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.

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 So Far

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:

A. Our senses act like thermometer, reporting the temperature in a servile manner
B. Our senses are poor indicators of temperature, as illustrated by illusions
C. Our senses are good indicators but generally less reliable than thermometers, reporting only values such as hot, warm, cool, and cold
D. 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:
1. There is a reliable correlation between what is represented and the representation.
2. The structure of the phenomenon represented (relations between different temperatures) is preserved in the representations.
3. 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 operate 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 what is 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.

Dynamic Temperature Response

<table>
<thead>
<tr>
<th>Time</th>
<th>Temp.</th>
<th>Dynamic Temperature Response</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>(a) Warm Spots</td>
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<tr>
<td></td>
<td></td>
<td>(b) Cold Spots</td>
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Clicker Question

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

- A. They are a serious impediment to our ability to understand the world around us since they generate distortions.
- B. They aren’t very useful and so humans have devised more acute tools like thermometers.
- C. They provide exactly the information organisms most need—the information needed to respond effectively.
- D. 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 sensors? 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 wagging 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:

\[ V = -a \cos \phi - b \cos 2\phi \]

\(V\) is change in relative phase

\(\phi\) represents the relative phase

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 Dynamical Approach

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".

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 rise.

The Options

Internal states of the organism that figure in information processing and are used to control behavior represent features of the organism and the world outside (perhaps in ways most relevant to the organism).

Only states of the organism that are used off-line as stand ins for other things count as representations.

There is a disconnect between the narcissistic sensory processing systems and what figure in human intentional states.

There are no representations within the organism—the organism and the environment together constitute a dynamical system that should be analyzed as such.