a path. Thus, there were gradations in the amount of motion implied, based on a visual context. Just as time and motion are continuous in the real world, so are they processed in the mind.

A third experiment by Matlock et al. (2005) investigated fictive motion and direction. The aim was to explore how fictive motion with explicit spatial direction would influence the conceptualization of time. Of interest was whether people would readily adopt a viewpoint that was consistent with the self moving toward a temporal landmark (Friday) or a viewpoint that is consistent with another entity moving toward the self (Monday). Participants first read a sentence with fictive 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", and then 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 more Friday responses (62 percent) than Mondays (38 percent) with the *goes to* fictive motion sentence but fewer Fridays (32 percent) than Mondays (68 percent) with *comes from* fictive motion sentence. Based on these results, it is reasonable to assume that fictive motion direction can also influence the conceptualization of time. Moreover, the effect brought on by fictive motion is directional and not simply a diffuse, undirected sense of motion.

In follow-up work, Matlock, Ramscar and Srinivasan (2005) explored the connection between reasoning about numbers (*5, 6, 7, 8, 9*… versus *9, 8, 7, 6, 5*…) and temporal reasoning. Numerical reasoning is known to be anchored in spatial thought, especially direction (Dehaene, 1997; Lakoff & Núñez, 2000). The task used the move-forward question, and 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 logic 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. 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). In a second experiment with letters, for instance, *G, H, I, J…* and *J, I, H, G…*, similar results were obtained. The results of these two studies showed that abstract motion need not involve physical objects or actual space. Merely thinking about the direction of a series of abstract entities affected whether people took an ego-moving perspective (see also Matlock, Holmes, Srinivasan, & Ramscar, under review).

These experiments on temporal reasoning revealed that non-literal motion can influence the understanding of time, to some extent in the same way as actual motion. However, there are still many questions about how fictive motion is interpreted in real time. Is the processing of fictive motion tied to general mechanisms that process motion? If these kinds of shared general processes are at work in generating the meaning of fictive motion, it would provide strong evidence that these seemingly abstract forms of language are intimately tied to the body's sensory and motor processes. These results are in line with the embodiment paradigm, where the information that constitutes thought is based in both the body's actions, as well as extending out into the environment (e.g. Hirose, 2002; Gibbs, 2006; Pecher & Zwaan, 2005).

Eye movement studies

If people simulate motion while interpreting sentences that include fictive motion, then simulated motion may influence how they visually process scenes that contain paths or other linearly extended trajectors. In an eyetracking 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 did not include abstract motion. During the task, eye movements were recorded by a remote eyetracker providing a fine-grain measure of where people are looking as a spoken sentence unfolds over time (Tanenhaus & Spivey-Knowlton, 1996; see also Henderson & Ferreira, 2004). On average, people spent more time viewing the region of the scene that contained relevant trajectors while they were processing sentences with fictive motion versus without fictive 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." This points to an emphasis on motion when static objects are described with motion verbs.

Indeed, fictive motion does exert an influence on processing of static visual scenes, but with a high degree of interactivity. Richardson and Matlock (2007) studied fictive motion sentences in congruence with static visual scenes. This was combined with a manipulation of a description of a path that was either difficult (e.g. "the valley was bumpy and uneven") or easy ("the valley was flat and smooth"). Importantly, the picture is the same in both conditions, and only the description of the path is different. In this instance, fictive motion sentences did not exhibit a main effect, but when combined with path descriptions, an interaction emerged between fictive motion and path description. With static descriptions of the path, there was no difference in eye-movement patterns for difficult and easy terrains. However, with fictive motion descriptions of the path, difficult terrain descriptions induced more scanning of the path itself, and easy terrain descriptions induced less scanning. The possible implications for this work are exciting to sentence processing in general, as it points toward grounded representations being integrated immediately, even in the absence of visual features indicating whether this path is difficult or easy.

This result is consistent with an interactive context-selective account of figurative language comprehension, but it does not necessarily require that figurative meanings be accessed "directly." A temporally dynamic interaction amongst the perceptual features that are associated with the words can account for all of these results. Rather than having to choose between the direct access account (where literal meanings are bypassed and figurative meanings are immediately constructed) and a two-stage account (where the literal meaning is accessed first, and then the figurative meaning is accessed in a second stage of processing), it maybe that multiple contextual factors conspire simultaneously to impart partial graded activation to both meanings at the same time. A competitive settling process then allows the majority bias from all the contextual and statistical factors (all of whom began their influence instantly, not in separate stages) to gradually resolve on one or the other meaning over the course of several hundred milliseconds (see, for example, Cacciari & Tabossi, 1988, for idiom comprehension; Kawamoto, 1993, for lexical ambiguity resolution; MacDonald, Pearlmutter, & Seidenberg, 1994, for syntactic ambiguity resolution). An embodied neural account for this would involve activation in the mental lexicon being shared with other brain regions (cascading activation), where this activation then unavoidably activates perceptual and motor features that one has learned to associate with the words (Pulvermüller, Shtyrov, & Ilmoniemi, 2005; Simmons, Hamaan, Harenski, Hu, & Barsalou, 2008). These are concrete sensorimotor features that are being activated by figurative meanings, many of which are shared in a richly connected neural network.

For example, imagine a sentence that begins with "That one rocky hill that runs up to the university...". At each word, the associated distributed meaning representation grows and changes dynamically over time, initially consisting of some sharp angles associated with many rocks, some faintly-active motor coordinates of actual running, and perhaps a higher level emergent concept of a man-made dwelling (the university) that has been learned from perceptual features and a rich network of words and meanings associated with a university. Current views of perceptual simulation of language generally benefit from these results and fit with this story. Crucially, a theory of perceptual simulation could greatly benefit from the addition of realistic neural mechanisms and computations, namely beginning with cascading activation. For example, the word "rocky" might activate visual and motoric features of bumpiness, and these features would then subtly tweak the range of features that get activated by the rest of the sentence as each next word is heard, including the word “runs”, which modestly activates sensorimotor features of actual running and will do so slightly differently in the context of “rocky.” Thus, fictive motion's contribution to processing is a continuum of motion, where context can affect the total amount of information simulated, or perhaps the speed at which something is simulated. Exactly what this distributed representation consists of requires further investigations, but it is likely to rely on this richly connected network of feature associations and shared activation.

Accordingly, these eye-tracking experiments suggest that fictive motion in language is capable of inducing some faintly active mental simulation of physical movement along a path, 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 because language and cognition are embodied (Gibbs, 2006; Lakoff & Johnson, 1999).

And so even though we have begun to consider how this kind of information interacts and influences processing, many questions must be addressed before any computational models of figurative language can be forged. A perceptual simulation is likely composed of percepts and features from vision, audition, proprioception, and all the sensory modalities, as well as more abstractly encoded heteromodal areas. On top of this, the way these features come to be activated in response to the spoken word is unknown. This process of how something comes to be can elegantly be addressed with the visual world paradigm.

Sensibly named, the visual-world paradigm takes advantage of how visually-driven we are as a species. Operationally, the visual-world paradigm is based upon the tenant of eye-movements being time-locked to speech. When presented with a set of pictures on a computer screen, one's eyes will tend to move to the picture of an apple when a sentence makes reference to "apple", with a delay of as little as 200ms (Cooper, 1974), the time it takes to plan and launch a saccade (Matin, Shao & Boff, 1993). Creating tasks that present visual referents allows for the careful examination of the time course of activating a particular word or parsing a sentence (e.g., McMurray, Tanenhaus & Aslin, 2002; Tanenhaus, Spivey-Knowlton, Eberhard & Sedivy, 1995). Further, in the past 10 years, this general paradigm has become less constrained. It now allows researchers to analyze eye movements during events such as natural conversation (Brown-Schmidt & Tanenhaus, 2008) and free-scene viewing (Richardson & Matlock, 2007).

Research on the online processing of language, especially that involving more realistic experimental settings, are necessary for future work in this area. Fictive motion descriptions often take place in the absence of any sort of referents. As a colleague informs, "Interstate 80 goes through the mountains," we are not looking at a map, or driving in the car on the road. We are sitting in a room entirely devoid of roads. And so even though the visual world paradigm has typically been used with concrete namable objects concurrent with speech, extending this paradigm is crucial to work on non-literal language. Further work without objects that are necessary to create a realistic picture of what kind of processing happens when we are sitting in rooms, without any roads. This kind of work has been called the blank visual-world, and a few instantiations of it with varying degrees of separation from concurrent visual stimuli have proven to be useful in looking at naturalistic language processing (Spivey & Geng, 2001; Altmann, 2004; Huette, Winter, Matlock & Spivey, 2011).

The constellation of experimental research discussed in this section led to new insights on the processing of fictive 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 fictive 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. These results also support embodiment of language as well as provide new insights into how meaning is built and modified as we listen to language.

4. Integrating paradigms

For many years, linguistics and psychology held their respective distances from one another. With the advent of cognitive linguistics, this has produced a paradigm shift where language is studied and framed in terms of humans. However, very little work has been done to take cognitive linguistics and integrate it with a mechanistic understanding of the mind: the information processing view from which cognitive science has grown. Albeit attempts have been made to play nicely and the functional level description can be thought of as different from the computational level description, much of this has lead to computational models not coming out of cognitive linguistic theory. Especially in fictive motion (where motion is the very definition of continuous change), one promising avenue is seeking out principles of computation (e.g., localist vs. distributed representation, one-stage or multiple-stage processing, feedforward versus interativity and feedback, etc.). The power in this is generalization: Should we find an underlying process that guides how we simulate language, we can then apply this principle to many areas figurative language. This approach differs radically from any linguistic perspective that seeks to account for every idiosyncrasy as opposed to making sweeping generalizations. Both of these are crucial, which is why an integrated nomenclature needs to arise between these fields of study.

Mental models, perceptual simulation, and embodiment are all fundamentally entangled with what is called *cascading activation*, a fundamental principle in any neural network (McClelland & Rumelhart, 1981; see also Collins & Loftus, 1975; McNamara, 1992; Anderson, 1983). A model must be encapsulated or in cascade. It always exists as a part of any model, either explicitly or as an assumption. Cascading activation is simply this: if it is connected, activation from a previous node will be carried over to the next node. This accomplishes several goals. The first is both figurative and literal language can arise from the same, embodied categories and percepts. Information and interactions are then not thought of as static objects, but rather the flow of activation over connections between objects. In plain terms, this equates to eyes being defined by being in the surrounding context of a face. Part of the meaning "sky" is "cloud" and the connections between these words, are what constitute the meaning. When we talk about this in terms of process, these features have positive connections through which excitation dynamically travel and activate meaning (Hinton & Shalice, 1991; McRae, de Sa, & Seidenberg, 1997; Howell, Jankowicz & Becker, 2005). These cross connections, and the strengths of their association with each other, and with features like *blue* and *up*, are the definition of both the literal and figurative uses.

Cascading activation is central to a framework that makes use of the word "simulation". A simulation the process of imitating the real thing, for example a flight simulator or a video game. For a cognitive theory of simulation, information from the world is changed into neural approximates of the real thing. Embodiment theories base assumption is that the world is continuous with our senses, which is continuous with our thoughts, which are continuous with action. As the outside world enters our thoughts, and we put our thoughts into the world through our actions, the way this information moves is in cascade. This is exceedingly important for motion, which is continuous in and of itself, as well as to the results of Richardson and Matlock (2007). The immediate integration of context about the road argues that as this sentence is being processed, before anything is well-formed or complete, it has already been shared with areas that drive eye-movements.

Simulation is outside of awareness, and very subtle, tiny changes to something such as using a motion verb to describe the static location of a road can produce large changes. This is one of the main characteristics of a dynamical system, that small changes in initial conditions yield huge differences in the qualitative outcome of an event. Cascading activation is a fundamental, but small aspect of this story. Dense-sampling methods such as eyetracking are needed to resolve theoretical debates on issues such as degree of interactivity, and how information moves.

5. Conclusions

Fictive motion is a dynamic, flexible simulation that reveals much about how one processes figurative language, and semantics in general. The proposed framework for understanding these results is that of an embodied mind, capable of unavoidably simulating meaning, and incorporating both real-world contexts, as well as previously learned relationships between objects in the world that exist and connection strengths between representations in the mind. Fictive motion processing is characterized by processing that is very similar to actual motion, and may activate areas in the brain used when viewing motion. Finally, the processing of fictive motion and our understanding of how meaning is built in the mind can benefit from making explicit the idea of continually sharing information systems, called cascading activation.

Future work in fictive motion will need to come from several angles and eventually be integrated to form a full understanding of this kind of language usage. Linguistic and philosophical analyses must address just how abstract figurative language is, when it shares so much overlap with concrete language, and why we have made such a distinction in the first place. Computational and cognitive models need to be built to fully comprehend the processing of language, such that we could implement these processes eventually in an intelligent agent. Otherwise when you tell the robot helpers of the future to "run you a bath" you may end up with a robot running down the street holding your shower curtain. The simulation of fictive motion, which could be considered an abstract area of language use, is actually tied to concrete, real motion processing. The mental trajectory of fictive motion follows a real trajectory of actual motion, at least to some degree. Future work would also benefit looking at dissimilarities between real and simulated motion, as well as drawing a distinction between imagined and simulated events.

Further, context-selectivity and there being hints of literal meaning components in figurative phrases are not incompatible. The addition of cascading activation along with modal and heteromodal distributed representations best accounts for the data reviewed in this chapter on fictive motion. More broadly, an integrative approach where one considers principles such as cascading vs. encapsulated processing, feedback connections between types of information, the kind of learning which must take place, how a concept or semantic interpretation evolves over time, etc. will all aid in discovering how seemingly completely different phenomenon are all based upon a similar principle underneath the surface level of observation. By using dense-sampling methods such as eyetracking, we are able to see under the water, and describe the oceans of the mind.

References

Altmann, G.T.M. (2004). Language-mediated eye movements in the absence of a visual world: the 'blank screen paradigm'. *Cognition, 93*, B79-B87.

Anderson, J. R. (1983). A spreading activation theory of memory. *Journal of Verbal Learning and Verbal Behavior, 22,* 261-295.

Bergen, B.K., Lindsay, S., Matlock, T., & Narayanan, S. (2007). Spatial and linguistic aspects of visual imagery in sentence comprehension. *Cognitive Science, 31,* 733-764.

Blasko, D.G., & Connine, C.M. (1993). Effects of familiarity and aptness on metaphor processing. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *19,* 295–308.

Boroditzky, L., & Ramscar, M. (2002). The roles of body and mind in abstract thought. *Psychological Science, 13,* 185-189.

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

Brown-Schmidt, S. & Tanenhaus, M.K. (2008). Real-time investigation of referential domains in unscripted conversation: A targeted language game approach. Cognitive Science, 32, 643-684.

Cacciari, C., & Tabossi, P. (1988). The comprehension of idioms. *Journal of Memory and Language,* 27, 668– 683.

Clark, H.H. (1973). Space, time, semantics, and the child. In T. E. Moore (Ed.), *Cognitive development and the acquisition of language* (pp. 28-64). New York: Academic Press.

Collins, A.M., & Loftus, E.F. (1975). A spreading-activation theory of semantic processing. *Psychological Review, 82,* 407-428.

Cooper, R.M. (1974). The control of eye fixation by the meaning of spoken language: A new methodology for the real-time investigation of speech perception, memory, and language processing. *Cognitive Psychology, 6,* 84-107.

Coulson, S., & Matlock, T. (2001). Metaphor and the space structuring model. *Metaphor & Symbol,* 16, 295-316.

Dehaene, S. (1997). *The number sense: How the mind creates mathematics.* New York: Oxford University Press.

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

Gibbs, R.W. (1994). Figurative thought and figurative language. In M. Gernsbacher (Eds.), *Handbook of Psycholinguistics* (pp. 411-446). San Diego, CA: Academic Press.

Gibbs, R.W. (1986). On the psycholinguistics of sarcasm. *Journal of Experimental Psychology: General, 115*, 3-15.

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

Giora, R. (2006). Anything negatives can do affirmatives can do just as well, except for some metaphors. *Journal of Pragmatics, 38*, 981–1014.

Grice, H.P. (1975). Logic and conversation. In P. Cole & J.L. Morgan (Eds.), *Syntax and Semantics: Vol. 3*, *Speech Acts (*pp. 41–58). New York: Academic Press.

Henderson, J., & Ferreira, F. (2004). Scene perception for psycholinguists. In J. Henderson & F. Ferreira (Eds.), *The integration of language, vision and action* (pp. 1–58). Hove: Psychology Press.

Hinton, G., & Shallice, T. (1991). Lesioning an attractor network: Investigations of acquired dyslexia. *Psychological Review, 98,* 74-95.

Hirose, N. (2002). An ecological approach to embodiment and cognition. *Cognitive Systems Research*, *3*, 289-299.

Hochberg, J., & Gellman, L. (1977). The effect of landmark features on mental rotation times. *Memory & Cognition, 5,* 23-26.

Howell, S. R., Jankowicz, D., & Becker, S. (2005). A Model of Grounded Language Acquisition: Sensorimotor Features Improve Lexical and Grammatical Learning*. Journal of Memory and Language, 53*, 258-276.

Huette, S., Winter, B., Matlock, T., & Spivey, M. (2011, March). Spatiotemporal fixation differences on a blank screen during aspect comprehension. Presentation at the 24th annual CUNY conference on human sentence processing. Palo Alto, CA.

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

Inhoff, A.W. (1984). Two stages of word processing during eye fixations in the reading of prose. *Journal of Verbal Learning and Verbal Behavior, 23*, 612-624.

Katz, A., Cacciari, C., Gibbs, R.W., & Turner, M. (1998). *Figurative Language and Thought*. New York: Oxford University Press.

Kawamoto, A.H. (1993). Nonlinear dynamics in the resolution of lexical ambiguity: A parallel distributed processing account*. Journal of Memory and Language, 32*, 474-516.

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

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

Lakoff, G., & Núñez, R. (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: A field guide to poetic metaphor*. Chicago, IL: The University of Chicago Press.

Langacker, R.W. (1987). *Foundations of cognitive grammar: Theoretical perspectives: Volume 1.* Stanford University Press.

MacDonald, M. C., Pearlmutter, N. J., & Seidenberg, M. S. (1994). The lexical nature of syntactic ambiguity resolution*. Psychological Review, 101*, 676-703.

Matin, E., Shao, K. C., & Boff, K. R. (1993). Saccadic overhead: Information-processing time with and without saccades. *Perception & Psychophysics, 53*, 372-380.

Matlock, T., & Richardson, D.C. (2004) 'Do eye movements go with fictive motion?' *Proceedings of the 26th Annual Conference of the Cognitive Science Society (*pp. 909-914). Lawrence Erlbaum Associates, Inc, Mahwah, NJ.

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

Matlock, T. (2004). Fictive motion as cognitive simulation. *Memory & Cognition, 32*, 1389-1400.

Matlock, T. (2006). Depicting fictive motion in drawings. In J. Luchenbroers, (Eds.) *Cognitive Linguistics Investigations: Across languages, fields and philosophical boundaries* (pp. 67-85). Amsterdam: John Benjamins.

Matlock, T. (2010). Abstract motion is no longer abstract. *Language and Cognition, 2,* 243-260.

Matlock, T., Holmes, K. Srinivasan, M., & Ramscar, M. (under review). Even abstract motion influences the understanding of time.

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

Matlock, T., Ramscar, M., & Boroditsky, L. (2005). On the experiential link between spatial and temporal language. *Cognitive Science, 29*, 655-664.

Matlock, T., Ramscar, M., & Srinivasan, M. (2005). Even the most abstract motion influences temporal understanding. *Proceedings of the 27th Annual Conference of the Cognitive Science Society* (p.2527). Mahwah, NJ: Lawrence Erlbaum.

Matsumoto, Y. (1997). Linguistic evidence for subjective (fictive) motion. In K. Yamanaka & T. Ohori (Eds.), *The Locus of Meaning: Papers in Honor of Yoshihiko Ikegami* (pp. 209-220). Tokyo: Kuroshio.

McClelland, J., & Rumelhart, D. (1981). An interactive activation model of context effects in letter perception: Part 1. An account of basic findings. *Psychological Review, 88,* 375-407.

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

McMurray, B., Tanenhaus, M., and Aslin, R. (2002). Gradient effects of within-category phonetic variation on lexical access, *Cognition, 86,* B33-B42.

McNamara, T.P. (1992). Priming and constraints it places on theories of memory and retrieval. *Psychological Review, 99,* 650-662.

McRae, K., de Sa, V.R., & Seidenberg, M.S. (1997). On the nature and scope of featural representations of word meaning. *Journal of Experimental Psychology: General, 126,* 99-130.

Mishra, R.K., & Singh, N. (2010). Online Fictive Motion Understanding: An Eye-Movement Study With Hindi. *Metaphor and Symbol, 25*, 144-161.

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

Ortony, A., Schallert, D.L., Reynolds, R.E., & Antos, S.J. (1978). Interpreting metaphors and idioms: Some effects of context on comprehension. *Journal of Verbal Learning and Verbal Behavior, 17,* 465-477.

Pecher, D. & Zwaan, R.A. (2005). *Grounding Cognition: The Role of Perception and Action in Memory, Language, and Thinking.* Cambridge: Cambridge University Press.

Pollio, H.R., Smith, M.K., Pollio, M.R. (1990). Figurative language and cognitive psychology. *Language and Cognitive Processes, 5,* 141-167.

Pulvermüller, F., Shtyrov Y., & Ilmoniemi, R. (2005). Brain signatures of meaning access in action word recognition, *Journal of Cognitive Neuroscience, 17*, 884–892.

Richardson, D.C., & Matlock, T. (2007) The integration of figurative language and static depictions: an eye movement study of fictive motion, *Cognition, 102,* 129-138.

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

Rumelhart, D.E. (1979). Some problems with the notion of literal meanings. In A. Ortony (Ed.), *Metaphor and Thought* (pp. 78-90). New York, N.Y.: Cambridge University Press.

Searle, J. R. (1979). *Expression and Meaning: Studies in the Theory of Speech Acts*. Cambridge: Cambridge University Press.

Shepard, R. N., & Metzler, J. (1971). Mental rotation of three dimensional objects. *Science, 191*, 952-954.

Simmons, W.K., Hamann, S.B., Harenski, C.N., Hu, X.P., & Barsalou, L.W. (2008). fMRI evidence for word association and situated simulation in conceptual processing. *Journal of Physiology – Paris, 102,* 106-119.

Sperber, Dan, Wilson, Deirdre, 1995. *Relevance: Communication and Cognition.* Blackwell, Oxford.

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

Takahashi, Kiyoko. (2000). Expressions of Emanation Fictive Motion Events in Thai. Ph.D. Dissertation, Chulalonkorn University.

Talmy, L. (1996). Fictive motion and change in language and perception. In P. Bloom, L. Peterson, L. Nadel, and M. Garrett (eds.) *Language and space.* (pp. 211-276). MIT Press, Cambridge.

Talmy, L. (2000). *In Toward a cognitive semantics: Concept structuring systems* (Vol. 1). Cambridge, MA: The MIT Press.

Tanenhaus, M.K., & Spivey-Knowlton, M.J. (1996). Eye-tracking. In F. Grosjean & U. Frauenfelder (eds). *Language and Cognitive Processes: A guide to Spoken Word Recognition Paradigms*, 11, 583-588.

Tanenhaus, M. K., Spivey-Knowlton, M. J., Eberhard, K. M., & Sedivy, J. C. (1995). Integration of visual and linguistic information in spoken language comprehension. *Science, 268,* 1632-1634.

Teuscher, U., McQuire, M., Collins, J., & Coulson, S. (2008). Congruity effects in time and space: Behavioral and ERP measures. *Cognitive Science, 32,* 563-578.