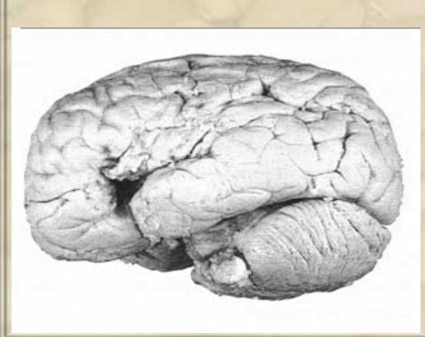
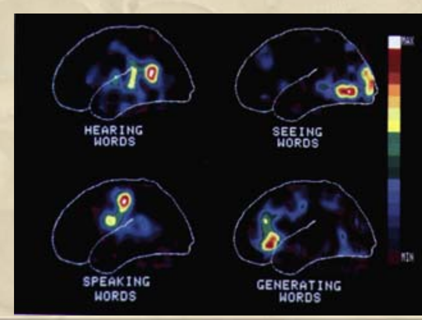
Reduction and Multiple Realizability: What Can Psychology Learn from the Brain?





Theory Reduction Model

Reduction as a deductive relation between laws or theories:

Lower-level theory	(Neuroscience)
Bridge principles	
<u>Boundary conditions</u>	
∴ Upper-level theory	(Psychology)

Fodor:

(1) $S_1x \rightarrow S_2x$	
(2a) $S_1x \leftrightarrows P_1x$	Bridge principle
(2b) $S_2x \leftrightarrows P_2x$	Bridge principle
(3) $P_1x \rightarrow P_2x$	

From 3, 2a, and 2b, one can derive 1

Variations on Physicalism

- Token Physicalism: "all the events that the sciences talk about are physical events"
- Materialism: "token physicalism is true *and* that every event falls under the laws of some science or other"

****

- Type Physicalism: "every *property* mentioned in the laws of any science is a physical property"
- Reductivism: "the conjunction of token physicalism with the assumption that there are natural kind predicates in an ideally completed physics which correspond to each natural kind predicate in any ideally completed special science"
  - "entails the generality of physics in at least the sense that any event which fails within the universe of discourse of a special science will also fall within the universe of discourse of physics"

Natural Kinds and Laws

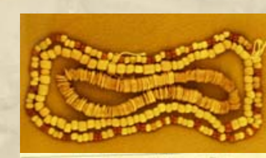
- "If I knew what a law is, and if I believed that scientific theories consist just of bodies of laws, then I could say that P is a natural kind predicate relative to S iff S contains proper laws of the form $P_x \rightarrow \alpha_x$ or $\alpha_x \rightarrow P_x$; roughly, the natural kind predicates of a science are the ones whose terms are the bound variables in its proper laws"

Betting Against Reductivism

a. "interesting generalizations (e.g., counter-factual supporting generalizations) can often be made about events whose physical descriptions have nothing in common
b. "it is often the case that *whether* the physical descriptions of the events subsumed by these generalizations have anything in common is, in an obvious sense, entirely irrelevant to the truth of the generalizations, or to their interestingness, or to their degree of confirmation or, indeed, to any of their epistemologically important properties, and
c. "the special sciences are very much in the business of making generalizations of this kind"

Relating Money to Physics

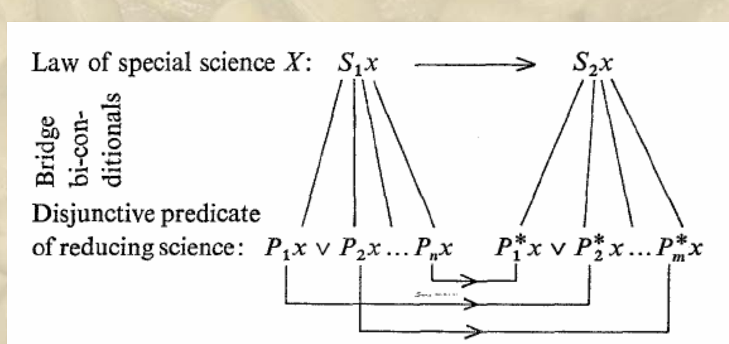
- Diversity of things that count as money
  - Strings of wampum
  - A signed check
  - A French 100 franc note
  - A US silver dollar
  - A wire transfer by computer
  - Bits in a computer
  - Etc.
- These various instances of money are not likely to have anything physical in common
- And the bridge law must also apply to counter-factual claims—claims about what might count as money in the future



Relating Psychology to Neuroscience

- "If psychology is reducible to neurology, then for every psychological natural kind predicate there is a co-extensive neurological natural kind predicate, and the generalization which states this co-extension is a law"
- "There are no firm data for any but the grossest correspondence between types of psychological states and types of neurological states, and it is entirely possible that the nervous system of higher organisms characteristically achieves a given psychological end by a wide variety of neurological means"

Special Science Laws Subsume Disjunctive Lower-Level Kinds



Positive Results

- Explain the fact that the laws of the special sciences have exceptions
  - Explained by the fact that the bridge principles relates some instances of the kinds in the special sciences to instances outside the corresponding physical kind
- Reason for the special sciences
  - Their taxonomies cross-cut those of physics
    - Hence, they incorpoate laws that physics cannot

The Multiple-Realizability Argument

- In the 1960s Hilary Putnam argued that pain could be realized in a wide variety of species with very different brains
- Pain could not be identified with any given brain state
  - Identity theory was therefore false
  - Functionalism offered the only promise




Multiple Realizability Became Orthodoxy

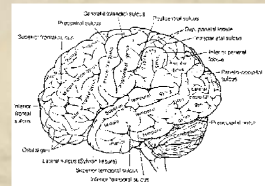
- During the 1980s and 1990s multiple realizability became orthodoxy
- Defenders of identity theory (Kim, Hooker, Churchland) held out the hope of separate reductions for each realizer, as seemed to apply in physics
  – Temperature in a gas = mean molecular energy
  – Temperature in a solid = mean maximal molecular kinetic energy
- Question: are the number of different realizers tractable in psychology?
  – If even two humans different brains but can think the same thought, then no hope of saving Identity Theory
  – And psychology has little to gain from neuroscience

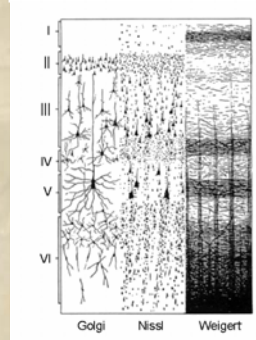
Psychology Re-engages the Brain

- From 1950 to late 1980s, there seemed to be little the brain sciences could provide psychology
  – No tools to acquire insight about the cognitive operations in humans
  – Neuropsychology: the exception that proves the rule
    - From patients with brain damage, learn what psychological abilities can be dissociated
- Beginning in the late 1980s
  – New techniques for studying brains of humans non-invasively (PET, fMRI)
  – Emergence of *cognitive neuroscience*
- Some philosophers start to question the multiple realizability argument: brain sciences has long been a comparative sciences

Brain Mapping

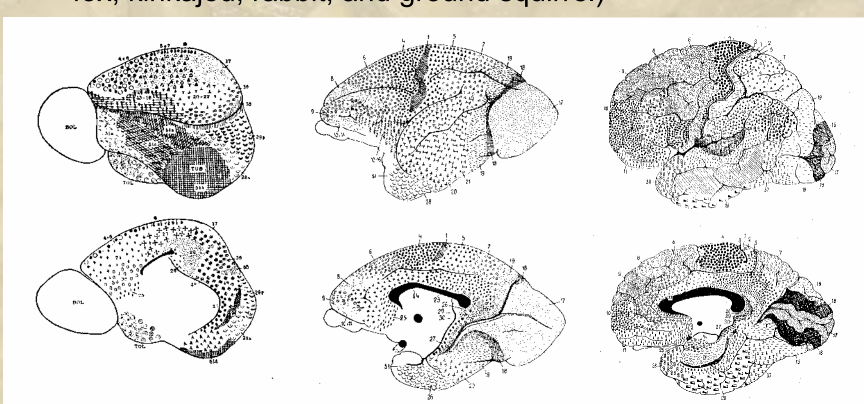
- 19th Century: name the various gyri and sulci in the brain
  - Problem: variability
    - Explanation: not functional areas
- Korbinian Brodmann (and others): use differences in composition of different brain areas to distinguish them
  - Took advantage of new stains (Golgi, Nissl, etc., that allowed for differentiating types of neurons
  - Discovered layered nature of cortex, based on studies of 55 species from 11 orders of mammals





Brodmann's Brain Maps

- Cytoarchitectural maps of 3 different species (also included maps of two lower monkeys (guenon and marmoset), flying fox, kinkajou, rabbit, and ground squirrel)



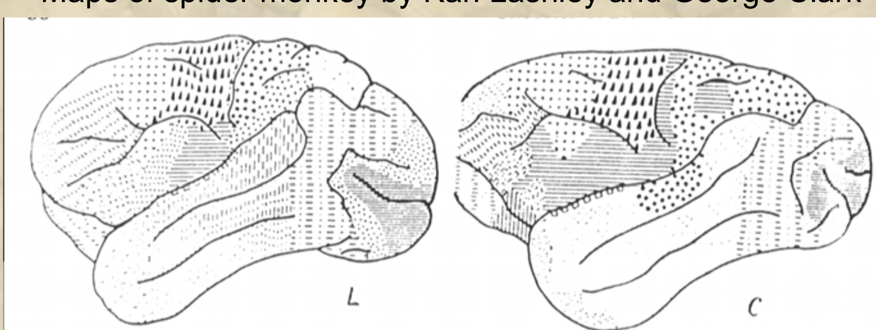
Hedgehog Lemur Human

Brodmann’s Project

- Assume commonality of brain parts across species and attempt to identify them
- Goal: provide a foundation for accounts of how brains functon:
  - “Although my studies of localisation are based on purely anatomical considerations and were initially conceived to resolve only anatomical problems, from the outset my ultimate goal was the advancement of a theory of function and its pathological deviations” (1909/1994, 243).

Refining Procedures for Brain Mapping

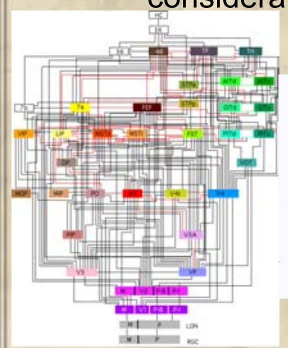
- Maps constructed by different scientists did not always agree
- Maps of spider monkey by Karl Lashley and George Clark



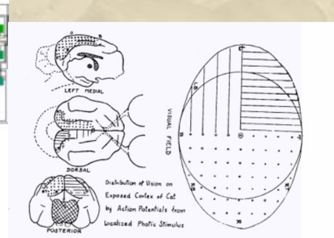
- Over time, however, procedures standardized
  - Brodmann’s maps became the standard

Adding New (Functional) Techniques for Brain Mapping

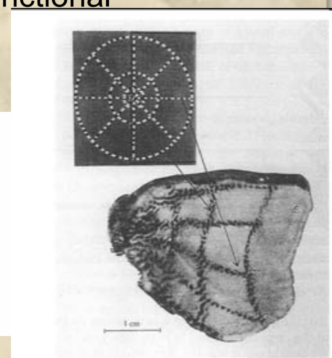
- Modern brain mapping relies on additional techniques for identifying brain areas, especially connectivity and topology
  - Connectivity and topology are functional considerations



Van Essen

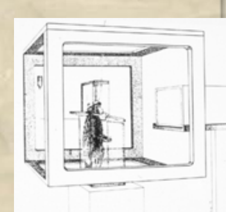


Talbot and Marshall

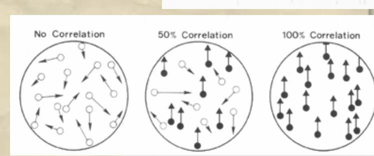


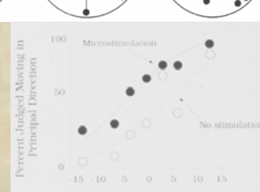
Tootel

Example: Newsome's Study of Motion Perception



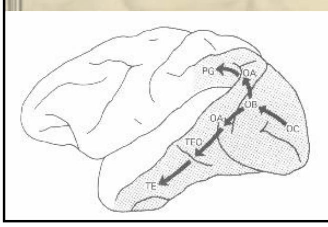
- In the 1974 Semir Zeki identified an area of the brain in front of striate cortex that responded to moving stimuli
- William Newsome showed:
  - Removing the area impaired the monkey's ability to respond to moving visual stimuli
  - Recording from the area when the stimuli were ambiguous
  - Stimulating the region increased likelihoods of particular responses

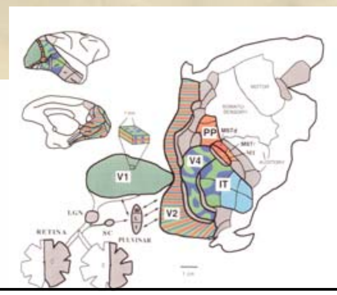


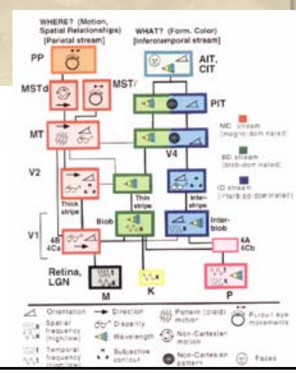


Using the Brain to Determine Functional Processes in Vision

- Identification of brain areas involved in vision revealed a host of different processing components that can be affected/damaged individually
- Two general processing streams (what/where) that are largely independent of each other







Why did Multiple Realizability Seem So Compelling?

- Assumption that mental/functional states are the same across a wide range of organisms with wildly different brains
  - Pain and hunger are shared by us and octopi but our brains don't resemble each other
- But hunger and pain aren't that similar in different species
  - They result in very different behaviors
- And brains show more similarity than we thought
- Different grains are used with respect to function and structure
  - Brains are different if we seem to detect differences
  - Minds are the same if we seem to find similarities

Apparent Multiple Realizations are Not Functionally Equivalent

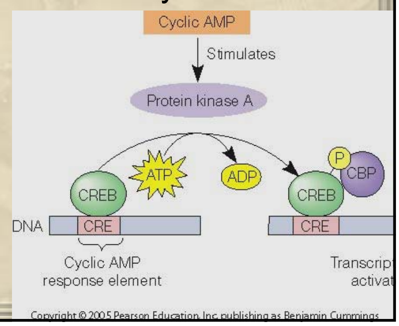
- Primate versus octopus eye
  - Different visual pigments in their photoreceptors
  - Different retinas
  - Different ways of focusing light
- Result: functional differences
  - In the optic stimuli the two eyes respond to
  - In reaction times

Conserved Mechanisms

- Bickle: principles of molecular evolution:
  - "The first principle holds that evolution at the molecular level—changes to the amino acid sequence of a given protein—is much slower in functionally important ("constrained") domains than in functionally less important ones. The second principle is that molecular evolution is much slower in all domains of "housekeeping" proteins, especially in ones that participate in cell-metabolic processes in many tissue types. These two principles imply that these molecules, their domains, and the intracellular processes they participate in will remain constant across existing biological species that share the common ancestor first possessing them."

Shared Building Blocks

- "In all systems studied, the cAMP signaling cascade has been identified as one of the major biochemical pathways involved in modulating both neuronal and behavioral plasticity. … More recently, elucidation of the role of *CREB*-mediated transcription in long-term memory in flies, LTP and long-term memory in vertebrates, and long-term facilitation in *A. californica* [a sea slug] suggest that CREB may constitute a universally conserved molecular switch for long term memory" (Dubnau & Tully, 1998, 438).



Shapiro's Dilemma

- "Consider what appears to be a genuine case of multiple realizability, that is, two objects that "do the same thing" but in very different ways. Either the realizing kinds genuinely differ in their causally relevant properties or they do not. If they do not, then we don't really have a case of multiple realizability (like the corkscrews that differ only in color or composition). If they do, then they are different kinds. But then they are not the same kind and again we don't have an instance of multiple realizability—of a *single* kind with distinct realizations."