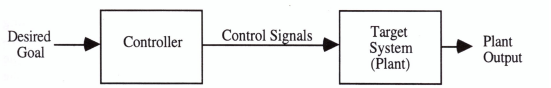
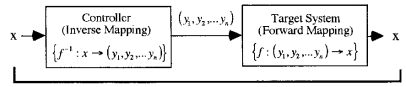
Representation II

Control Theory Ideas

Open loop control: Controller specifies the actions the plant is to take



To do so, the controller performs an inverse mapping of the forward mapping performed by the target: Map the goal into actions so that the plant can perform them as reach the goal



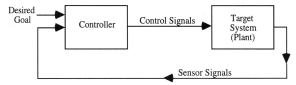
Entire system : Controller + Plant

Identity Mapping $\{i : (x \rightarrow x)\}$

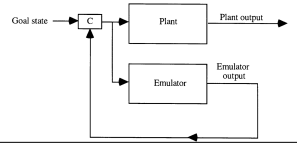
Control Theory Ideas

Closed loop (feedback) control: The departure of the output of the plant from the target is the basis for action to produce the target

Watt's governor is an example of closed loop control



Pseudo-closed-loop control: Emulator stands in for the plant and effects of actions on the emulator are fed back to guide action



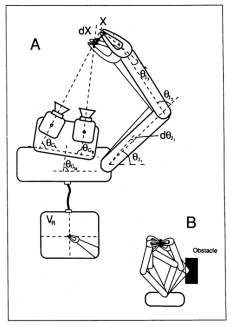
Running Emulator Off-Line

A part of the power of an emulator is that it can be run off-line
- To plan behaviors
- To consider alternative possibilities

To suggest how, Grush uses the example of using a second chess board to try out possible moves to see what happens
- What is the comparable way of using an emulator that is part of a motor control system?
  - What sort of access does the system need to the internal states of the emulator?

Emulators in Robots

Murphy was designed to use a mechanical arm to interact with objects
- Challenging when there are other objects and Murphy must determine how to extend its are to reach its target
- Murphy develops an internal model from experience of seeing the consequences of its movement
- Can use the internal model in place of feedback
- Can reason counterfactually



Using an Emulator to Update Motion

When humans engage in motor actions such as reaching, they seem to correct their movement as they proceed
- But this happens too fast to be under feedback control

Grush's proposal: humans are using pseudo-closed-loop control
- Or a combination of pseudo-closed-loop and closed loop

Grush extends the framework to motor imagery--used off-line in planning motor activities
- And to visual imagery accomplished through off-line driving of the visual system

Questions for the Emulator Theory

- Does the specification of the goal count as a representation?
  - Presumably not because it is not part of an emulator
- How does the emulator come to represent the plant?
  - In engineered systems, emulators are designed to do so
  - In biological systems, they must be acquired by evolution or learned
- How do states in the emulator represent distinct features of the plant?
  - Grush appeals to the user, but how does the user establish the right connection between states of the emulator and actions?
- Can we represent more than just our motor system?
  - Grush suggests that we can also represent the environment as part of the forward model, but doesn't say how this is to work.

Evaluating the Alternatives

- My account makes representations nearly ubiquitous
  - They will be found in any control system since such a system requires information about the plant and its operations to regulate its activity
  - Representations are not a distinctive feature of cognitive systems
  - But this seems to track neuroscientist's usage
- Grush is concerned to connect representations with cognitive activities
  - Only a system that can be taken off-line and used in reasoning (a paradigmatic cognitive activity) involves representations
    - The rest of what neuroscientists call representations are recategorized as presentations
- Should presentations and representations be sharply distinguished?
  - Or might presentations provide the building blocks for Grush's representations? I.e., presentations that get taken off line
  - This has the advantage of being able to invoke causal connections to link up internal states with what they will then represent

Intentionality: The Content of Representations

- *Intentionality* refers to the ability of representations to represent something
  - A photograph of a person represents that person
  - A diagram is about a phenomenon or mechanism
  - A noun or verb in a text refers to a thing or its properties
  - A belief represents some putative fact
- Since Brentano introduced the concept of *intentionality* the connection between the representation and what it represents has been mysterious
  - Especially since the represented thing may not exist at all or as represented
- A common strategy has been to appeal to how representations carry information by being causally dependent on what they represent
  - In the case of the brain, this must be mediated by the senses

Clicker Question

Imagine standing on the beach and someone asks you what you think the temperature is. You reply "It's hot—probably in the upper 80s." What is the "traditional view of the senses" (as characterized by Akins) that explains this

- Our senses act like thermometer, reporting the temperature in a servile manner
- Our senses are poor indicates of temperture, as illustrated by illusions
- Our senses are good indicators but generally less reliable than thermeters, reporting only values such as *hot*, *warm*, *cool*, and *cold*
- Our senses typically only report changes in temperature, not the actual temperature

Traditional View of Sensory Representations

The brain only accesses the world via representations provided by the senses

- Without them, the brain is a solipsist

Assumptions

- There is a reliable correlation between what is represented and the representation
- The structure of the phenomenon represented (relations between different temperatures) is preserved in the representations
- The senses offer *servile* reports--they do not impose their own interpretation

This does not require that the senses function perfectly, but error should not be widespread

- For only if sensory representations satisfy these conditions will the brain acquire the information needed to operation in the world
  - And avoid solipsism

Narcissistic Sensory Systems

Narcissists focus primarily on themselves

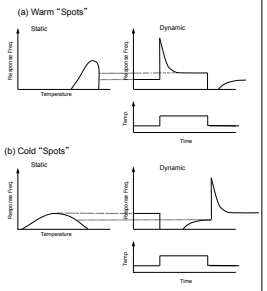
- Interpret everything in terms of its significance to themselves

Narcissism with respect to thermoreception

- Receptors are not in the business of objectively reporting whats in the world, but only what the organism needs to know
- Two temperature receptors, one for warm and another for cold
- Two pain receptors for extreme hot and cold
- Different parts of the body have different concentrations of warm and cold receptors and so are more sensitive to one or the other

Warm and Cold Receptors

- The "static" function of the warm and cold spots is its response frequency at different temperatures
  - The non-linear relations shown on the left
- Also have "dynamic" responses to changes in temperature
  - For the warm spot
    - When the temperature increases, the response first spikes, then gradually drops back to the new static response
    - When the temperature drops, the response drops before gradually returning to the new static response
    - Size of spike depends on size of change
  - Reverse for the cold spots

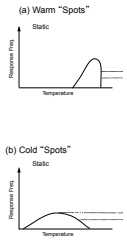


Reports Temperature as it Matters to the Organism

- The organism is narcissistic: what it needs to know is not how the world is, but how the world is affecting it
  - Hot and cold receptors are reporting changes in temperature that might matter
  - What matters most is how things are changing
- If temperature is changing differently for different parts of the body, they report the same stimulus differently
  - Hand initially in warm water
  - reports tepid water as colder than hand initially in cold water

From the Traditional View

- Thermoreception is a poor sensory system if what it is supposed to do is provide accurate information about temperature
  - It reports the same temperature in different ways
    - Depending on how many receptors are in a given tissue
  - It gives the same response to different temperatures
    - To stimuli on either side of the maximal response



Clicker Question

What is Akins' own assessment of the usefulness of narcissistic sensory systems?

- They are a serious impediment to our ability to understand the world around us since they generate distortions
- They aren't very useful and so humans have devised more actuate tools like thermometers
- They provide exactly the information organisms most need—the information needed to respond effectively
- They are OK, but they could have been much better designed

Evolutionarily Sensible

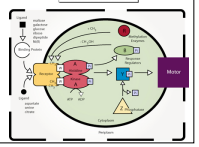
"one realizes that this system is not merely inept, a defective indicator of surface temperature. Rather, the system as a whole constitutes one solution to man's various thermal needs--that he be warned when thermal damage is occurring or before it is likely to occur, when temperature changes are likely to have specific consequences, and so on."

Would an objectively accurate recording of temperature work better?

- In order to use such information to plan action, the organism would need to know how to reason with that information

For many purposes, what the motor system needs to know about is what matters for action

- For a bacterium, is it moving up or down a chemical gradient
  - It doesn't need to know the actual quantity



Processing Information and Representation

Akins emphasizes the various types of information organisms must acquire in order to direct motor activity

- Why do the neural processes involved in processing this information not count as representations?

At some points Akins seems to acknowledge that they do:

- "Even our simplest actions, then, involve numerous sources and types of information (here, visual, proprioceptive, and haptic information) and, within a single system such as vision, specialized information (about shape, position using a variety of reference frames, rotation, movement, and so on) which requires diverse **representational schemes**."

Her objection seems not to be to the occurrence of representations in the brain, but to the nature of those representations

- They don't represent objective features of the external world
  - Rather, they represent narcissistic information

But elsewhere she speaks of such as "nonrepresentational systems"

Intentional Representations of which we are Conscious

Akins real concern seems to be with the intentional grounding of our conscious representational states

- Her contention is that sensory receptors don't ground these states

But how do we come to have such states?

- A plausible answer is that we extract them from what is represented by the senses
- But Akins rejects this answer: "This suggestion, however, amounts to little more than an expression of one's faith in the traditional view. Empirically, there is little reason to think that all sensory systems carry within them the means to "decode" their own responses."

But why think we do represent consciously all information acquired by our senses?

- We may not be able to make objective claims about temperature
- But with other systems, such as vision, we do reach more objective representations of the world outside us--tables, chairs
  - Of course this requires a lot of neural processing

Akins' Doubts about the Detector Theory

Akins raises a further objection to the construal of sensory systems as detectors of specific properties (including narcissistic ones)

- Internal systems in the organism regularly modify the response properties of the senses so that they are not fixed detectors of a given property
  - Example: feedback processes alter the response of muscle spindles to changes in muscle length as the muscle is extended or contracted

What is wrong with context sensitive detectors--detectors whose sensitivity is calibrated by other activities in the system?

- Of course whatever utilizes the response of the detector must also be responsive to the way the receptor was calibrated

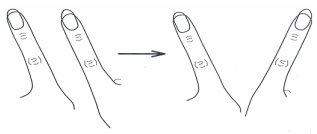
Radical Anti-Representationalism

A number of theorists have rejected the project of understanding systems by identifying representations and operations that alter representations

- Like van Gelder, they argue that a better approach, motivated by physics, is to characterize cognitive systems in terms of differential equations that specify how values of variable changes

Kelso introduced the finger waging task: wag your index finger on either hand

- At slow speeds, you can either move them out of phase or in phase with each other
- As the speed increases past a critical point, only the in phase motion is possible



The HKB Coordination Model

A simplest mathematical model that describes this behavior is:

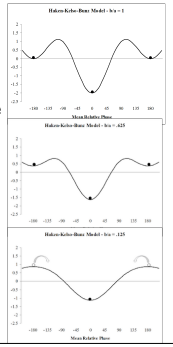
$V = -a \cos\varphi - b \cos 2\varphi$,

V is change in relative phase, φ represents the relative phase and the ratio of the parameters b/a is inversely related to the rate

When b/a = a, there are two relatively deep attractors but

as b/a declines, a point is reached at which there is only one attractor

The HKB account describes coordination behavior without representations: "there simply is no likely candidate in the system as described by the HKB model that might serve as an information-bearing state of the animal that mediates between it and the world"



Clicker Question

What role do representations play in finger movement coorindation according to the HKB model?

- The variable φ represents the phase difference between the fingers
- Representations are the states within the brain that figure in the control of finger movement
- The attractor basins represent the stable phase relations at a given velocity
- None

The Dynamical Approach

Chemero describes the method

- "First, observe patterns of macroscopic behavior; then seek collective variables (like relative phase) and control parameters (like rate) that govern the behavior; finally, search for the simplest mathematical function that accounts for the behavior

This approach has been applied to a broad range of behavioral and neural phenomena

Note: the approach is non-mechanistic: there is no attempt to decompose a system into its component parts and operations and to show how they together generate the phenomenon

- The mathematical function explains the dynamic behavior to which it gives raise