

19th Century Roots of Behavioral Neuroscience

Review: D-N and Kuhn

The received view of scientific explanations made laws central

Laws (Newton's force law: $f=ma$)

Initial conditions (object of a given mass is acted upon by a specific force)

∴ Phenomenon to be explained (Object will experience a specific acceleration)

Science advances by proposing and testing hypotheses, generally in a cumulative fashion

Reduction involves deriving the laws of one science from those of a more fundamental science

Kuhn—science often progresses through revolutions that replace one “paradigm” with another

Normal science consists of trying to force a paradigm onto nature, not testing hypotheses

Biology and Mechanistic Explanation

Despite the received view's focus on laws, biologists (including neuroscientists) seldom appeal to laws (except laws of chemistry and physics, as appropriate)

Apparent counter example: Mendel's laws of dominance, segregation, and independent assortment

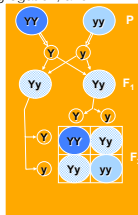
None of which are true (there are exceptions to each)

What Mendel did offer was a sketch of a mechanism of inheritance

He posited factors, a process through which they were inherited, and an account of how they related to traits

He had no evidence for the mechanism other than that it gave the right answers to inheritance patterns in peas

But in the 20th century Mendel's factors were named *genes*, their location on chromosomes established, their composition out of DNA was determined, and the mechanism by which they are expressed in proteins discovered



Characterizations of Mechanisms

Machamer, Darden, and Craver [MDC] (2000)

"Mechanisms are entities and activities organized such that they are productive of regular changes from start or set-up to finish or termination conditions"

Bechtel and Abrahamsen (2005, cf. Bechtel and Richardson, 1993):

"A mechanism is a structure performing a function in virtue of its component parts, component operations, and their organization. The orchestrated functioning of the mechanism is responsible for one or more phenomena"

Besides the incidental differences in vocabulary, the major difference involves the last phrase of MDC—imposing an order from start to termination conditions

Clicker Question

Which of the following represents a way in which mechanistic explanations are different from D-N explanations

They don't explicitly refer to laws

They attempt to account for why events happen

They can be presented in language

They must be tested

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Mechanistic Versus Nomological Explanations

Both nomological and mechanistic explanations can be concerned with causal phenomena—something happens which brings about something else

Nomological explanations focus on the regularity (law) characterizing the change itself and does not specifically identify causes

And don't respect temporal order (you can explain what was true in the past given what is true today and laws)

Critical feature of mechanistic accounts is that they focus on the system in which change is occurring and ask what is going on inside to produce its behavior—specific causes

Laws are not central to mechanistic accounts (they may be invoked to characterize operations, but they need not be)

Mechanistic explanations are not presented as logical arguments

Whereas in D-N explanations logic is the "glue" that links laws and initial conditions to phenomena being explained, in mechanistic explanations scientists model (mentally, physically, or computationally) how the parts and operations produce the phenomenon

Descartes: The Orgins of the Mechanical Philosophy

"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 bits of physical matter that push and pull against each other

No vacuum

No action at a distance

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



Descartes: Human Bodies are Machines

For Descartes, any behaviors we share with animals are the products of mechanisms

Perception

Memory

Emotion

Action

"... the reception of light, sounds, odors, tastes, warmth, and other like qualities into the exterior organs of sensation; the impression of the corresponding ideas upon a common sensorium and on the imagination; the retention or imprint of these ideas in the Memory; the internal movements of the Appetites and Passions; and finally, the external motions of all the members of the body ... I wish that you would consider all of these as following altogether naturally in this Machine from the disposition of its organs alone, neither more nor less than do the movements of a clock or other automaton from that of its counterweight and wheels"

Descartes: Mind-Body Dualism

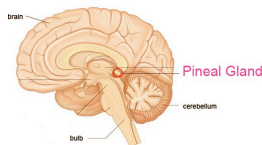
But Descartes could not conceive how thought or language could be generated mechanically

We have an unlimited capacity for generating new sentences and new thoughts

Which are appropriate to their context

Res cogitans: thinking thing

Which affects the physical body at the pineal gland



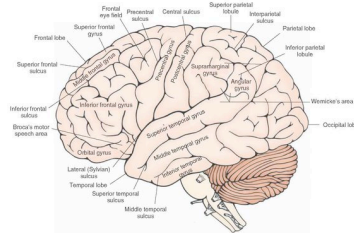
Connecting Cognition to the Brain

A first step in relating two things is to find some correlation between them

Identify some components of thinking
Correlate them with some components of the brain

Observationally, the brain seems inert

One ultimately misleading clue: its convoluted structure of sulci and gyri—these might be parts that individually are responsible for different mental activities



Franz Gall and Phrenology

Around 1800 Gall proposed a way to correlate mind and brain

Divide the mind into mental faculties

Capabilities that some people are better and some are worse at

Identify differences in people's skulls

Attribute bumps on the skull to increased growth in the underlying brain area

Relying especially on individuals with especially developed mental traits (good or bad), correlate faculties with bumps on their skulls



Clicker Questions

What role do animals play in Gall's discussion of faculties?

He performed experiments on their brains to identify what happened when parts were removed

He treated different species as exhibiting high levels of different faculties that corresponded to the parts of their brains

They are never mentioned since he thought mental activity occurred only in humans

Other

Faculties and Brain Regions

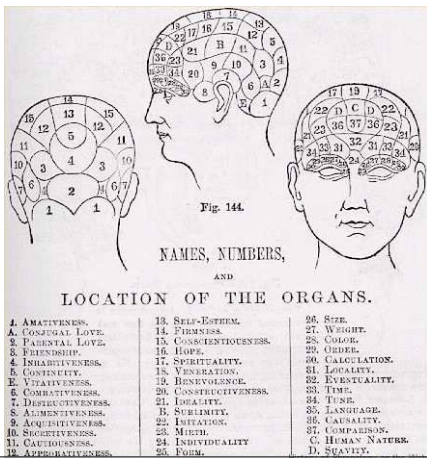
Different species of animals have different behavioral propensities

Different people show greater development in specific propensities (some are better at arithmetic, some faster to anger, etc.)

Propensities are due to different regions of the brain

Propensities would be stronger when the responsible brain region is larger

Propensities would be lost when the corresponding brain region is absent or damaged



The Popularity of Phrenology

Phrenology became very popular with the public —people would pay to have their skull read



Against Phrenology: Pierre Flourens

“The entire doctrine of Gall is contained in two fundamental propositions, of which the first is, that understanding resides exclusively in the brain, and the second, that each particular faculty of the understanding is provided in the brain with an organ proper to itself. Now, of these two propositions, there is certainly nothing new in the first one, and perhaps nothing true in the second one.”

Flourens

Four Functionally Separate Parts of the Brain

Cerebellum: regulates locomotion

Tubercula quadrigemina (inferior and superior colliculus): involved in vision

Medulla oblongata (part of the brain stem): involved in respiration

Brain proper (cerebral hemispheres or neocortex): “the exclusive seat of intelligence”

Flourens conducted experiments on pigeons and rabbits

He removed (lesioned parts of their brain proper (cerebral cortex) and examined the effects on behavior

Clicker Question

What did Flourens discover from his lesion studies with animals

Specific lesions produced specific deficits in their intelligence

Some animals seemed to be more intelligent as a result of lesions

Lesions had absolutely no effect on the intelligence of the animals

The more tissue Flourens lesioned, the greater the loss of intelligence

No Divisions in the Hemispheres

No lesion results in a specific loss of intelligence

"As has been shown by my late experiments, that we may cut away, either in front) or behind, or above, or on one side, a very considerable slice of the hemisphere of the brain, without destroying the intelligence. Hence it appears, that quite a restricted portion of the hemispheres may suffice for the purposes of intellection in an animal.

But overall intelligence is reduced proportional to the amount removed

"On the other hand, in proportion as these reductions by slicing away the hemispheres are continued, the intelligence becomes enfeebled, and grows gradually less; and certain limits being passed, is wholly extinguished. Hence it appears, that the cerebral hemispheres concur, by their whole mass, in the foil and entire exercise of the intelligence! As soon as one sensation is lost, all sensation is lost; when one faculty disappears, all the faculties disappear. There are not, therefore, different seats for the different faculties, nor for the different sensations."

Phrenology Falls into Disrepute

Despite its popularity with the general public, the scientific community rejected phrenology

This put a damper on any attempts to localize mental activities in the neocortex

Those who did embrace any claim to localize functions in the cortex were labeled *neophrenologists*

Clicker Question

What was the language deficit that Broca identified in his patient Leborgne (Tan)?

All language abilities were lost

Tan could not produce any vocal sounds

Tan could not produce articulate words

Tan could neither produce words nor understand those spoken to him

Aphemia: Loss of Articulate Speech

Broca begins by identifying a specific kind of loss of intellectual capacity: the loss of the ability to produce articulate speech

Not the loss of all language: could still understand language

Not the loss of general intelligence: could still perform tasks requiring intelligence

Cannot fully resolve whether this is a loss of learned coordination of motor activity or of a higher cognitive capacity

Leborgne (Tan)

Became Broca's patient only when already close to death at the age of 50

Had experienced epilepsy from youth and lost the capacity for articulate speech at about 30

No loss of understanding or of intelligence

Around 40 began to lose the capacity for movement

Died soon after coming under Broca's care and, upon death, Broca performed an autopsy

Massive amount of damage

Broca argued that the damage was centered on the third frontal convolution and that is where it originated



Discussion Question

You open the hood of your car, remove something, and your car will no longer drive in reverse. You conclude that you have removed the reverse engine. How could you be wrong?

There is a possibility that the part you removed only connects the reverse engine to the wheels

The car may not have a reverse engine—it has only one engine whose torque is applied either in moving forward or backwards

You might have removed the controls that activate the reverse engine, which is still perfectly functional

All of the above

Ungoing Challenge

There is no question that the damage to the region Broca identified (there is some question as to where precisely it is located) results in language deficits

But what exactly do the deficits consist in and what does the region do?

Broca—center for articulate speech

1970s—center for syntactic processing

in recognition that Broca's patients do

experience some comprehension deficits

And other proposals

From Localization to "Connectionism"

Model for mimicking speech

(a) Center for "acoustic images"

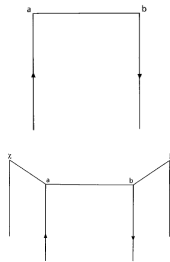
(b) Center for "motor speech images"

Connection between them

damage results in conduction aphasia

To account for reading and writing, one might add centers for visual letter imagery and graphic motor imagery

All the rest due to connections: " Any higher psychic process, exceeding these mere primary assumptions, could not, I reasoned, be localized, but rested on the mutual interaction of these fundamental psychic elements mediated by means of their manifold connections via the association fibers."



Classification of Aphasias

Adds a concept center B

Identifies 7 different possible aphasias (likewise alexias and agraphias)

Cortical sensory aphasia

Subcortical sensory aphasia

Transcortical sensory aphasia

Cortical motor aphasia

Subcortical motor aphasia

Transcortical sensory aphasia

Conduction aphasia

Empirical question: do all of these occur?

