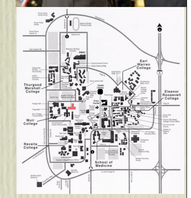
Representation 1

Representation in Information Processing Theories



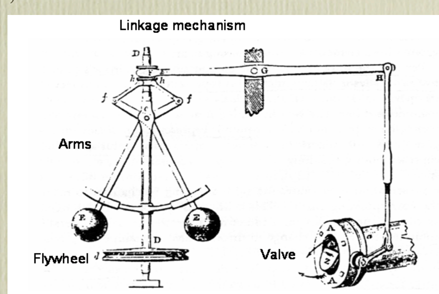
- Representations are entities that stand in for something external and are used instead of that for which they stand in
  - A picture can be used to tell us what someone looks like
  - A map can stand in for the actual world as we plan a route
  - A name can stand in for the person in a sentence we use to make inferences about the person
- Cognitive theories are distinguished from behaviorist theories not just by "going in the head"
  - But by construing mental activity as operations performed on representations
- Neuroscientists as well often characterized brain activity as representing something outside the brain

Doing Without Representations

- Watt faced a challenge in utilizing the steam engine--appliances (e.g, sewing machines) need to be driven at a constant speed, but as different appliances go on and off line the speed will change
  - Watt developed a governor in which, as the engine ran faster, arms attached to a spindle would rise by centrifugal force
    - Through a linkage connection, steam valve would be closed
- Van Gelder argued that
  - Watt's governor contained no representations
    - Its behavior is described by differential equations

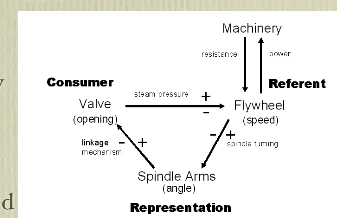
$$\frac{d^2\Theta}{dt^2} = (n\omega)^2 \cos\Theta \sin\Theta - \frac{g}{l}\sin\Theta - r\frac{d\Theta}{dt}$$

  - The governor could provide a model for how the mind/brain could work without representations



Is the Watt Governor Devoid of Representations?

- My first attempt to defend representations in the governor: the angle of the spindle arms seems to carry information about the speed of the engine
  - Van Gelder's response: angle of the spindle arms lags behind the actual speed of the engine
  - So it never actually corresponds to the actual speed
    - Is this really a problem? Representations should be able to misrepresent
- Nielsen's revision: solve the equation for ω
  - The engine speed is represented in the angle arms, but only if we take into account the φ and its first and second derivatives
  - Lesson: representations may be harder to detect than we initially thought, but they can be found
  - But we should expect them in control systems
    - Such as the brain



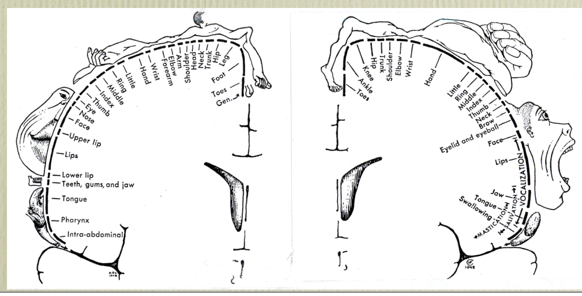
$$\frac{d^2\Theta}{dt^2} = (n\omega)^2 \cos\Theta \sin\Theta - \frac{g}{l}\sin\Theta - r\frac{d\Theta}{dt}$$

Θ is the angle of arms
n is a gearing constant
ω is the speed of engine
g is a constant for gravity
l is the length of the arms
r is a constant of friction at hinges

$$\omega = \frac{\sqrt{\dfrac{\dfrac{d^2\varphi}{dt^2} + \dfrac{g}{l}\sin\varphi + r\dfrac{d\varphi}{dt}}{\cos\varphi \sin\varphi}}}{n}$$

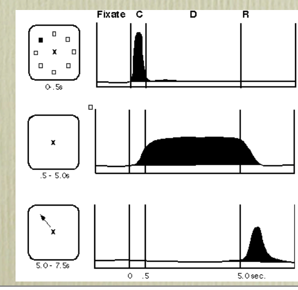
Representations in the Brain

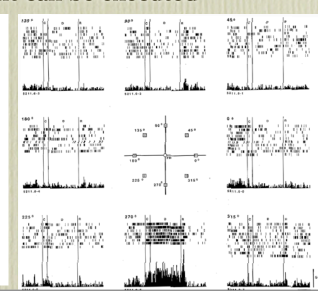
- On this analysis, we should expect to find lots of representations in the brain since brains are in the business of respond to stimuli with appropriate behaviors
  - The strategy of finding areas that respond to a given stimulus is a step towards identifying representations
  - But the neural activity that is assigned a representational function must also be used, at least on occasion, to regulate behavior



Demonstrating that Representations are Used

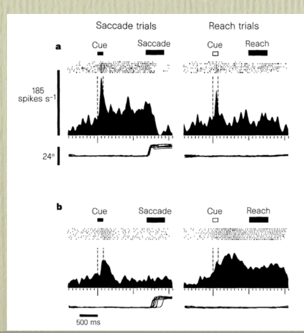
- Goldman-Rakic studied working memory tasks in which an animal is required to delay a response while remembers information
  - Animal is presented a stimulus telling it the direction it is to move (or move its gaze), but it must delay until a specified action time
  - Individual neurons remain active during the delay period, and then promptly return to base-line
  - These neurons are interpreted as representing the direction of motion until such time as the movement can be executed

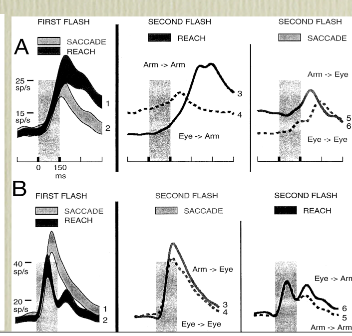




Determining What is Being Represented

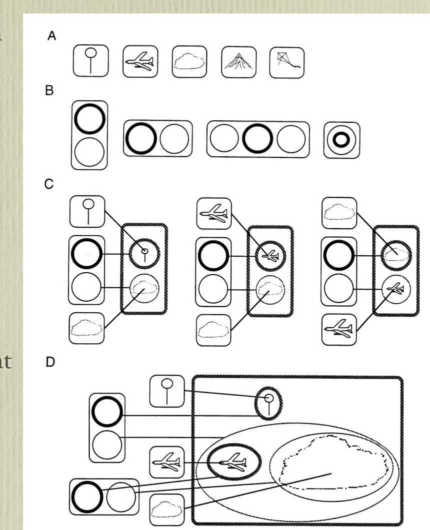
- In the Goldman-Rakic study, the animal could be representing either the location of the stimulus or the direction it was to move
- Snyder and colleagues found different neurons in posterior parietal cortex that fired depending on whether the animal intended to reach or saccade to the target--represented intention
- Whereas neurons in lateral inferior parietal cortex showed the same firing regardless of intention--represented location





Using Neural Representations to Simulate

- Reasoning has often been modeled on logical inference
- But to infer what will happen we can often mentally simulate an activity: imagine an object undergoing some change
- Many have objected that visual representations are too holistic to support inference
  - Only a propositional system in which nouns and predicates perform different roles can account systematic inference
- Barsalou has argued that that abstract relations can be captured by relating visual symbols that facilitate using them in reasoning



The Challenge Grush Sets

(i) representational status is a matter of how physical entities are **used**, and specifically is not a matter of causation, nomic relations with the intentional object, or information;

(ii) there are genuine (brain-)internal representations, contra theorists who maintain that only external symbols can be representations;

(iii) such representations are really representations, and not just farcical pseudo-representations, such as attractors, principal components, state-space partitions, or what-have-you; and

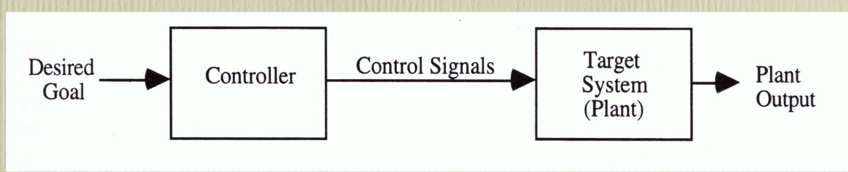
(iv) the theory allows us to sharply distinguish those complex behaviors which are **genuinely cognitive** from those which are merely complex and adaptive, contra dynamical systems theoretic and related views which treat cognitive phenomena as just complex adaptive behavior on the same continuum with 'simple' sensorimotor integration.

Presentation and Representation

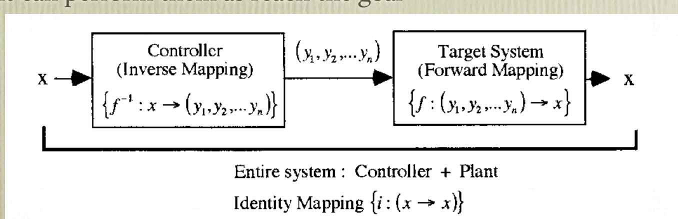
- Presentations are used to carry information about some other state of affairs
  - Informationally linked to the target
- Representations are used "**off-line**"--as a counterfactual presentation
  - A representation is, "in very rough terms, a model of the target which is used off-line to try out possible actions, so that their likely consequences can be assessed without having to actually try those actions or suffer those consequences."
- Presentations, but not representations, carry information about targets in the world
  - Leaves a question: what does relate a representation to its target
    - The way it is used

Control Theory Ideas

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

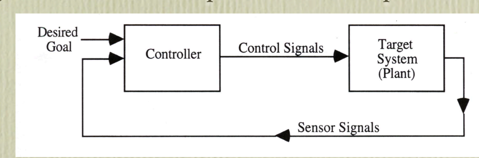


- To do so, the controller performs an inverse mapping of the forward mapping performed by the target: Map the goal into actions so that the plant can perform them as reach the goal

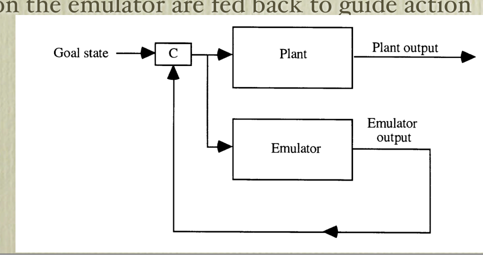


Control Theory Ideas

- 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

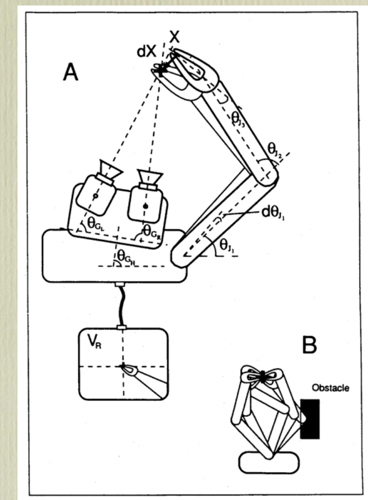


Running Emulator Off-Line

- 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?

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 they movement as they proceed
  - But this happens too fast to be under feedback control
- Proposal that 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, they were so designed
  - 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 do this?
- 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.