Mechanism and Mechanistic Explanation

Clicker Question

Researchers are concerned about confounds

- because they show that the dependent variable is not the cause of the independent variable
- because they, rather than the dependent variable, might be the cause of the independent variable
- because they, rather than the independent variable, might be the cause of the dependent variable
- only when they are conducting retrospective studies

Clicker Question

A prospective study differs from an experiment in that

- it involves manipulation of the dependent, not the independent variable
- it involves measuring the independent variable rather than manipulate it
- it involves measuring the dependent variable rather than manipulate it
- it divides subjects on the dependent variable, not the independent variable

Clicker Question

A retrospective study differs from a prospective study

- In that it involves manipulating the independent variable
- In that it involves manipulating the dependent variable
- It divides subjects by their value on the independent variable
- It divides subjects by their value on the dependent variable

Two limitations of focusing only on causes

- Individual causal relations do not accomplish much
  - It often requires a coordinated system of causes to get something done
- Establishing a causal relation does not explain what relates causes to their effects
  - Typically there are processes intervening between causes and their effects

From Causal Relations to Mechanisms

- As important as individual causal relations is, much of science is concerned with identifying coordinated systems of them
  - Mechanisms consist of parts (entities) and operations (causal activities) organized to produce a phenomenon
- Mechanisms are appealed to
  - To explain causal relations
  - And appeal to causal relations between their parts

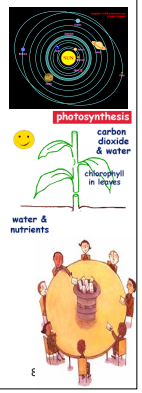
Clicker Question

Imagine someone has traveled in time from 1885 to 2011 and is trying to figure out how a car works. They do a series of experiments from the driver's seat, without ever looking under the hood of the car, and conclude that turning the ignition key explains why the car runs. What is a major limitation of their experiments?

- The person failed to control for subject confounds
- The person failed to control for procedural confounds
- The person missed the causal intermediaries that explain how the car worked
- The person failed to consider more ultimate variables such as the refinement of gasoline

The Ubiquity of Mechanisms in Science

- Mechanisms in physical sciences
  - Solar system mechanics
  - Mechanisms of chemical reactions
- Mechanisms in biological sciences
  - Mechanisms of photosynthesis
  - Mechanisms of reproduction
- Mechanisms in behavioral sciences
  - Mechanisms of memory encoding
  - Mechanisms of decision making
- Mechanisms in social sciences
  - Mechanisms of consensus formation



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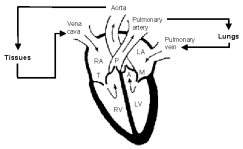
Mechanisms as Coordinated Causation

- Mechanisms consist of parts whose operations cause changes in other parts, enabling mechanisms to cause changes in yet other things
- Muscles in heart contract while valves open and shut, enabling
  - The heart to move blood through arteries and veins
- Understanding a mechanism requires analysis, often experimental, procedures designed to figure out the parts, their causal operation, and how these operations are coordinated (organized) so that the mechanism can produce its effect



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Designing Mechanisms vs. Discovering Mechanisms

- The challenge in engineering is to design new mechanisms that produce the phenomena we are interested in
  - Typically, engineers begin with a goal and recruit parts already known to perform operations
  - Their challenge is to discover new modes of organization that enable the parts to together do something new
- Scientists do not have access to the design manuals of the mechanisms operative in the natural world
  - They must reverse engineer them—discover the parts, the operations, and the organization

Designing Mechanisms in Your Life

- [?] Design a mechanism (set of operations) for making a beef taco
- [?] Design a mechanism (set of operations) for getting to Kotzebue, Alaska
- [?] Design a mechanism (set of operations) for making sure you get to class on time

Fish an Olive Out of a Long-Necked Bottle

At 6:30 weight (A) automatically drops on head of dwarf (B), causing him to yell and drop cigar (C), which sets fire to paper (D). Heat from fire angers dwarf's wife (E). She sharpens potato knife (F) on grindstone (G) which turns wheel (H) causing olive spoon (I) to dip repeatedly into olives. If spoon does not lift an olive in 15 minutes, clock (J) automatically pushes glass-cutter (K) against bottle and takes out a chunk of glass big enough for you to stick your finger in and pull out an olive.

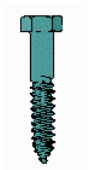
An Automatic Back Scratcher

Flame from lamp (A) catches on curtain (B) and fire department sends stream of water (C) through window. Dwarf (D) thinks it is raining and reaches for umbrella (E), pulling string (F) and lifting end of platform (G). Iron ball (H) falls and pulls string (I), causing hammer (J) to hit plate of glass (K). Crashof glass wakes up pup (L) and mother dog (M) rocks him to sleep in cradle (N), causing attached wooden hand (O) to move up and down along your back.

Early machines: Putting Shape to Work

Wedge

Ramp

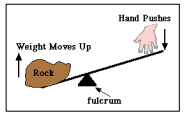


Screw

Early simple machines used human energy but extended its capacity

- In these cases, shape and spatial layout explain the causal efficacy

Early machines: Organizing Parts



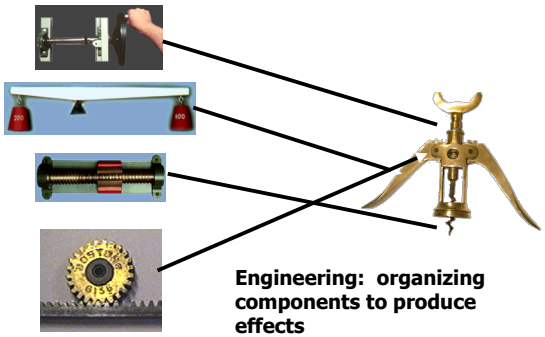
Lever

Wheel

Pulley

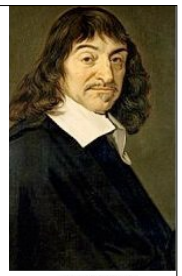
In these cases, shape and layout together with coordination of parts explains the effect

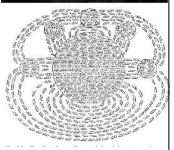
Combining simple mechanisms



Engineering: organizing components to produce effects

Nature as a machine: Rene Descartes





- "I have described this earth and indeed the whole universe as if it were a machine: I have considered only the various shapes and movements of its parts" (Principia IV 188).
- All action in the physical universe due to shape and motion of physical matter
  - No vacuum
  - No action at a distance
- Magnetism: Screw-shaped particles (formed in vortices) fit into threads in iron.

Descartes: Animals as machines

Automated garden figures and main driving mechanism in the grottoes of the royal gardens at Saint Germain-en-Laye. From engravings in Salomon de Caus, *Les raisons des forces mouvantes avec diverses machines tant utiles que plaisantes* ... Nantes, 1615. This grotto is described by Descartes on page 13 of the French text.

Impressed by the statuary in the Royal Gardens that moved by hydraulic principles

- Animal bodies are purely mechanical devices

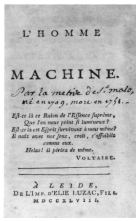
Circulation of blood due to heating in the heart, causing the expansion of droplets of blood, which then forced their way through the arteries

Nerve transmission and brain activity purely mechanical (albeit influenced by the mind in humans)

Humans as machines

Descartes could not conceive of a mechanism that could think or use language

- Accordingly, held that the human capacity for thought was not due to a mechanism
- Rather, thought due to a non-material mind



Julien Offray de La Mettrie objected that Descartes did not go far enough—all human activities, including thinking explained in mechanical terms

- *Man the Machine* in 1748

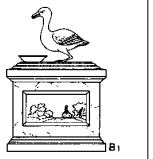
Clicker Question

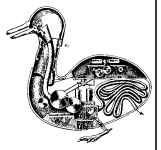
In treating animal (and human) bodies as machines, Descartes was

- Maintaining that they consisted of metallic parts that moved like the parts of a clock
- Denying the possibility of causal explanation of the behavior of animal bodies
- Claiming that their behavior could be explained in terms of the organized causal activities of their parts
- Claiming that it was easy to explain how animals worked

Jacques de Vaucanson (1709-1782): "Moving Anatomy"

- Mechanical duck
  - could move in the typical, wagging way of a duck
  - eat and digest fish
  - excrete the remains in a "natural" way
- Mechanism was driven by a weight
- Consisted of more than a thousand moving parts, concealed inside the duck and the base on which the bird stood
- Besides the duck, a flute and tambourine player



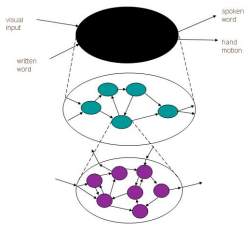


Explaining an Existing Mechanism

- Instead of designing a mechanism, scientists reverse engineer existing machines
  - After making sure one knows what phenomenon the mechanism exhibits
  - Decompose the mechanism
    - parts
    - operations
  - Figure out how it is organized

Mechanisms at Multiple Levels

- The system as a whole engages its environment by performing its activity
- That system is composed of components that perform different operations
- Those components in turn are composed of components that perform yet different operations



Holism versus 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)
- As a result, holism (vitalism) and reductionism are often pitted against each other
  - Holists charge that reductionists fail to consider the consequences of organization
  - Reductionists charge that holists fail to provide explanations

Clicker Question

A reductionist, in contrast to a holist,

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

Denies any importance to discovering the parts of the mechanism

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

Emphasizes the discovery of components as the key to understanding how a mechanism behaves

Mechanistic explanations: both reductionist and holist

- To understand a mechanism you must be both a holist and a reductionist
- Look both
  - Upwards to higher levels of organization at which the mechanism is an organized system that performs its activity and thereby interacts with other entities
- and
  - Downwards to lower levels of organization in which parts perform their operations in interaction with other parts