Language, Visual Cognition and Motor Action

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Introduction

From the beginning of the cognitive revolution, thinking about cognition has been dominated by the computer metaphor of mind. Cognition is conceptualized in terms of software that stores, retrieves, and manipulates abstract, amodal, arbitrary symbols (e.g., Pylyshyn, 1984; Turing, 1950). In principle, this software can be instantiated in a number of media, such as the human brain or a computer system. The assumption that the 'software' of cognition could be studied independently of the 'hardware' has had a marked impact on the field. Whereas before the cognitive revolution systems of perception and action held a central place in explaining human behavior, after the cognitive revolution these systems became irrelevant to the study of cognition. If cognition could be implemented and studied on a computer, then the fact that humans have sense organs and effectors is unimportant.

This 'disembodied' conceptualization of cognition has recently come under fire in the constituent disciplines of cognitive science, such as artificial intelligence (e.g., Brooks, 1991; Pfeifer and Scheier, 2000), philosophy (Clark, 1997; Newton, 1996; Prinz, 2001), cognitive psychology (e.g., Barsalou, 1999; Glenberg, 1997), cognitive neuroscience (Damasio, 1999; Pulvermüller, 1999), and linguistics (Langacker, 1987; Talmy, 1988). Theoretical arguments and empirical data have been adduced suggesting that cognition is grounded in perception and action. According to this 'embodied' view, perception, action, and cognition are closely intertwined. Here, we consider the implications of this view for language processing.

The embodied view of cognition conceptualizes language comprehension as the mental simulation of the state of affairs that is being described. These simulations are thought to involve the reactivation of patterns of brain activation that were recorded during the comprehender's interaction with the world (Barsalou, 1999; Damasio, 1999). These experiential traces (Zwaan, 2004) are not abstract, amodal, and arbitrary mental representations but, rather, are sensorimotor in kind. There is an increasing amount of evidence for the use of sensorimotor representations in language processing. This evidence is reviewed below.

Perceptual Processes and Representations in Language Comprehension

Researchers in cognitive linguistics have long argued that linguistic meaning is rooted in perceptual processes (e.g., Lakoff, 1987; Langacker, 1987). Consider a sentence such as, 'The cord runs from my laptop to the cable modem.' This sentence conveys a visual scan path from the laptop to the modem. The alternative wording, 'The cord runs to the cable modem from my laptop' sounds odd because it conveys an interrupted scan path, followed by another one (see Langacker, 2005, for a discussion). Consider also the sentence, 'The book is on my desk in my office on the fourth floor of the Longmire building.' Several variants of this sentence can be constructed that are all equally grammatical. One example is, 'The book is in the Longmire building on the fourth floor in my office on my desk.' However, some variants are awkward. 'The book is in the Longmire building on my desk on the fourth floor in my office,' sounds awkward because it does not convey a linear zooming-in or zooming-out process.

Brain-imaging studies have provided evidence that the processing of words engages the cortical and subcortical structures that are active when the words' referents are perceived. When subjects name words referring to actions associated with objects, brain areas just anterior to areas active during motion perception are activated, and when words referring to colors are processed, sites just anterior to areas active during color perception are activated (see Martin and Chao, 2001, for a review). Also, negative emotion words engage the amygdala, which is active when negative emotions are being experienced (Isenberg *et al*., 2000). This evidence is consistent with the idea that words activate memory traces of perceptual experiences regarding the words' referents.

Behavioral evidence has provided further evidence that language and perception are closely intertwined. Subjects tend to make horizontal eye movements when listening to narratives describing horizontal motion and vertical eye movements when listening to narratives describing vertical motion (Spivey and Geng, 2001). Readers routinely activate the shape and orientation of objects described in sentences (Stanfield and Zwaan, 2001; Zwaan *et al*., 2002). For example, on reading 'He saw the egg in the carton,' people name a picture of a whole egg more quickly than they do a picture of a broken egg, whereas the reverse is true on reading 'He saw the egg in the frying pan.' There also is evidence that visual primes

affect subsequent language processing (Boroditksy, 2000) and that visual displays presented concurrently with linguistic input may create interference (Fincher-Kiefer, 2000).

To summarize, linguistic analyses, brain-imaging studies, and behavioral experiments all converge on the conclusion that there is a close connection between language and perceptual processes. The argument can be made that meaning arises in part out of the perceptual simulations of the referential situation rather than out of the manipulation of abstract, arbitrary, amodal symbols (Barsalou, 1999; Glenberg, 1997; Pecher and Zwaan, 2005; Zwaan, 2004). The qualification 'in part' is important, because meaning does not just arise out of the language-mediated activation of perceptual representations and processes. Consider the sentence, 'John pounded the nail into the wall.' If the embodied view is correct, understanding this sentence involves not only the visual representation of a horizontal nail (Stanfield and Zwaan, 2001) but also an activation of motor representations and processes involved in pounding nails. In other words, the hypothesis is that meaning arises out of the simulation of actions in addition to the simulation of perceptions.

Motor Representations and Processes in Language Processing

Evidence for the claim that motor representations play a role in language processing can be drawn from three main sources: behavioral studies on adult language comprehenders, neuroscience, and studies of language acquisition.

Klatzky, Pellegrino, McCloskey, and Doherty (1989) describe one of the earliest experiments to show a relationship between motor activity and language comprehension. In their experiments, participants were asked to strike poses, such as raising their arm to eye level and pinching their index finger and thumb together. When holding these poses, the participants responded to sentences such as, 'Aim a dart.' Klatzky *et al*. (1989) report that participants were faster to respond when the action described in the sentence was consonant with the posture they were currently holding. Glenberg and Kaschak (2002) provide further evidence for the role of motor activity in sentence processing. When reading sentences that described action toward the body (e.g., 'Sam gave you a pen') or away from the body (e.g., 'You gave Sam a pen'), participants were asked to decide if the sentences were sensible. Half of the time, a 'Yes' response required making an arm movement toward the body; the other half of the time, a 'Yes' response required making an arm movement away from the body. Participants were faster to respond when the action described in the sentence was consonant with the action required to make a response. Most important, the participants' direction of response interacted with the direction of the action in the sentence not only for concrete actions (e.g., giving someone a pen) but also for actions that are abstract or metaphorical (e.g., the metaphorical transfer of information in, 'John told you a story').

Additional support for the role of motor representations in language processing comes from work in neuroscience. Pulvermüller (1999) reviews a body of research showing that perceptual and motoric representations underlie the processing of words. For example, processing words denoting actions or instruments (e.g., a hammer) appears to engage neural regions known to be involved in the planning and execution of actions (Grafton *et al*., 1997; Martin *et al*., 1996).

That perceptual and motor traces are recruited to build mental simulations of the events described in the language is congruent with research in cognitive development (e.g., Piaget, 1954) and language acquisition (e.g., Landau and Gleitman, 1985; Goldberg, 1998). One of Piaget's seminal contributions to the field of cognitive development was the discovery that the abstract thinking (or, formal operations) of adult cognition has its roots in children's understanding of literal, concrete events. For example, children may learn about abstractions such as 'causation' by observing how movements of their body effects change in the external environment (Meltzoff and Moore, 1997). Concepts such as 'equality' may be learned via experiences such as counting the number of marbles placed in two bowls.

Studies of language acquisition (e.g., Bailey, 1997; Landau and Gleitman, 1985) suggest that children's early acquisition of verb meanings (and, their acquisition of subcategorization preferences for verbs) relies on knowledge of the action that the verb describes. The relationship between action and verb meaning likely arises because the verbs are produced and understood in the context of particular actions (e.g., 'give' is likely to be accompanied by an arm movement to transfer an object from one person to another). Once a child understands what it means to 'give' in terms of literal actions (e.g., extending one's arm to give an object to someone), they can begin to understand metaphorical actions (e.g., transfer of information, as in telling someone a story) in terms of those literal actions (see Glenberg and Kaschak, 2002, for a discussion). Thus, the use of perceptual and motoric information in language comprehension that has been detailed

in psychology and cognitive linguistics may be, in part, a vestige of the processes involved in cognitive development and language acquisition.

Limitations of the Current Research, and Future Directions

Although there are theoretical arguments and an increasing amount of evidence in support of an embodied view of language comprehension, there are major hurdles to be taken. We identify three areas in need of further development.

First, as yet there is no coherent theory that specifies how perceptual and motor processes are integrated during perception. A key factor to consider in this regard is perspective (MacWhinney, 2005). For example, when we read, 'John stirred his coffee,' do we simply activate a dynamic visual representation of the coffee and the cup, of the hand stirring it, or perhaps of both? This is a matter of overt and covert 'visual' attention. However, an equally important question is whether we take the perspective of John or that of an observer. In the first case, we also would activate the corresponding motor representations of stirring a fluid in a cup with a spoon. In the observer perspective, we also might activate motor representations – given that viewing actions activates areas in the premotor cortex that overlap with areas active during self-performed actions (Rizzolatti and Arbib, 1998) – but presumably in a less elaborate fashion. We may further ask whether other sensory experiences are triggered by the sentence, such as the smell, taste, and temperature of coffee. An important challenge will be to identify the role of linguistic cues in perspective activation. Another important challenge will be to examine how background knowledge influences perspective taking. Conceivably, comprehenders are more likely to adopt agentive or observer-like perspectives depending on the extent to which they can recruit relevant experiences for each.

A second area in which theoretical development and data are needed is in the treatment of abstract concepts. It has been hypothesized that our knowledge of abstract concepts, such as 'justice' and 'slander,' is grounded in perception and action by way of metaphorical extension (Lakoff, 1987). For example, it has been suggested that applying the adjective 'warm' to an abstract notion such as relationships is grounded in the physical experience of warmth a child feels when she is being held by a parent. However, it is doubtful that this is sufficient. People have many direct experiences with abstract concepts, such as 'justice,' and without these, the metaphor would have not-ing to map onto (Barsalou and Wiemer-Hastings, 2005). Instead, Barsalou and Wiemer-Hastings suggest that abstract and concrete concepts are similar in that both involve situational context, but that they differ in which elements of the situational context are activated.

A third area in which theory development and data are needed concerns the operation of sensorimotor representations in complex linguistic situations. Currently, evidence in support of the embodied position is drawn from studies of the processing of single words and sentences. This leads to a simple and straightforward view regarding how and when sensorimotor representations are used in language comprehension. This simple view is probably inadequate to account for the role of this information in naturally occurring contexts of language use, such as having conversations and arguments, or reading stories. It will be important to examine what happens to sensorimotor representations in language processing tasks that are more representative of the way that language is used in our daily lives.

In conclusion, there is mounting evidence that language comprehension is best understood from an embodied perspective rather than from a disembodied perspective. Sensorimotor representations are clearly active during language comprehension. These findings notwithstanding, several challenges lie ahead for theories of embodied language processing.

See also: Cognitive Linguistics; Developmental Relationship between Language and Cognition; fMRI Studies of Language.

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Language/Dialect Contact

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Introduction

The emergence of sociolinguistic approaches to dialectology in the 1960s represented a sharp break with the traditions of the discipline. Previously, dialect studies had largely focused on the collection of the most conservative speech forms in the community – research attention was largely directed toward rural areas, toward older people, toward men, and toward those with socially and geographically restricted lifepaths (Chambers and Trudgill, 1998). The studies which followed deliberately shifted attention away from such conservative language users to consider the urban, the young as well as the old, women as well as men, different ethnic groups and people of differing social statuses – the classic case is Labov's (1966) research in New York. They demonstrated, to highlight just a few of the very important contributions of this new approach, the orderly heterogeneity of language variation, and methods enabling us to examine language change as it was actually happening, as well as to spot the locus of change in the