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The Embodied Cognition Research Programme

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Abstract

Embodied Cognition is an approach to cognition that departs from traditional cognitive science in its reluctance to conceive of cognition as computational and in its emphasis on the significance of an organism's body in how and what the organism thinks. Three lines of embodied cognition research are described and some thoughts on the future of embodied cognition offered.

The embodied cognition research programme, hereafter EC, departs from more traditional cognitive science in the emphasis it places on the role the body plays in an organism's cognitive processes. Saying more beyond this vague claim is difficult, but this is perhaps not surprising given the diversity of fields – phenomenology, robotics, ecological psychology, artificial life, ethology – from which EC has emerged. Indeed, the point of labelling EC a *research programme*, rather than a *theory*, is to indicate that the commitments and subject matters of EC remain fairly nebulous. Yet, much of the flavour of EC becomes evident when considering three prominent directions that researchers in this programme have taken. Before turning to these lines of research, it pays to have in sight the traditional view of cognitive science against which EC positions itself.

I. Traditional Cognitive Science

Unifying traditional cognitive science is the idea that thinking is a process of symbol manipulation, where symbols lead both a syntactic and a semantic life (Haugeland, 'Semantic Engines'). The syntax of a symbol comprises those properties in virtue of which the symbol undergoes rule-dictated transformations. The semantics of a symbol constitute the symbols' meaning or representational content. Thought consists in the syntactically determined manipulation of symbols, but in a way that respects their semantics. Thus, for instance, a calculating computer sensitive only to the shape of symbols might produce the symbol '5' in response to the inputs '2', '+', and '3'. As far as the computer is concerned, these symbols have no meaning, but because of its programme it will produce outputs that, to the user, 'make sense' given the meanings the user attributes to the symbols.

Cognition, on the traditional view, is the same kind of process one finds in a calculator. An organism's sense organs serve as input devices, translating stimulation from the environment into a syntactic code that the nervous system can then manipulate according to various rules that are either innate or learned. This symbol manipulation *is* cognition, and its products are additional symbols, some of which might be translated into a form that causes bodily motions or other sorts of behavior. The nervous system, on this account, performs the same function that a CPU does in a computer. For this reason, traditional cognitive science has typically claimed that cognition is computation and that minds are programmes that run on brain hardware.

Of particular note in this description of traditional cognitive science is the insular nature of thought. Cognition is cut off from the world in the sense that cognitive processes operate only on symbolic deliverances from the sense organs. Conceivably, were a psychologist able to create sensory code, she could deliver to the nervous system of an organism in her laboratory the same symbols it would have received were it roaming a jungle or a university. In such a case, the organism's cognitive processes would not differ from those of the freely roaming organism. Because cognition begins and ends with inputs to and outputs from the nervous system, it has no need for interaction with the real world outside it.

II. Cognition as Embodied

Traditional cognitive science faces various challenges, perhaps the most serious of which concerns the origin of mental content. How do symbols in the head acquire their semantics? Interpreting the outputs of a calculator as numbers is one thing, but, presumably, mental symbols have their meanings independently of how anyone chooses to interpret them. But, then, from what are these meanings derived? Yet, whereas many proponents of EC are aware of this 'philosophical' problem, and, indeed, cite it as a motivation for pursuing an alternative approach to cognition, there is little doubt that frustration over the limited 'practical' success of traditional cognitive science has also played a large role in the attraction of EC. Critics are quick to point out that the greatest success stories emerging from traditional cognitive science involve analyses of symbol driven tasks that lend themselves to easy algorithmic description, like playing chess or solving the tower of Hanoi puzzle. In contrast, building a robot that can move about a cluttered environment, which seems to call for cognitive capacities far less impressive than those necessary for chess, is a terribly difficult engineering problem from the perspective of traditional cognitive science. Robots that depend on symbol manipulation to perform activities that would be easy for a cockroach might take days to calculate a course through a busy room and tend to be very slow and inflexible.

In response to these difficulties, EC typically places less emphasis on the role of representations, i.e. semantically endowed symbols, in thought and action. For instance, EC researchers often express bemusement with the traditional assumption that organisms must produce a representation of the world around them in order to navigate its topography. Why bother with a representation of the world if the world is right there in front of you? The idea that an organism must consult a representation invites a vicious sort of homuncularism. Must the representation of the world also be represented if it is to be useful? If so, an infinite regress begins. If not, if the representation of the world can guide action without itself being represented, why can't the world do the same?

Of course, EC is more than a collection of complaints about the traditional approach to cognition. It is convenient to distinguish within EC three related but distinct research goals (Shapiro, *Mind Incarnate*). Common among these goals is an effort to elevate the importance of the body in the explanation of various cognitive abilities. How might this elevation take place? First, steps in a cognitive process that a traditionalist would attribute to symbol manipulation might, from the perspective of EC, emerge from the physical attributes of the body. Second, rather than conceiving of cognition as the churnings of a brain isolated from the body and environment in which it is situated, EC might attempt to account for the content of cognition by appeal to the nature of the body containing the brain. Third, instead of viewing cognition as beginning with stimulation of afferent nerves and ending with signals to efferent nerves, cognitive processes or states might extend into the environment in which the organism lives.

Research in pursuit of the first goal, an explanation of cognition that relies on bodily properties to do work that a traditionalist would assign to symbol manipulation, has had a significant impact in studies of perception. Making depth perception possible, for instance, are a number of factors. Among them are the detection of the disparity between two retinal images that results from the distance between the two eyes. But, in addition to this depth cue are others deriving from movements of the body and head (Churchland, Ramachandran, and Sejnowski). Turning one's head will make objects in the foreground appear to move against objects in the background. The claim then is that movements of the head actually constitute a kind of visual processing. Relative depth can be directly perceived without the need for intervening representational states simply as a consequence of the fact that when a head moves *so* objects in the fore appear to move against objects behind.

Perhaps a better illustration of the significance of the body in cognition comes from studies of auditory perception. Generally, larger distances between ears provide greater auditory acuity. But also important is the density of the matter between the ears because sounds of varying frequencies will behave differently when traveling through a given medium. The auditory system incorporates facts about ear distance and head density in its processing, but not in a way that requires their symbolic representation. There is no need to represent the distance between ears because it is the distance itself

– not its representation – that creates the opportunity for greater auditory acuity. By analogy, a spring scale needn't represent the compression of the spring in order to determine the weight of an object. The compression of the spring tells directly the weight of the object.

Naturally, traditional cognitive scientists might wish to describe the contributions of head movements to vision and ear distance to audition in different terms. For instance, traditionalists might insist that cognition begins with the neural encoding of stimulation as the head moves, or after it is delivered differentially to the two ears. However, an EC researcher can respond, why not take things like ear distance as an important feature in auditory perception, as a feature that forms a stage in auditory processing? At the very least, an analysis of audition that does not appreciate the significance of ear distance cannot be complete. Perhaps Chiel and Beer (553) summarize this view most succinctly: 'body structure creates constraints and opportunities for neural control'. A cognitive science that sees the nervous system alone as the beginning and end of cognition misses this important fact.

Consideration of the second EC research goal – to understand the body's contribution to the contents of cognition – requires attention to Lakoff and Johnson's seminal work on concepts (*Metaphors*; *Philosophy*). Lakoff and Johnson argue that human beings make essential use of metaphor in their conception of the world. Metaphorical reasoning involves understanding one kind of thing, e.g. love, in terms of another, e.g. a journey. Thus, to be told that love is like a journey implies that love has a beginning but perhaps no end, that it can be difficult going sometimes but rewarding other times, that it can lead to unexpected places, and so on. According to Lakoff and Johnson, almost all of our concepts derive originally from the use of metaphorical reasoning: we learn something new only by understanding it in terms of something more familiar. However, on pain of circularity, there must be some basic concepts that human beings can understand without relying on metaphorical reasoning. These basic concepts, Lakoff and Johnson hold, stem directly from the type of body human beings possess and the manner in which this type of body interacts with the environment.

Among the basic concepts, Lakoff and Johnson argue, are spatial ones like *up*, *down*, *front*, *back*, *in*, *out*, *near*, and *far*. Human understanding of these concepts derives from facts about human bodies. Because human beings stand erect and human movement typically involves changing or maintaining this up-down orientation, humans develop or innately possess the concepts *up* and *down*. Lakoff and Johnson offer a similar account of concepts like *front*, *back*, and so on. Moreover, these basic concepts serve as a foundation for the origin of new concepts. Possession of the concepts *up* and *down*, for instance, can be recruited in metaphorical descriptions of concepts like *happy* and *sad*. These basic concepts *structure* the meanings of *happy* and *sad*, as Lakoff and Johnson's following examples illustrate: 'I'm feeling up. That boosted my spirits. My spirits rose. You're in high spirits. Thinking about her always gives me a lift. I'm feeling down. I'm depressed. He's really low these days. I fell into a depression. My spirits sank' (*Metaphors* 462).

Questions remain, of course, about why happiness should be described in terms of the basic concept *up* and *sadness* in terms of down, and Lakoff and Johnson offer some speculations about this; but the crucial point from the perspective of EC is that a critical tool of concept acquisition – metaphorical reasoning – might depend crucially on the physical properties of body. Indeed, Lakoff and Johnson conjecture that beings with bodies quite distinct from human bodies could not acquire the human concepts: '[i]magine a spherical being living outside of any gravitational field, with no knowledge or imagination of any other kind of experience. What could UP possibly mean to such a being?' (476). Furthermore, with no concept of *up*, these beings would not likely describe happiness in terms of boosted spirits, feeling high, and so on. Although this does not mean that such beings could not conceive happiness in other terms, it does mean, Lakoff and Johnson think, that their concept of *happiness* would differ from human beings' concept of *happiness*. We would have different concepts of happiness because we have different kinds of bodies.

Although Lakoff and Johnson are perhaps the most prominent, they are certainly not the only researchers with an interest in showing that body type constrains the contents of thought, thereby challenging traditional views of cognition as being in some sense medium independent. The psychologist Art Glenberg ('What Memory is For'; 'Symbol Grounding') and his group have focused on the body's role in sentence comprehension. Kaschak and Glenberg have found that subjects have greater difficulty understanding sentences that describe actions to which human bodies are not suited, which is striking on the view that language comprehension is simply a matter of learning how words fit together. At the very least, Glenberg's research, like Lakoff and Johnson's, suggests that studies of cognition cannot limit themselves to the traditional view of the mind as 'envatted' (Shapiro, *Mind Incarnate* 169). Cognition reflects in profound and hitherto underappreciated ways, these researchers believe, the properties of an organism's body.

A third EC research goal attempts to broaden the traditionalist's conception of cognition to include within cognitive processing not just aspects of the body but of the environment too. Clark and Chalmers, for instance, argue that something like a PDA might literally be part of one's cognitive system. The argument assumes a functionalist theory of mind, according to which mental states are individuated by their role in a larger system. Clark and Chalmers claim that the information in a PDA might play precisely the same role as information normally stored in a brain. If one considers information in the brain as constituting cognitive states, then, by parity, one must also agree that the information in the PDA constitutes cognitive states. Similarly, R. Wilson (*Boundaries of the Mind*) has urged that the use of pencil and paper to aid in the solution of, say, multiplication problems, marks an actual extension of a cognitive system. The pencil and paper are integrated so essentially into the cognitive act that there is no principled reason to distinguish these external items from the rest of the cognitive system involved in solving the multiplication problem. Moreover, Clark (*Being There*) has pointed out the extreme measures human beings take to organize their surrounding environments in a way that 'eases' cognitive burdens. Human beings make a habit of placing their keys by the door so that they don't have to remember where they are; they place landmarks so that they don't have to memorize routes; they catalogue files alphabetically to minimize searching demands. In these ways and others human beings can incorporate the structure of the environment into their cognitive processing. The environment becomes cognitively friendly in the sense that it eliminates steps that cognitive tasks would otherwise require.

Again, traditionalists are not without their responses. In particular, a traditionalist might wonder whether philosophers like Clark, Chalmers, and R. Wilson are merely playing word games when they suggest that information in a PDA or symbols on a slip of paper are parts of a cognitive system. Certainly these things aid in the completion of cognitive tasks, but so, for instance, do eyeglasses. To suggest that eyeglasses are in fact part of the visual system is simply to re-conceive the meaning of 'visual system'. The choice marks no profound insight in researchers' understanding of how vision is achieved. Similarly, one might choose to call the information in a PDA a cognitive state, but this decision makes little or no difference to how one might analyze memory. What, the traditionalist might grumble, is the payoff for extending the mind in these ways?

Perhaps the matter boils down to a question of burden bearing. The traditionalist might charge that EC must prove the utility in its demand for an expanded conception of cognition. On the other hand, proponents of EC might ask why, if items in the environment play the functional role of mental states, they should not be counted among them.

III. The Future of Embodied Cognition

Worth mentioning again is that EC remains at this point a research *programme*. As such, one should not dismiss it if its subject matters are not tightly unified or if its methods are not proven. However, the future of EC depends on its meeting at least two challenges. The first challenge is reminiscent of one that advocates of EC level against traditional cognitive science. Just as dissatisfaction with symbolists' attempts to produce robots that can match wits with a cockroach have led some researchers to embrace a embodied view of mind, it is easy to be suspicious of the kinds of tasks and abilities that researchers in the EC framework study. Among the most famous success stories in EC are Rodney Brooks's robots ('New Approaches to Robotics'; 'Intelligence without Representation') and Esther Thelen's work on the development of motor behavior in infants. Brooks has built robots that can navigate through rooms, collect soda cans and place them in recycling bins, and so on. Furthermore, these robots are equipped with an architecture that, rather than depending on rich representations of the environment for its success, depends on a collection of simple sensors connected directly to motors. The interaction of these sensors and the motors they control makes it appear as if the robot has a map of the environment and a sophisticated means by which to avoid or locate objects.

Likewise, Thelen has shown that coordinated kicking or stepping behavior in infants is modeled better in terms of a dynamical system than it is in terms of painstakingly calculated neural signals. The large muscles in the legs act as springs under the control of gravity. Stepping and kicking movements, rather than under the direction of a cognitive plan, are nothing more than the oscillatory movements of a spring. Similarly, the coordination involved in stepping, Thelen argues, does not involve any cognitive control, but results from the coupling between single-leg oscillators. In like manner, two pendulums mounted on a single wall will, over time, synchronize their swing. The coordination in both cases is simply a product of unguided physical forces.

A traditionalist might happily concede that Brooks's robots show surprising versatility given the simplicity of their computational architecture, and that Thelen's work on infant stepping provides an elegant explanation for a behavior that for many years was thought to be under exclusively neural (if not cognitive) control. Yet, traditionalists might not feel threatened by this work simply because they might deny that room navigation and stepping behavior are interestingly cognitive tasks. Thelen's studies are especially open to this criticism. An attempt to explain the mechanisms involved in stepping marks a significant departure from standard cognitive explanantia: attention, memory, problem solving, perception, language, and so on. Both Brooks and Thelen have expressed the belief that the theoretical apparatuses by which they understand simple behavior will 'scale up' and provide a platform for understanding all or most cognitive behavior, but until this work is done the traditionalist is on firm ground when wondering how much fruit EC is likely to bear in the science of cognition.

This last point introduces a second challenge to EC. Proponents of EC display a range of optimism. Some, like Brooks and Thelen, suggest that all of cognition will lend itself to description in computationally meager terms, or in the language of representationally bereft dynamical systems. Others, like Clark (*Being There*), are much more measured in their enthusiasm for EC, acknowledging a role for symbol processing, especially involving tasks like planning for the future or the consideration of counterfactual events. Still others, like Lakoff and Johnson and Glenberg seek to highlight the body's importance in cognition, but might remain neutral regarding the question whether metaphorical reasoning or language acquisition have symbolic components. Resolution of this sort of disagreement requires careful thinking about what, exactly, belongs in the domain of EC. Also, more reflection is needed on the relationship between EC and traditional cognitive science. Must EC abandon all of the traditional framework, or might the computer metaphor still be of service? Most pressingly, EC owes a clearer account of why many of its findings cannot simply be subsumed within traditional cognitive science. Perhaps cognitive scientists have failed to realize the significance of bodies in cognitive processes, but does this failure demand a new paradigm for the study of cognition? For instance, couldn't head density be construed as information that the auditory system encodes in its calculation of sound location? Couldn't a traditionalist explain limits on concept acquisition by appeal to a symbolic representation of the body's properties? The future of EC depends on articulating more precisely why the study of cognitive capacities should not or cannot incorporate facts about the body in these symbol-friendly ways.

Short Biography

Larry Shapiro's research ranges over topics in philosophy of mind, philosophy of biology, and philosophy of psychology. His articles about computational theories of perception, evolutionary psychology, multiple realization, and embodied cognition have appeared in journals such as *The Philosophical Review*, *Philosophy of Science*, *The Journal of Philosophy*, and *The British Journal for the Philosophy of Science*. In his book *The Mind Incarnate* (MIT, 2004), he tests the hypothesis that human minds are multiply realizable against the hypothesis that there is only one or only a few ways to realize a human mind. He also considers evidence for the hypothesis that minds are in some sense embodied. His current research remains divided between issues concerning multiple realization and embodiment. Shapiro has been a member of the Department of Philosophy at the University of Wisconsin – Madison since 1993. His Ph.D. in philosophy is from the University of Pennsylvania, and his B.A. is from Dickinson College.

Note

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