Excerpts: A Survey of Embodied Cognition

Jeff Cox

1. Introduction

Given mind and body to be two fundamentally different things, there exists no third “bridging” kind between the two. Even so, theories that are based on symbolic representation of physical entities and reside inside an organisms mind are the most prevalent within cognitive science[3]. In fact, most of the literature in cognitive science until recently has described cognition as computation. Relating the mind to a computer that has been programmed with symbolic representations of its environment. Relatively recently, this computational approach has been facing more and more opposition, mostly due to a variety of difficulties and limitations with the approach. Researchers have thus been seeking new ways to understand cognition [4].

2. What is Embodiment?

The term “embodiment” is actually rather difficult to define, still being widely debated, and as an interdisciplinary concept, is often used in varying contexts. Within philosophy it is most broadly used as a counter to the Cartesian philosophical account of the mind [5-9].

3. Embodied Cognition

As the limits of a representational view of cognition inspire a rediscovery of the importance of the body many researchers are quick to jettison representation entirely as is evident in brooks [10]. Clark however, rallies for a more compromising approach, hoping to not entirely reinvent the rich symbolic approach to cognition afforded by representational theories [11]. In more current work by Johnson and Rohrer, though, Clark’s limited view is dismissed, seeing the artifacts of first generation cognitive science as representational baggage. They build a fundamentally non-representational framework rooted in the early works of the pragmatists of William James and John Dewey.

> James and Dewey understood something taken for granted in contemporary biological science: cognition emerges from the embodied processes of an organism that is constantly adapting to better utilize relatively stable patterns within a changing environment.[3]

In many ways similar to Van Gelder’s dynamic approach in [4], Johnson and Rohrer see embodied cognition as “…a series of bodily activities immersed in the ongoing flow of organism-environment interactions that constitutes experience” [3].

3.1 Mind and Body?

From the perspective of the embodied scientist there is no separate “mind” and “body”. So the answer to the question of how do we bridge the gap between the two is that there is no gap! Thinking is action and action is thinking. Using MYCIN [12] as an example, Brooks points to the brittleness of representational systems as proof that there is not a clear mind/body distinction [10]. Johnson and Rohrer show how the sensorimotor functions of single-cellular organisms, can lead to a continuous human cognition. Beginning with the dynamic relationship between the sensory and motoric surfaces of an amoeba’s cell membrane and ending with locomotion of the multi-cellular hydra [3].

3.2 Embodied Learning

In order to properly address cognition the proponents of an embodied approach should address the fact that human cognition involves learning. Given the strong non-representation claims of current theorists this could be a tall order. Unfortunately, there seems to have been little work addressing this issue.

Brooks asks the question, “ Is learning and such possible” in [10] and eludes to an isolated subsystem which learns similar to what he terms “insect learning”. Indicating however, that the system is one of dangling inputs and outputs. Admitting to the ironic lack of embodiment.

Johnson and Rohrer explain learning via a system of neural maps. They point to experiments in neuroscience such as [13, 14] to define their notion of a neural map. These experiments show how nervous systems will actually exploit topographical and topological organization. A neural map from their perspective is the set of adjacent neural cells that will fire sequentially when adjacent positions of the sensory field are stimulated [3]. Further claims are made that these neural maps are plastic in nature, again pointing to a number of experiments in neuroscience. For example, they refer to an experiment done by Gaze R.M. and Sansar C. Sharma in which goldfish have their optic nerve cut and part of the optic tectum destroyed. The result is a new and complete retinal map in the remaining part of the tectum. Another example is regarding cross-modal neural maps in owls as they pertain to hearing and sight. In this experiment [15, 16] adult and juvenile owls wear prismatic glasses that distort the owls vision by 23 degrees for 8 weeks. Juvenile owls learned to hunt accurately, but the adult owls did not. Most interesting is that though the original adult owls were not able to compensate for the visual impairment, the juveniles who had worn the glasses and then had them reintroduced once adults were able compensate. These behavioral adaptations are further solidified by an anatomical comparison of the two categories of adult owls. What has been found is that the patterns of axonal projections between the two modalities are different Not only implying the plasticity of juvenile cross-modal maps, but their permanency [3, 16].

Johnson and Rohrer are adamant that these neural maps are in no way representations. Instead claiming them to be the structures of an organisms experienced world. Their claim is not necessarily that representation is a bad word, but that neural maps are in no way related to the traditional metaphysical dualisms. They want to abolish the notion of an inner/outer view of cognition [3].

> In short, what we (as scientists) theoretically recognize and describe as an organism’s “maps” are not *for that organism* internal representations. Rather, what we call sensorimotor and somatosensory maps (whether in multi-cellular organisms, monkeys, or humans) are *for that organism* precisely the structures of its experienced world! Consequently, we must be careful not to be misled by philosophers of mind and language who would treat these maps as internal representations of external realities, thereby

surreptitiously introducing an "inner/outer" split that does not exist in reality for the organism.

In other words, the use of terms such as "map" are useful to the observer of the cognitive process to denote immediate neural activation in a persons brain corresponding to some thing (i.e. the color blue) in the observer's perceived world. However for the person, the map does not represent the "thing" but *IS* the "thing" in the persons world [3, 17].

Ultimately Johnson and Rohrer claim that embodied learning is a "…process of neural arbor selection akin to natural selection taking place in concert with specific patterns of organism-environment interactions"[3]. That human's have a set of visual, auditory and somatosensory neural maps mapping not only perceptual space, but also increasingly abstract topological structure and that our sensorimotor maps are the basis of reasoning [3].

4 Experimental Support

The most interesting aspect of the embodied approach is the amount of experimental support over the last so many years. One particularly interesting series of experiments was done by Parsons in [18, 19]. This experiment asked subject to perform mental rotations of images depicting line drawing of human hands. Subjects were quicker and better at identifying rotations that corresponded to the easiest actual hand rotations. In other words, if one puts their left hand out palm up and rotates, it is easier and requires less effort to rotate to the right rather than to the left. The subjects in the experiment experienced similar difficulty in performing the mental rotations of line drawings [20].

References

1. Cooper, J.M., *Plato: Complete Works.* Indianapolis: Hackett Publishing Company, 1997.
2. Barnes, J., *The complete works of Aristotle*. 1984: Princeton University Press.
3. Rohrer, M.J.a.T., *We Are Live Creatures: Embodiment, American Pragmatism, and the Cognitive Organsim.* Body, Language and Mind, forthcoming 2006. **1**.
4. Van Gelder, T., *What might cognition be, if not computation?* The Journal of philosophy, 1995. **92**(7): p. 345-381.
5. Johnson, M., *The body in the mind: the bodily basis of meaning, imagination, and reason*. 1987: University of Chicago Press.
6. Lakoff, G. and M. Johnson, *Metaphors we live by*. 1980: University of Chicago Press Chicago.
7. Lakoff, G. and M. Johnson, *Philosophy in the Flesh: The Embodied Mind and Its Challenge to Western Thought*. 1999: HarperCollins Publishers.
8. Rohrer, T.C., *WHEN METAPHORS BEWITCH, ANALOGIES ILLUSTRATE, AND LOGIC FAILS: CONTROVERSIES OVER THE USE OF METAPHORIC REASONING IN PHILOSOPHY AND SCIENCE*. 1999, University of Oregon.
9. Geeraerts, D., *Paradigm and paradox: explorations into a paradigmatic theory of meaning and its epistemological background*. 1985: Leuven University Press.
10. Brooks, R.A., *Intelligence without Representation.* Artificial Intelligence, 1991. **47**(1): p. 139-159.
11. Clark, A., *Embodiment and the Philosophy of Mind.* Philosophy of mind: Royal Institute of philosphy supplement 43, 1998.
12. Shortliffe, E.H., *Computer-based medical consultations: MYCIN*. 1976: Elsevier New York.
13. Fraser, S.E., *Cell interactions involved in neuronal patterning: An experimental and theoretical approach.* Molecular Bases of Neural Development, 1985: p. 481-507.
14. Sperry, R.W., *Effect of 180 degree rotation of the retinal field on visuomotor coordination.* J Exp Zool, 1943. **92**: p. 263–279.
15. Knudsen, E.I., *Capacity for Plasticity in the Adult Owl Auditory System Expanded by Juvenile Experience.* Science, 1998. **279**(5356): p. 1531-1533.
16. Knudsen, E.I., *Instructed learning in the auditory localization pathway of the barn owl.* Nature, 2002. **417**: p. 322-328.
17. Brooks, R.A. and L.A. Stein, *Building brains for bodies.* Autonomous Robots, 1994. **1**(1): p. 7-25.
18. Parsons, L.M., *Temporal and kinematic properties of motor behavior reflected in mentally simulated action.* J Exp Psychol Hum Percept Perform, 1994. **20**(4): p. 709-30.
19. Parsons, L.M., et al., *Use of implicit motor imagery for visual shape discrimination as revealed by PET.* Nature, 1995. **375**: p. 54-58.
20. Rohrer, T., *The Body in Space: Embodiment, Experientialism and Linguistic Conceptualization.* Body, Language and Mind, forthcoming 2006. **2**.