Discovering and modeling mechanisms

Phil 12: Logic and Decision Making
Spring 2011
UC San Diego
6/2/2011
# CAPE response rate

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Please fill out a philosophy department course evaluation
Final exam

• Tuesday June 7th, 11:30am-2:30pm
  - just need something to write with
  - covers material since the midterm

• Correlation
• Causation
• Mechanism
Office hours

- Mitch: HSS 8037
  - Monday June 6th: 1-4pm and by appointment
- Nat: HSS 7054
  - Thursday 1-3pm
  - Friday 2-4pm
- Jeremy: HSS 7059
  - Friday 9-10am, 11am-12pm
What’s the first step in characterizing a mechanism?

A. Identify the parts of the mechanism
B. Figure out what the parts do
C. Accurately describe the behavior of the whole mechanism
D. Figure out how the parts are organized
Review

- Since the 17th century, science often appeals to mechanisms to explain phenomena

- A **mechanism** consists of parts (entities) and operations (activities) organized to produce a phenomenon
  - **Phenomenon**: what the mechanism does
  - **Parts**: the working parts of the mechanism
  - **Operations**: the work done by the parts that contributes to the activity
  - **Organization**: how parts and operations are organized
The importance of organization

- Why do diseases spread so quickly?
- “Six degrees of separation”
  - After Marconi created the telegraph and networks developed, he claimed that it would take an average of 5.83 telegraph stations to link any one person to another
  - confirmed by psychologist Stanley Milgram in a famous experiment in 1967
Stanley Milgram and Acquaintance Networks

• How many acquaintances would it take to connect two randomly selected individuals in the US?

• Sent letters to randomly selected people in Midwest with the name of a target person and the following directions

  1. Add your name to the roster at the bottom
  2. Detach one postcard. Fill it out and return it to Harvard Univ.
  3. If you know the target person on a personal basis, mail this folder directly to him (her).
  4. If you do not know the target person on a personal basis, do not try to contact him directly. Instead, mail this folder to a personal acquaintance who is more likely than you to know the target person

• Mean number of intermediate persons was 5.5--round up to 6 for 6 degrees of separation

Thursday, June 2, 2011
“Six Degrees of Kevin Bacon” game

- Created by three Albright College fraternity brothers in 1994
- Pick an actor or actress
  - If they have ever been in a film with Kevin Bacon, then they have a Bacon number of 1
  - If they have never been in a film with Kevin Bacon but have been in a film with somebody else who has, then they have a Bacon number of two
  - And so on....
Hitchcock and Bacon

• Alfred Hitchcock was in *Show Business at War* (1943) with Orson Welles, and Orson Welles was in *A Safe Place* (1971) with Jack Nicholson, and Jack Nicholson was in *A Few Good Men* (1992) with Kevin Bacon!

• Hitchcock’s Bacon number is 3
Bacon numbers

- Of the 225,000 actors listed in the Internet Movie Database as of April 1997:
  - 1,300 have a Bacon number of 1
  - 80,000 have a Bacon number of 2
  - 150,000 have a Bacon number of 3
  - No American actor, living or dead, has a Bacon Number greater than four
  - There are 20,000 foreign actors who can never be connected to Bacon and therefore have a Bacon number of infinity
  - No one else has a Bacon number higher than eight
The small-world simulation model

- How must a network be structured such that it exhibits the “six degrees of separation” phenomenon?
- Let’s work with a population of people, and start by assuming that you line up all people in a very large circle
Largest world

• Regular network
  - Only local connections
  • Since on average each person has 1000 friends, assume they know the 500 people to their left and 500 to their right
  - Long average path length ("degrees of separation"): 
    • On average, you will have 2.5 million degrees of separation from other people
Smallest world

- **Random network**
  - Random connections across whole network
  - Each person picks 1000 friends at random from whole world population
  - Very short path lengths:
    - Now on average you have 4 degrees of separation from other people
Small-world networks

- Take a regular network (lots of local connections), add a few random long-range connections
Applications of small world phenomenon

• How do diseases spread so quickly?
• Can an accident at a single power station bring down the rest of the grid?
• How does a joke spread across the Internet?
• How are the neurons of the brain connected?
• How do you design the most efficient office building?
Levels of organization within mechanisms
• The system as a whole engages its environment by performing its activity

• That system is comprised of components that perform different operations

• Those components in turn are comprised of components that perform yet different operations
Holism vs. Reductionism

• Tension:
  - Emphasizing organization focuses on the integration of the components into a whole system (holism)
  - Emphasizing components focuses on the decomposition of the system into separate components (reductionism)

• Often conflict between holists and reductionists
  - Holists charge that reductionists fail to consider the consequences of organization
  - Reductionists charge that holists fails to provide explanations
Mechanistic explanations:
both reductionist and holist

- Mechanistic explanations look both upwards and downwards
  - Upwards to higher levels of organization at which the mechanism is an organized system that performs its activity and thereby interacts with other entities
  - Downwards to lower levels of organization in which parts perform their operations in interaction with other parts
Discovering How Mechanisms Work

• Just like simple causal interactions: **correlated** activity suggests causal linkages

• But the best evidence for causation comes from **experiments**
  - Manipulating the input to the mechanism and determining the effects
  - Manipulating components of the mechanism and determining their effects
Discovering what components do

- **Recording studies:** record from an individual component while the mechanism is operating and inferring from the conditions in which the component is active what operation it might perform.
Discovering what components do

- **Inhibition, lesion, or ablation studies**: Lesioning or ablating a component and inferring from the deficit in the behavior of the whole what operation the component performed.

- **Excitation or stimulation studies**: Stimulating a component and inferring from its affect on the whole system what operation it performed.
Each technique is limited

- Recording, lesioning, and stimulating studies each require inference, and inference is fallible
  - Just showing that a component is active given a specific stimulus does not tell you
    - Specifically what about the stimulus it is responding to
    - What it is doing in response to that feature
  - Just showing that lesioning a component interrupts an activity does not tell you
    - That it alone was responsible for the activity
    - What it contributed to the activity
  - Just showing that stimulating a component increases the performance of the activity
    - Does not tell you how it figured in generating the activity
Need to orchestrate multiple techniques

- There is no foolproof strategy for figuring out how a mechanism works

- The best results stem from combining different strategies to determine what the components of a system are and what they do
Example: Multi-level account of spatial memory
Delineating the phenomenon of spatial memory

- To understand spatial memory you must know how it is exhibited, including in what larger contexts.
- In the Morris water maze, rats quickly learn where the submerged platform is and swim directly to it.
Going inside to explain the phenomenon

- Inside the rat’s brain one finds a structure—the hippocampus—that, if removed, leaves the rat unable to navigate (inhibition/lesion experiment)

- Inserting an electrode into the structure one finds cells that respond to specific places (recording experiment)
Molecular changes and long-term potentiation (LTP)

- LTP is a long-lasting enhancement in signal transmission between two neurons that results from stimulating them synchronously
  - discovered via stimulation studies in rabbit hippocampus
  - might be due to release of more glutamate, change in receptor properties, or both
Multi-level account of memory

- Organisms develop memories
- Particular parts of their brains are especially important for encoding or storing memories
- Within these components, biochemical changes result in altered systems that behave differently in the future
- The operations of these components only results in memory insofar as their operations are properly coordinated with each other
  - Organization often produces surprising results from even simple components
The goal in decomposing a mechanism is

A. To find out how the parts are organized to produce the phenomenon of interest

B. To render the mechanism inoperable

C. To identify the parts and operations in the mechanism

D. To show that the mechanism doesn’t do what it is claimed to do
A reductionist, in contrast to a holist:

A. Focuses on how the components of the system fit into an integrated whole

B. Denies any importance to discovering the parts of the mechanism

C. Denies that organization plays any role in the operation of a mechanism

D. Emphasizes the discovery of components as the key to understanding how a mechanism behaves
Where we have been in this class

- **Logic**: structure of arguments for confirmation and falsification
- **Observation**: variables and their measurement
- **Correlation**: predictions based on correlations and statistically significant differences with samples
- **Causation**: experimental and non-experimental evidence
- **Mechanisms**: discovering component operations and their organization
Final thought

- Reasoning and making decisions, whether about Perception, Correlation, Causation, Mechanism is fallible

- We can (and should) strive to come closer to the truth
  - But we must also recognize that tomorrow something might be discovered that makes us revise our best conclusions of today