

## From Embodiment to Cognitive Extension

## The active body

- The computation that gets done in interaction of brain body and world, does not have to be done by the brain alone
  - Decentralized mindset.
  - A new place to look for the origins of organization.
- Walking taking advantage of the dynamics of the body. Thelen & Smith; Passive dynamic walker
- Inhabit rather than control the body

## Active Sensing

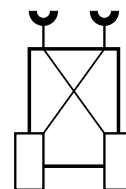
- “Perception is not something that happens to us, it is something we do.” (Noe, 2004)
- And we only sense when needed.
- Deixis, binding objects in the world to conceptual entities.
  - Because we must establish and maintain connection, coupling between brain, body and world.
- Sensing for coupling – catch a fly ball.
- Taking advantage of the structure of multimodal signals.

## Dynamical Systems and Cognitive Science

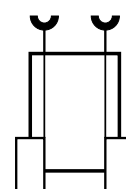
## The attribution problem

- If mind is caused by something inside of us, what exactly is it that one must assume is IN THERE in order to account for the organized behavior one can observe?
- Valentino Braitenberg *Vehicles: Experiments in Synthetic Psychology*, MIT Press 1984.
  - A robot that loves light

## Braitenberg's Vehicle 2

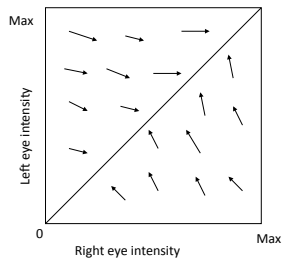


Loves Light



Hates Light

### Vehicle #2 state space



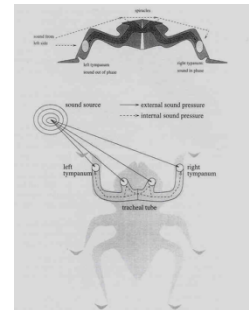
### Cricket Phonotaxis

The importance of sensor placement

Three tasks:  
Tune, locate, locomote

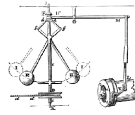
No representations  
No computations

A dynamic state space a lot like Vehicle #2

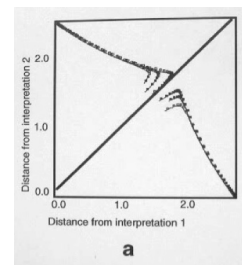


### Key features of the dynamical systems approach

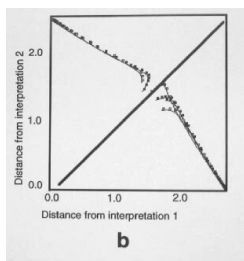
1. The discovery of powerful but low-dimensional descriptions of systemic unfolding.
2. The provision of intuitive, geometric images of the state space of the system.
3. Isolating **control parameters** and **collective variables**.
4. Using the technical notion of coupling to model and track processes involving continuous reciprocal causality among the multiple subsystems. (Watt governor, e.g.)



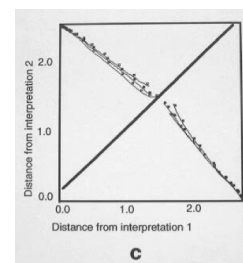
### No communication



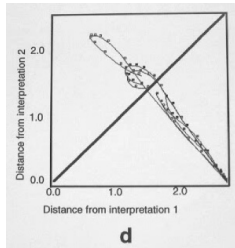
### Little persuasiveness



### More Persuasiveness



## A lot of Persuasiveness



## What is the brain doing?

- The brain is revealed not as an engine of reason or quiet deliberation, but as an organ of environmentally situated control. (*Mindware*: 95)

## What sort of explanation do we want?

- Perception – computation – action loop?
- Well, what needs to be explained?
- The answer to that depends on where we place the boundaries of the unit of analysis.
  - Boundary at skin of the creature -> explain behavior in terms of brain processes
  - Boundary around creature/environment dynamical system -> explain powerful regularities in the behavior of the complex dynamical system composed of brain, body and world. (Finger wagging, Infant stepping, e.g.)

## Dynamical Cognitive Science

- Body and world (and hence time, movement, etc.) all matter and can play powerful roles in adaptive problem solving.
- Neural, bodily, and environmental elements are intimately intermingled in continuous **mutual** and reciprocal causality.
- The traditional “input – compute – act” cycle cannot explain such systems.

## The negotiable body

- The boundaries of bodies are not as clear cut as we thought.
- An implicit syllogism
  - The body plays an important role in cognition
  - The boundaries of the body are negotiable
  - Therefore, (maybe) the boundaries of cognition are also negotiable

## Three grades of embodiment

1. Mere embodiment: body as control problem
2. Basic embodiment: exploit the dynamics of the body
3. Profound embodiment
  - “...constantly search for opportunities to make the most of body and world, checking for what is available, and then (at various timescales and with varying degrees of difficulty) integrating new resources very deeply, creating whole new agent-world circuits in the process” StM p.42

### Cognitive Incrementalism: the BIG issue

- What in general is the relation between the strategies used to solve basic problems of perception and action and those used to solve more abstract or higher level problems?
- Are the neural mechanisms of higher thought fully continuous with mechanisms of on-line action control?
- Or, are other sorts of processes needed?

### Block Copying

