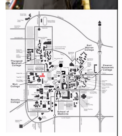
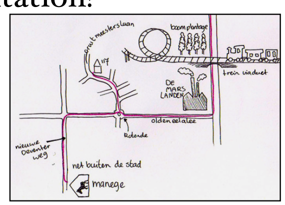
Representation 1

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

What Makes a Map a Representation?



- While snooping at a friend's house you encounter the drawing to the right. It looks like a map, but is it?
  - It could just be some doodling someone did while bored
- What would it take to show that it is a map?
  - That is happens to be isomorphic to some location in the world?
    - That could be mere coincidence
  - That it was drawn by someone in response to their experiences of particular locations?
  - That it was drawn for the purpose of guiding someone to locations?
- Common view: representations are entities that stand in and carry information about something and enable the system to direct its behavior with respect to that thing

Clicker Question

In mounting his argument against appealing to representations in cognitive science, what example did van Gelder employ?

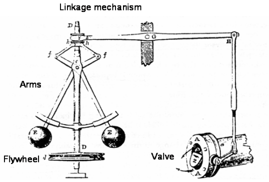
- The system of place cells in the hippocampus
- The activity of the visual cortex when presented with stimuli
- The steam engine designed by Watt
- The governor Watt used in the steam engine

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

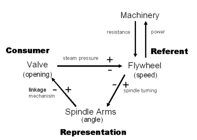
$$\frac{d^2\Theta}{dt^2} = (n\omega)^2 \cos\Theta \sin\Theta - \frac{g}{l}\sin\Theta - r\frac{d\Theta}{dt}$$

  - 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 typically doesn't 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



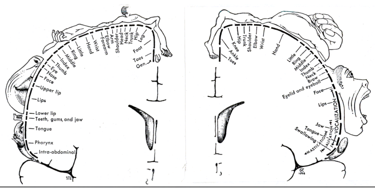
$$\frac{d^2\Theta}{dt^2} = (n\omega)^2 \cos\Theta \sin\Theta - \frac{g}{l}\sin\Theta - r\frac{d\Theta}{dt}$$

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

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

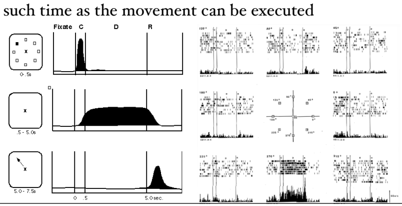
Representations in the Brain

- On this analysis, we should expect to find lots of representations in the brain since brains are governors (control systems) in the business of responding 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 of the sort that the system can use to regulate its behavior



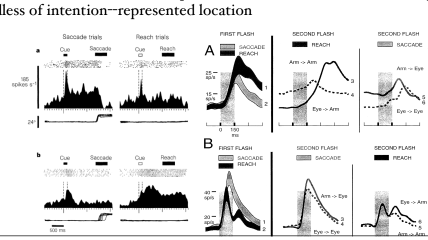
Demonstrating that Representations are Used

- 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 by Considering Use

- 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
- Other neurons (in lateral inferior parietal cortex) showed the same firing regardless of intention—represented location



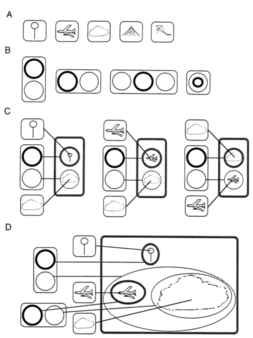
Clicker Question

Philosophers such as Fodor argue that mere stand-ins are insufficient to support reasoning. We need representations that are systematic. How is “the florist loves Mary” systematic?

- Love is a systematic relation
- Mary must also love the florist
- It entails that there is someone who loves Mary
- If one understands it, one can also understand “Mary loves the florist”

Using Neural Representations to Simulate

- Reasoning has often been modeled on logical inference
- But to infer what will happen we often mentally simulate an activity: we imagine an object undergoing some change
- Many philosophers 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
  - Suggesting how visual symbols could be used in reasoning



Grush’s Emulator Approach to Representations

(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?
    - Only strategy available: the manner in which it is used

Clicker Question

To illustrate the contrast between presentations and representations, Grush introduces two chessboards. What are the two different chessboards?

The one Grush uses to track the actual game and the one he uses to try out moves

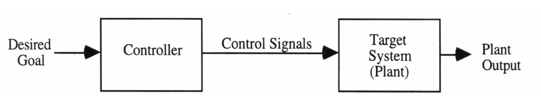
The actual game board and the one Grush uses to try out moves

The actual game board and the one Grush uses to track it since he is not present but on the phone

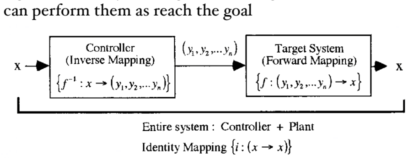
The chess board that Grush uses to track the actual game and another that accidentally has an extra piece on it

Control Theory Ideas

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

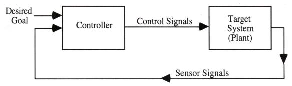


- To do so, the controller performs an inverse mapping of the forward mapping performed by the target: Map the goal into actions so that the plant can perform them as reach the goal

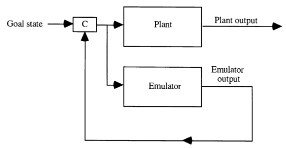


Control Theory Ideas

- 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

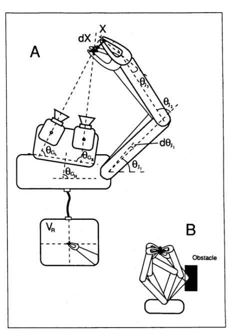


Running Emulator Off-Line

- 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?
    - 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 they 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 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.

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