The Embodiment of Meaning

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Abstract

One of the many puzzles philosophy is dealing with is how meaning comes about. An increasing number of investigations in cognitive science indicate that the body plays a central role in grounding the meaning of concepts and language. Particularly there are many indications that our abilities to move, perceive and act upon the world are directly related to our capacity to understand linguistic expressions. In this paper we will review some of the more salient findings in this area of research and indicate their consequences for the debate about how meaning and body are related.

Introduction

Meaning has been a vexed problem all throughout the history of cognitive science. How do representations acquire meaning for the system that has them? Harnad (1990, p.335) formulated the basic question as follows:

> "How can the semantic interpretation of a formal symbol system be made intrinsic to the system, rather than just parasitic on the meanings in our heads? (...) The problem is analogous to trying to learn Chinese from a Chinese/Chinese dictionary alone."

For Harnad meaning has to be grounded in something different than just other (equally meaningless) symbols. In accordance with him and several other authors we look for this grounding in bodily processes of perception and action. We will review several experiments that seem to indicate that way perception and action contributes to meaning, even at abstract levels. We will relate these experiments to a broader embodied embedded view on cognition.

Embodied Embedded Cognition

The basic idea of embodied embedded cognition (EEC) (Clark 1997; Lakoff & Johnson, 1999; Haselager 2004) is that the organism's bodily interaction with the environment is of crucial importance to its cognitive processes, both in relation to the kind of processes it engages in, as well as the way these processes are performed (Chiel & Beer 1997). The body is more than a mere transducer of information between the organism and the environment: It actively shapes the form cognitive tasks can take and also presents possibilities for solving them. If this position is right, it should be possible to find traces of sensorimotor interactions with environment, of aspects of perception and action, in the way organisms understand (and respond to) meaning.

According to the perspective of EEC, then, bodily action in the world and meaning are thoroughly related. Meaning depends on an individual's history of bodily interactions with the world. People recreate those experiences in response to linguistic input, and use them to produce meaningful linguistic output. From this perspective, perceptual and motor processes are not peripheral to but form the *core* of mental content.

In line with this view, Glenberg & Robertson (2000, p.383) propose that the meaning of a particular situation for a specific organism can be related to the coordinated set of actions that are available to it:

> "When affordances, experiences, and goals are successfully meshed, they form a coherent, doable, and envisionable set of actions: the individual's meaningful construal of the situation."

In the embodied cognition framework the grounding problem is addressed by assuming that linguistic representations (words, phrases and sentences) are grounded in bodily and perceptual experience with the world. In this framework linguistic representations get their meaning through a direct coupling of the representations and that which they stand for. This does not only hold for representations of concrete concepts, such as objects in the world, but also for representations of abstract concepts.

Following this tradition a number of empirical studies have been carried out that focused on bodily and perceptual components in linguistic meaning as involving mentally *simulating* actions and perceptions as would have been performed in the extern world.

> "Research on perceptual simulation also provides evidence to show that people simulate the experience of "being there" when thinking about situations, including where people look when thinking about relevant properties of an object (Barsalou, 2002). For example, when listing the relevant properties of a bird (e.g., wings, fly), people naturally gaze upward, and when listing the relevant properties of a worm (e.g., dirt, ground) they naturally gaze downward." (Matlock et al., 2003)

> "Taken together, this research suggests that people (a) construct models that resemble physical space, (b) simulate objects and movement in these spatial models, and (c) simulate in a way that is to some extent analogous to the enactment and perception of physical movement." (Matlock et al., 2003)

In the domain of language comprehension, a number of studies have shown that simulation is central in the comprehension of language. If the understanding of an utterance does involve the activation of perceptual and motor processes, these specific representations should be primed for subsequent use (Bergen, in press). If this is the case, simultaneous activation of perceptual or motor processes on the one hand and simulation processes on the other should influence each other. In fact, this is what a number of studies have focused on.

Experiments on linguistic meaning and mental simulation

Glenberg and Kaschak (2003) have performed an experiment in which participants had to make judgments on sentences they read on a computer screen. They had to choose whether these sentences were sensible sentences (e.g. Andy handed you the pizza) or nonsense (e.g., Leonard drank the sun). Three kinds of transfer sentence were used: Imperatives like (1), concrete transfer sentences like (2) and abstract transfer sentences like (3). All sentences were constructed both in a condition where the transfer or movement is towards the "you" person, and in a condition where the transfer or movement was away from the "you" person.

(1) Open the drawer / Close the drawer

(2) You handed Andy the pizza / Andy handed you the pizza

(3) You told Jim the story / Jim told you the story

The participants had to make their yes/no judgments with a button-box with three vertically aligned buttons. While pressing the middle button the sentence appeared on the screen. The position of the "yes" button was either above or below the middle button. This means that the motor response that the participant has to make is either in line with the motion that is described in the sentences, or in conflict with the motion that is described in the sentences. Glenberg and Kaschak have found that participants are faster to accept a sentence (to respond "yes") *when the motor response and the described action matched*.

This is not limited to movements from and towards the body. Zwaan et al. (in prep) for instance have conducted an experiment in a similar paradigm. Now participants had their dominant hand on a rotating button. The button was spring-loaded and could be turned clock-wise and anti clock-wise, but when released it would jump back to zero degrees. Participants made sensibility judgments again. Half of the participants had to make a yes response by turning the knob anti clock-wise, and half of the participants made the yes-response by turning the knob clock-wise. Using this methodology they had participants making sensibility judgments on sentences like “Jack turns the volume down” and “Jack turns the volume up”. The same pattern of results was found as in the study by Glenberg and Kaschak, that is, participants were faster when the motor response was congruous to the movement described in the sentences than when the movement was incongruous to the movement in the sentences.

This interaction methodology is not limited to the domain of motor control. Kaschak et al. presented auditory sentences like “The car approaches you” to participants while they were looking at visual illusions. These visual illusions consisted of a spiral that was either turning towards the observer or away from the observer. Their participants had to make sensibility judgments. Kaschak et al found that response latencies were longer when the direction in the sentences matched the direction in which the spiral was turning. So response latencies to a sentence like “The car approaches you” was longer when the spiral was turning towards the participants than when the spiral was turning away from the participant. This was not only the case for sentences away from or towards the "you" person, but also for sentences that implied a vertical movement upwards or downwards. Sentences like ”The smoke rose into the sky” were presented together with a pattern of horizontal stripes moving upwards or downwards. The same pattern of results, inhibition by a matching pattern, was found for these sentences. Kaschak et al. argued that inhibition instead of facilitation arose in this study because the two sources of information are addressing the same neuronal groups at the same time, which leads to this pattern of interference. By contrast, in the experiment of Glenberg & Kaschak (2002), the sentence and the motor response succeed each other, and hence prime each other, which leads to facilitation.

Wiemer-Hastings et al. (in prep.) have shown in a series of studies that the visual cortex plays an important role in the representation of content words. In their first study they selectively "turned off" cells in the visual cortex while they were measuring response times to words. The cells in the visual cortex were selectively turned off by means of habituation. In this procedure participants have to look at a computer screen on which either horizontal or vertical bars were depicted. After looking at these grids for 2.5 minutes, the cells in the visual cortex that have selectively vertically aligned receptive fields become insensitive and stop responding to input with this alignment. When the participants were habituated to a particular direction they were presented a word on the screen, e.g., a "vertical" word like TOWER for the vertical habituation, or a "horizontal" word like TRAIN for the horizontal habituation. They had to push a button as soon as they had recognized the word. The results showed an interaction between habituation type and target word, showing that participants had longer recognition times for words like TOWER when they were habituated on a vertical pattern than when they were habituated on a horizontal pattern. Likewise, recognition times for words like TRAIN were longer for the horizontal habituation than for the vertical habituation. The striking fact about these results is that the cells with the specific receptive fields are very low-level feature detectors. These results suggest that even these low-level cell assemblies contribute to the meaning of concepts.

In a variation on this first study, Wiemer-Hastings et al. used the same habituation methodology, but now using colors. Cells in area V4 of the visual cortex are selectively sensitive to one color. Like the selective receptive field cells, these "color-cells" can be habituated so that they stop responding to that color. Like in the first study, participants were habituated to a color or it's opposite color and had to produce recognition times to target words (e.g., they were habituated to yellow and had to recognize BANANA, and were adapted to blue and had to recognize GRAPE). The results were similar to those of the first study: Participants were slower to react to words like BANANA when they were habituated to yellow that when they were habituated to blue. Likewise, participants were slower to react to words like GRAPE when they were habituated to blue than when they were habituated to yellow. These two studies show that low-level perceptual information is part of the representations of objects. This is not through any semantic relation, rather by the involvement of the primary devices we have to cope with this perceptual information.

In addition to these behavioral studies, Chwilla et al have performed a study that takes on a much broader perspective by looking at the assignment of meaning in *new and creative* uses of objects. The authors presented sentences to participants in which described a problem that could be solved using an object in a non-standard way, e.g., example (4). These sentences were embedded in a context in which the default objects to perform this action (paddles) was not available. In the absence of paddles it is certainly possible to propel a canoe using frisbees (see example (4a)). In other words, frisbees afford paddling. By contrast, it is impossible to propel a canoe using a sweater: sweaters do not afford paddling. In this context the term affordances refers to whether or not the described action can be performed with the object.

(4) The boys found a canoe in the spare room.

With this they wanted to go canoeing on the canal whatever the costs. The fact that they could not find the peddles did not lead them to make up their mind. According to the boys you do not at all need them.

a) They let the canoe into the water and paddled with frisbees.
b) They let the canoe into the water and paddled with pullovers.

While participants were reading sentences like (4a) and (4b) their EEG was recorded. The authors were interested in the occurrence of a specific brain reaction to semantic information called the N400. Numerous previous studies have shown that each content word elicits an N400 (e.g., Kutas and Hillyard, 1983). The more related a word is to its context, the better this word fits in its context, the smaller the N400 is. Chwilla et al. compared the size of the N400 to words like frisbees in (4a) to the N400 to words like sweaters in (4b). In the design of the study they made sure that the semantic relation between the afforded objects (frisbees) and the described action was just as strong as (in fact, just as weak as) the semantic relation between the non-afforded objects (sweaters) and the described action. That is, both conditions had no relation or association between the object and the action that was performed with it: frisbees is as unrelated to paddling as sweaters is to paddling.

The results of the study showed that the N400 to affording objects was smaller than that to non-affording objects. This is interpreted as showing that the afforded objects fit better in the context than the non-afforded objects. At first sight a pretty straightforward conclusion, but considering the time-course of the effect a striking conclusion. The brain was able to differentiate between afforded and non-afforded words within 400 ms of reading these words. This difference cannot be ascribed to association or semantic relatedness as both conditions were equally unrelated. This means that the participants immediately know whether the action can be performed with the described object. How can we account for this seemingly effortless attribution of meaning in new and creative situations? A traditional approach would focus on overlapping semantic features between frisbees and paddles that would activate both frisbees and paddles, and thus leads to a better integration of paddles than of sweaters. However, this approach would fail here, since this direct semantic association does not exist. An alternative approach is to interpret the results from an embodied language perspective. The dominating view in this perspective is the idea that language understanding is contingent upon the understander mentally simulating, or imagining, the content of utterances. In our example, frisbees is easily integrated because it fits the mental simulation of the sentence. That is, one can paddle with frisbees, and our motor representations of frisbees (or similar objects such as dinner plates) are congruent with our (embodied) knowledge of the physics of paddling. Thus, we know that frisbees are afforded to paddle because the meaning of frisbees and the meaning of paddling are represented in an embodied way. By contrast sweaters do not afford paddling, and thus are harder to integrate into the mental simulation of the scene. Our motor representations of sweaters are incongruent with our knowledge of the physics of paddling.

Conclusion

This simulation-based view of meaning grows out of theories of language and the mind in which "embodiment" plays a central role. The idea of embodiment in cognitive science is quite straightforward - it is the notion that aspects of cognition cannot be understood without referring to aspects of the systems they are embedded in - in the biology of the organism, including its brain and the rest of its body, and in its physical and social context. When it comes to understanding language, the embodied perspective suggests that meaning centrally involves the activation of perceptual, motor, social, and affective knowledge that characterizes the content of utterances.

The way this works is as follows. Through exposure to language in context, language users learn to pair chunks of language like kick, Mary, or John with perceptual, motor, social, and affective experiences. In subsequent instances of language use, when the original perceptual, motor, social, and affective stimuli are not contextually present, the experience of them is recreated through the activation of neural structures responsible for experiencing them in the first place. This view of meaning is embodied in that meaning depends on an individual having had experiences in their body in the actual world, where they recreate those experiences in response to linguistic input, and use them to produce meaningful linguistic output. To conclude, a number of studies have shown that representations in meaning are inherently modal in nature. Perceptual and motor information are not peripheral sources of information, but form the core of these representations. These representations are not processed upon by abstract rules, instead the force that is driving higher-order cognition is mental simulation. Through simulation linguistic representations re-activate sensorimotor interactions with the environment. Ultimately, meaning is grounded in the way our bodies interact with the environment.

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