

Embodied Cognition

How do bodily form, action, and the material and social environment affect biologically evolved intelligence?
Is there a fundamental science of the embodied mind?

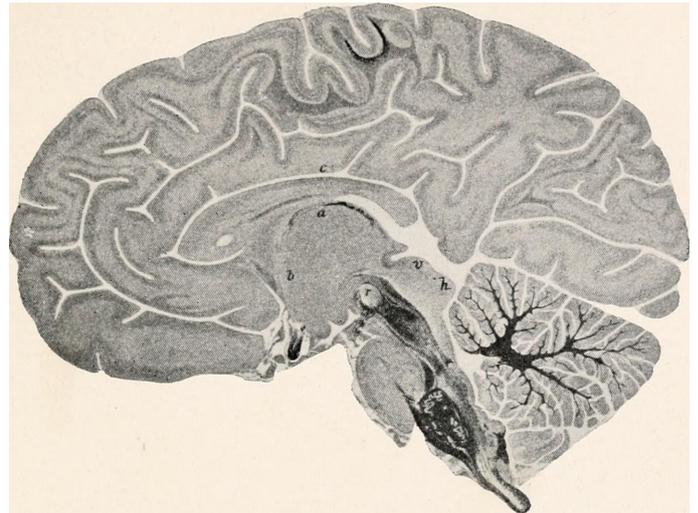
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Embodied cognition studies the difference that having an active body and being situated in a structured environment make to the kind of tasks that the brain has to perform in order to support **adaptive** success.

This kind of work provides a useful antidote to the increasingly **neurocentric** vision that we encounter in contemporary media.

How much or how little brain might be needed to make a robot do intelligent things or to explain adaptive behaviour in humans or other animals?

A classic example of this are the passive dynamic walking machines built at Cornell University. This robot has no motors or controllers, but rather, its motion is begun by falling forward on a slight slope. This makes one of its legs swing forward by pendulum motion and the other leg to swing forward.



Understanding and actually building the physical system tells us more about how we walk than trying to introspectively think about how we move our legs, swing the foot forward, etc.

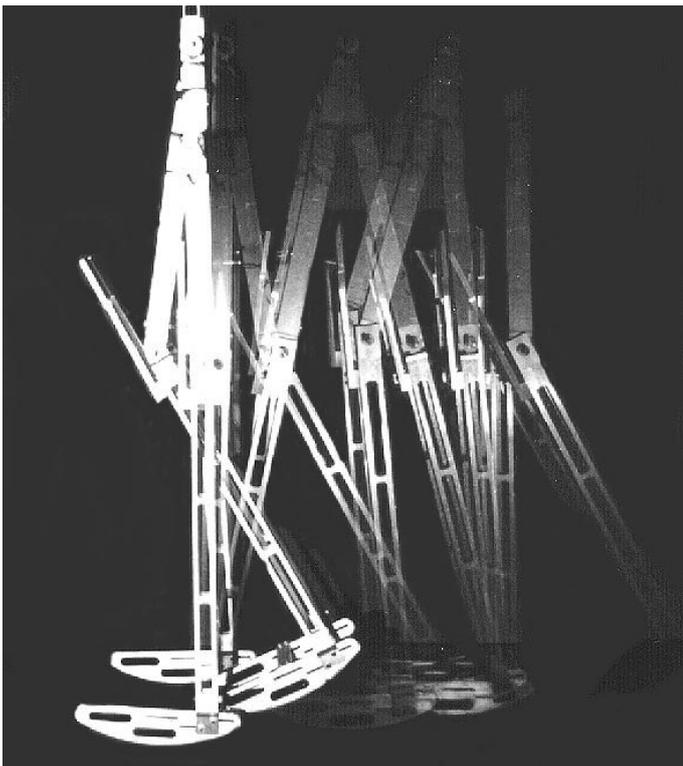
Key idea: control and information processing are not restricted to the brain

The reliable properties of the body are always present during the evolutionary time period in which the brain is evolving.

To understand perception and action in the natural order, we need to understand how creatures can exhibit seemingly sensible bits of behaviour on the basis of information that they take in from the world.

The Naked Brain Fallacy

Giving full credit for intellectual achievement to the biological brain alone, instead of seeing it as one player on a busy stage full of props and scaffoldings whose contributions are complex and profound.



Three steps for understanding cognition

1. Control and processing leaks into the body

Bodily shape (morphology) and bodily biomechanics re-configure a wide variety of problems in ways that promote fluidity and efficiency by simplifying the neural commands required to bring about complex behaviours, effectively delegating aspects of control and processing to the body itself.

It is not just the gross form and bio-mechanics that may be doing unexpected work, but also the skilled use of the body in action.

In *higher cognition* we constantly sketch, scribble, gesture, and talk to ourselves, creating structured flows of visual and auditory stimulation that can enhance and guide our own cognitive activity.

2. Cognition leaks into whole action-perception loops.

The presence of a self-controlled, acting, sensing body allows an agent to sculpt her own sensory input streams in ways that promote learning, reasoning, and efficient problem-solving.

The engine of some forms of cognizing is thus not the naked brain but a complex whole involving the brain in concert with the sensing acting body.

Consider our own *artifact-enhanced cognitive processing*. We use all kinds of external operations and media, from spreadsheets to iPhones, to enhance and extend our problem-solving powers.

We write notes as we think, we draw diagrams that we ourselves immediately inspect. We talk out loud, we gesture while we talk, and we feel the gestures and hear what we say... Just as the Tuna structures its world to promote better swimming, we structure our worlds in ways that – incrementally, and at multiple scales of space and time – promote better thinking.

It is not that all the thinking happens inside the head, and the loop out into symbols on a page is just a kind of convenience or a way to avoid forgetting. Rather, the loops to external media, just like physical gestures, form part and parcel of an integrated system for thinking.

3. Cognition leaks not just into the body, but into the world, including (especially) the world of external symbol structures, diagrams, etc.

As a result, some of an agent's cognitive processes are run on new machines constituted by combinations of resources spanning brain, body, and world.



To understand real human cognition, we need to take the 3 points exposed very seriously. Cognition, control, and processing leak messily into **body, action, and world**.

Brain-body-world processes are **multiply hybrid** involving: neural representations and computations, bio-mechanical propagations of force and energy, physical manipulations of external symbol systems all held together by sensorimotor loops in which real timing is often critical. And all located in complex material and socio-cultural settings.

Further important questions

- The crucial role of other agents in the sociotechnological matrix.
- Considerations concerning the body and emotion
- Questions concerning the precise role of embodiment and action in the generation of conscious experience and awareness

Open question

Can there be a fundamental theory linking morphology, perception, action and neural control in ways that reveal their co-operative role in the construction and control of situated intelligent behaviour?
