LabSi
EXPERIMENTAL ECONOMICS LABORATORY
University of Siena

LECTURE 5 COGNITIVE ECONOMICS AND NEUROECONOMICS

Aim: To provide an introduction to cognitive economics and neuroeconomics.

Outline: Cognitive economics and neuroeconomics: key principles. Tools. Basic facts about the brain. Cognitive processes. Automatic processes. Affective processes. Main findings. Implication for economics. A critique of neuroeconomics.

Readings:

Camerer, C. F., G. Loewenstein, and D. Prelec (2005) "Neuroeconomics: How Neuroscience Can Inform Economics", *Journal of Economic Literature*, XLIII, 9-64.

G. W. Harrison (2008) "Neuroeconomics: A Rejoinder", *Economics and Philosophy*, 24, 533-544.

Blogs, Videos and Websites:

Predicting Consumer Choices with Neuroeconomics

http://www.behaviouraldesignlab.org/latestarticles/predicting-consumer-choices-with-neuroeconomics

COGNITIVE ECONOMICS

Cognitive economics is not a distinct subfield of economics but a school of thought based on the idea that the study of economic behaviour has to be founded on the **interdisciplinary approach** of cognitive sciences

The research field of Cognitive Science is formed by the intersection of a variety of different disciplines including **cognitive psychology**, **philosophy of mind**, **linguistics**, **artificial intelligence** and **neuroscience**

The field of cognitive economics is the analysis of the mental and cognitive processes through which the economic agent collects, processes, interprets and uses information and knowledge to make economic choices.

Its main object is **to open the black-box** containing all the processes through which preferences are formed and are translated into choices.

Cognitive economics departs from behavioral economics, whose methodology is based on the analysis of the effectively exhibited behaviors, which is consonant with the axiom of revealed preferences and allows ignoring the mental processes leading to decisions or judgments.

NEUROECONOMICS

Neuroeconomics is a sub-field of cognitive economics

Studies how the brain interacts with the environment to produce economic behavior

Neuroeconomics is the grounding of microeconomics in **details of neural functioning**.

While the revealed preferences approach has deliberately avoided trying to discover the neural determinant of choices, neuroscience is beginning to allow direct measurement of thoughts and feelings

Methodologically, neuroeconomics is not intended to test economic theory in a traditional way - particularly under the view that utilities and beliefs are only revealed by choices - but **to establish the neural circuitry underlying economic decisions**, for the eventual purpose of making better predictions.


Dr., I've never seen anything like it. All the rational regions have shut down!
2006

BASIC PRINCIPLES

- Much of the brain is constructed to support automatic processes which are faster than conscious deliberation and which occur with little or **no awareness or feeling of effort**

- Economic behavior is under the pervasive and often unrecognized **influence of finely tuned affective (emotion) systems** that are localized in particular brain region

- **If affective systems are damaged or perturbed** by brain damage, stress, imbalances in neurotransmitters, alcohol or "the heat of the moment" **the deliberative system generally is not capable of getting the job done**

- Many behaviors that are clearly established to be caused by automatic or affective systems **are *interpreted*** by human subjects, **spuriously**, as the product of cognitive deliberation

- The deliberative system, which is the system that is responsible for making sense of behavior, **does not have perfect access to the output of the other systems**, and exaggerates the importance of processes it understands when it attempts to make sense of the body's behavior.

TOOLS

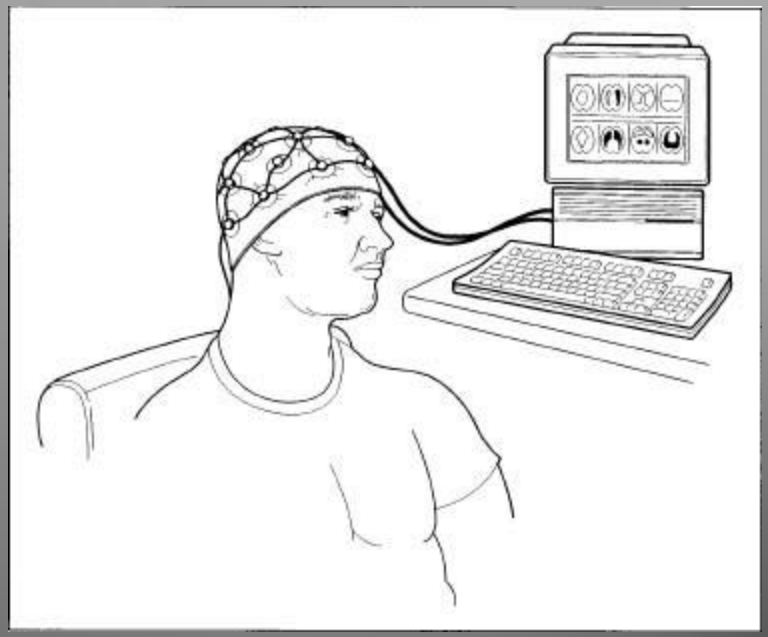
- Animal studies
- Human studies
- Lesion studies (i.e., studies of patients with deficits that follow specific brain damage)
- Single neuron measurement (non-human mammals)
- Eye-tracking
- Measuring hormone levels
- Physiological activations (Heart rate, Skin conductance level, Blood pressure, Finger temperature, Respiratory rate)
- Transcranial magnetic stimulation (TMS)
- Imaging of brain activity

  Electro-encephalogram (or EEG)

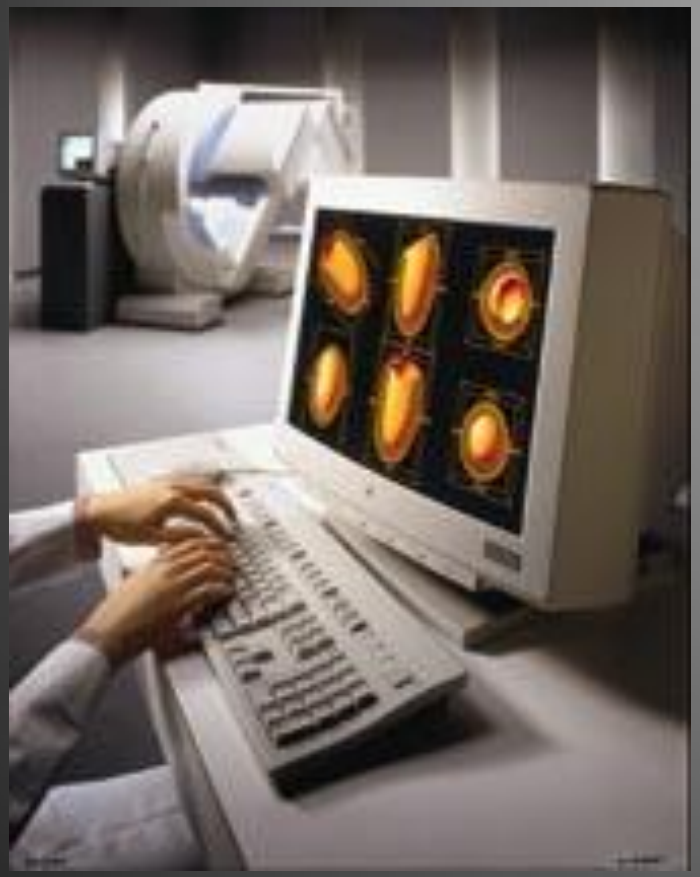
  Positron emission topography (PET)

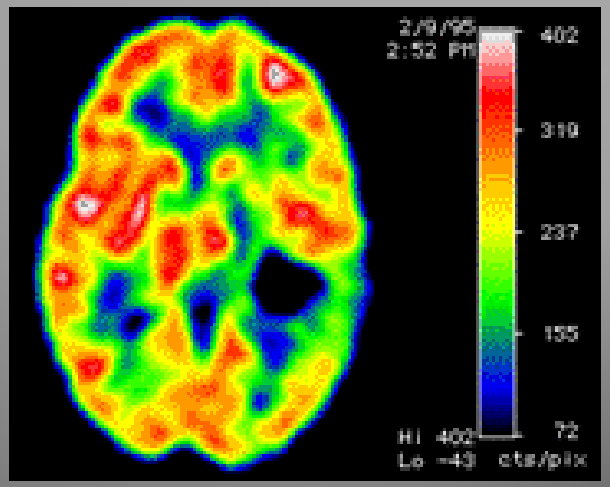
  Functional magnetic resonance imaging (fMRI)

EEG



PET





University of Washington

BRAIN IMAGING

Comparison of people performing different tasks (experimental + control task) by observing the images of the regions of the brain that are differentially activated by the experimental task.

- **Electro-encephalogram (or EEG)** uses electrodes attached to the scalp to measure electrical activity synchronized to stimulus events or behavioral responses known as Event Related Potentials, or ERPs

  (poor spatial resolution but unobtrusiveness and portability)

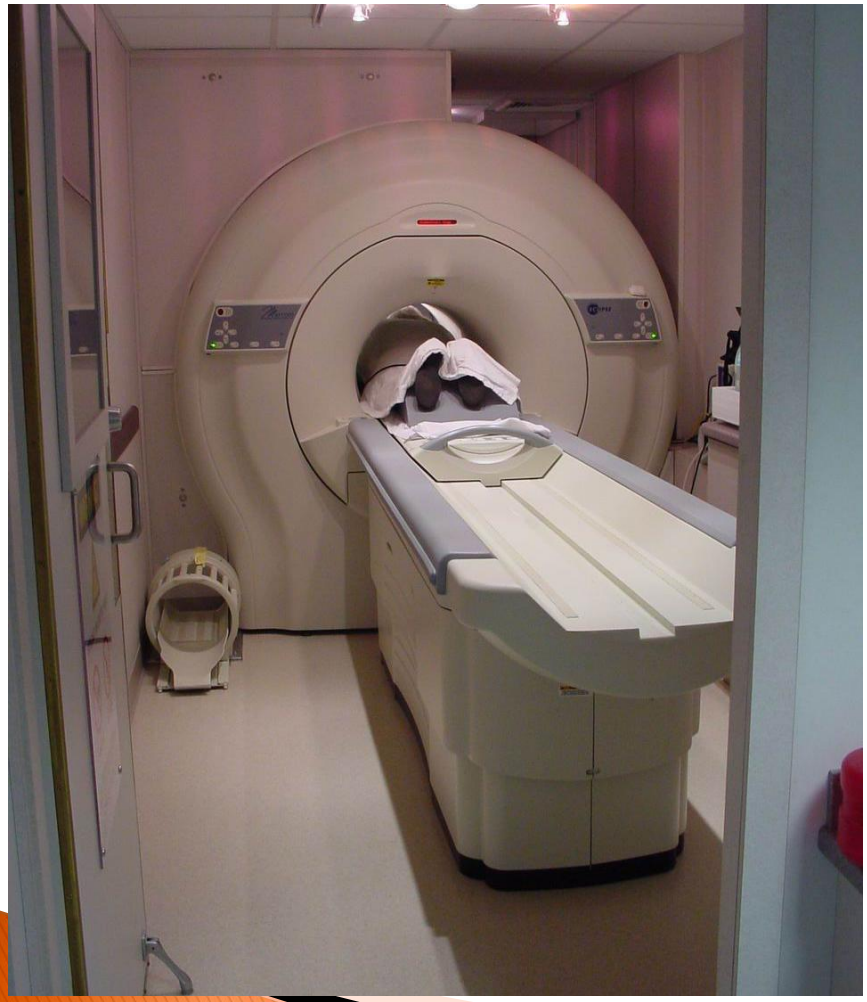
- **Positron emission topography (PET)** scanning measures blood flow in the brain, which is a reasonable proxy for neural activity, since neural activity in a region leads to increased blood flow to that region

  (poor temporal resolution for stochastic lag of blood, i.e. flow)

- **Functional magnetic resonance imaging (fMRI)**, which tracks activity in the brain proxied by changes in blood oxygenation - neural processes are thought to occur on a 0.1 millimeter scale in 100 microseconds (msec)

  (the spatial and temporal resolution of a typical scanner is only 3 millimeters and about two seconds)

Functional Magnetic Resonance Imaging (fMRI)

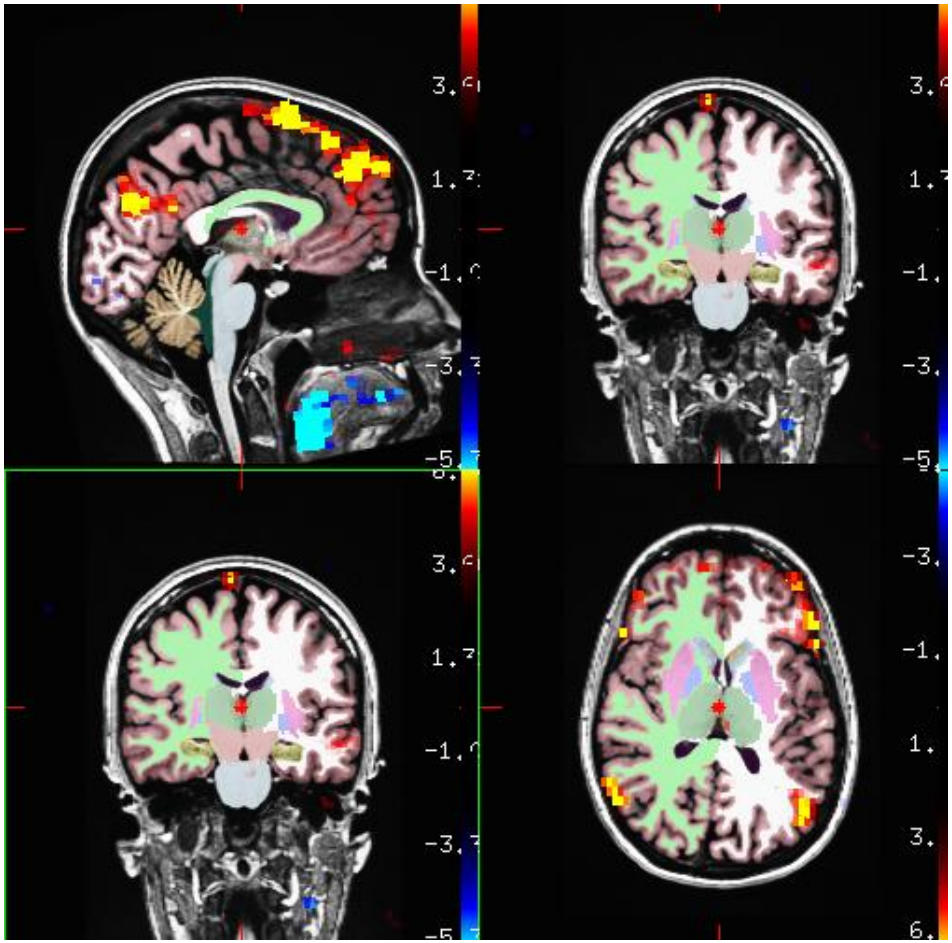


Source: UC Irvine Center for [illegible]ional Onco-Imaging

- Uses strong magnetic fields to create images of biological tissue
  - Measures hemodynamic signals related to neural activity
    - Blood Oxygenation Level Dependent (BOLD) contrast
    - MR signal of blood is dependent on level of oxygenation
    - Changes in deoxyhemoglobin
- Blood flow in the brain implies function
  - Studies have shown regional brain activity when exposed to cues (Huettel et al. 2004)

Why is fMRI so exciting?

- Non-invasive
- Better temporal resolution
- Good and improving spatial resolution
- Can be used in conjunction with other methods



Source: MGH/MIT/HMS Athinoula A. Martinos Center for Biomedical Imaging Visiting Fellowship Program in fMRI, 2005

BASIC FACTS ABOUT THE BRAIN

The brain is divided into two halves and each half is divided into four lobes: frontal, parietal, occipital and temporal

Regions of these lobes are interconnected and create specialized "circuits" for performing various tasks.

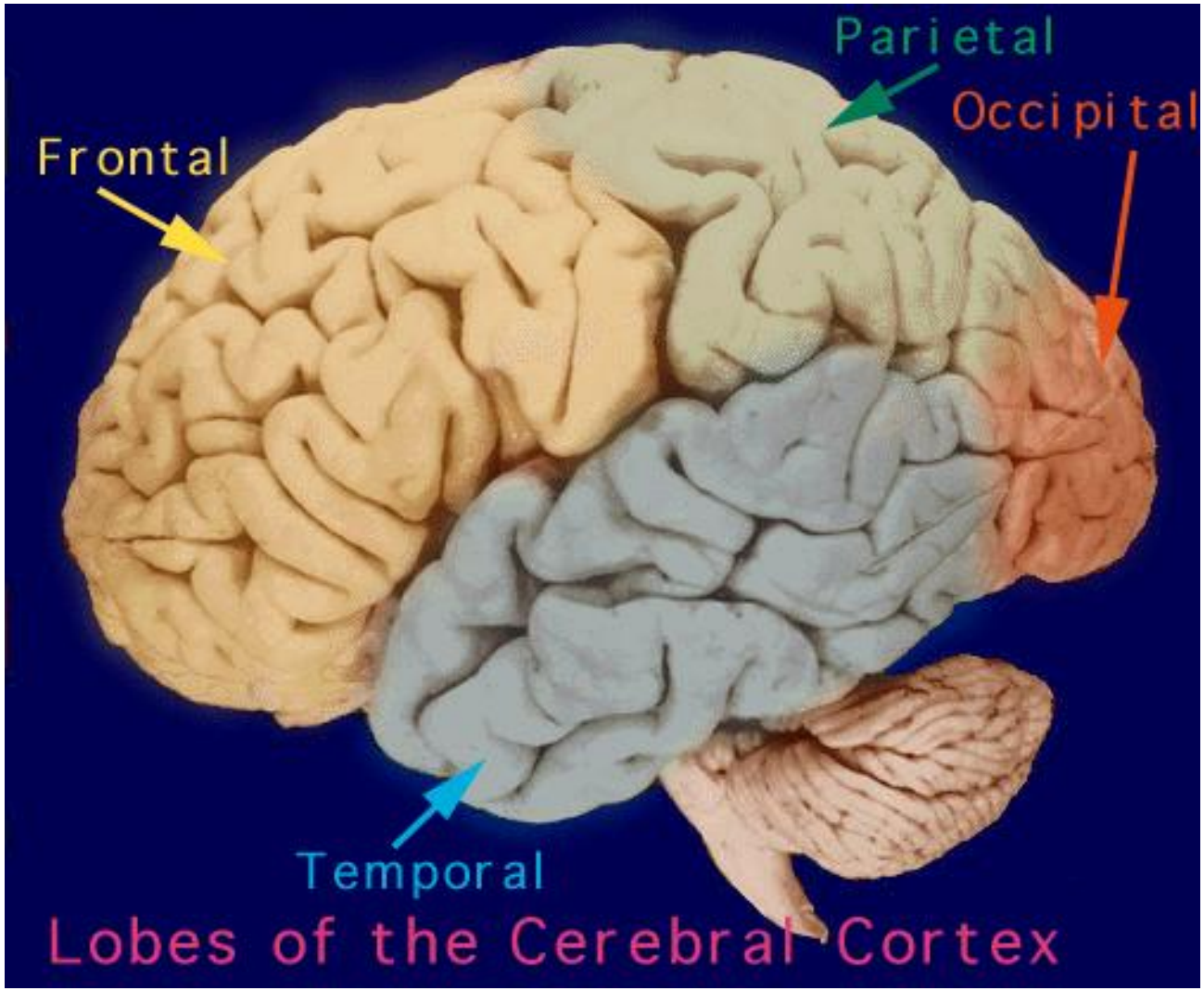
What do each of these lobes do?

Frontal Lobe - associated with reasoning, planning, parts of speech, movement, emotions, and problem solving

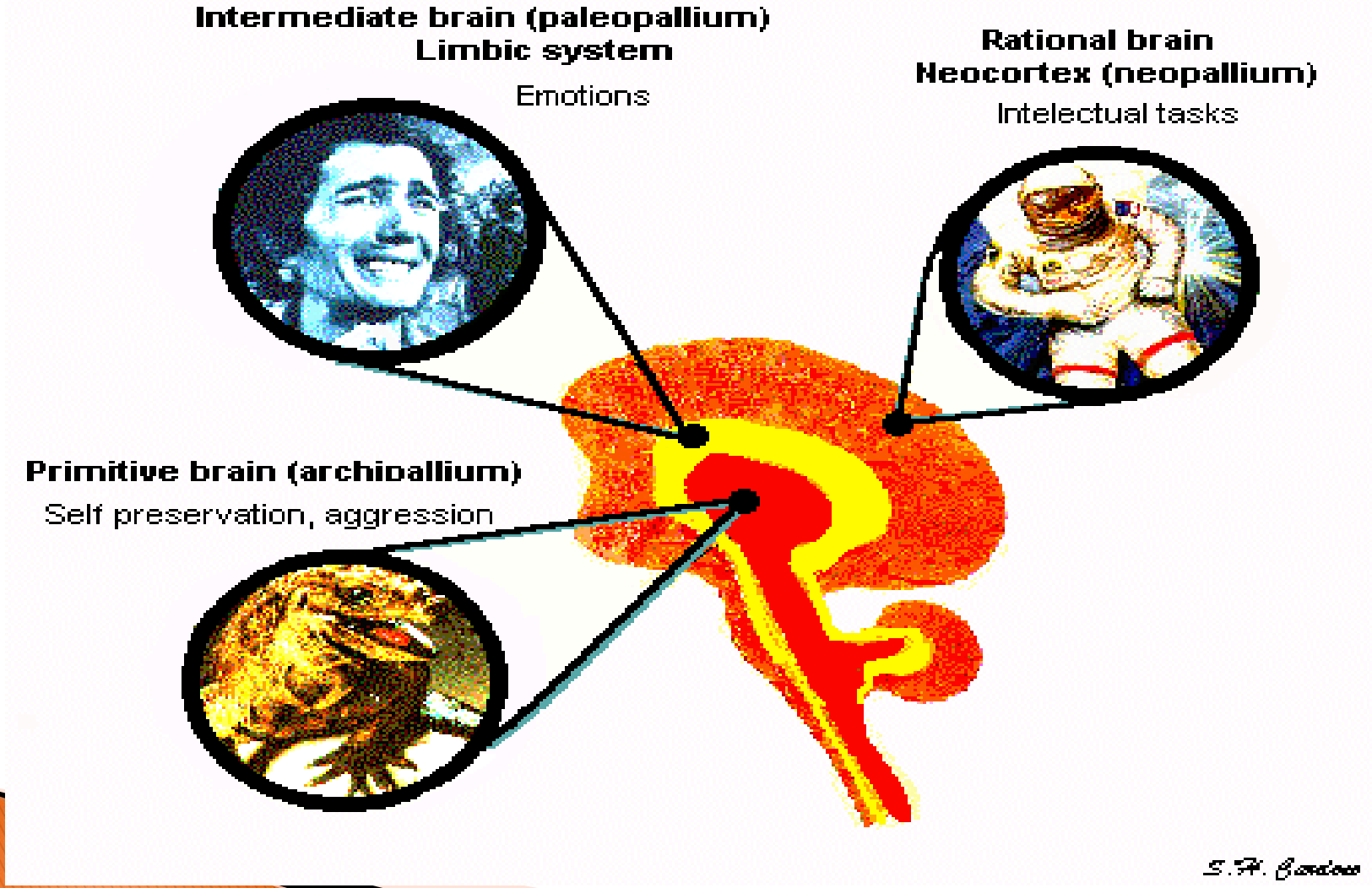
Parietal Lobe - associated with movement, orientation, recognition, perception of stimuli

Occipital Lobe - associated with visual processing

Temporal Lobe - associated with perception and recognition of auditory stimuli, memory, and speech


Parietal
Occipital
Frontal
Temporal
Lobes of the Cerebral Cortex

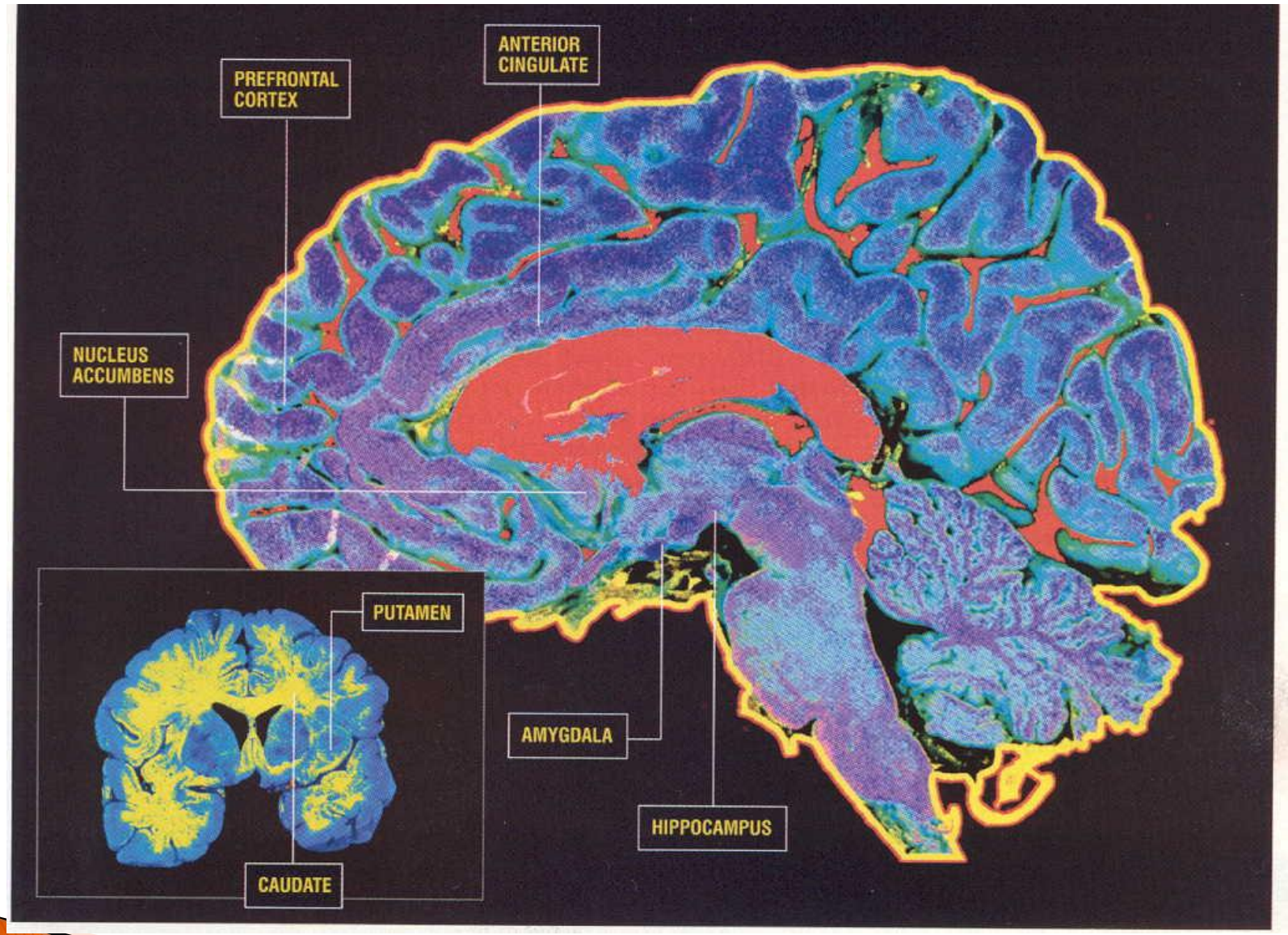
The human brain is a primate brain with more neocortex. The fact that many human and animal brain structures are shared means that human behavior generally involves interaction between “old” brain regions and more newly-evolved ones.



TRIUNE DIVISION OF BRAIN

Paul MacLean (1990)

- "**reptilian brain**," which is responsible for basic survival functions, such as breathing, sleeping, eating
- "**mammalian brain**," which encompasses neural units associated with social emotions
- "**hominid**" brain, which is unique to humans and includes much of our oversized cortex—the thin, folded, layer covering the brain that is responsible for such "higher" functions as language, consciousness and long-term planning


PREFRONTAL CORTEX
ANTERIOR CINGULATE
NUCLEUS ACCUMBENS
PUTAMEN
AMYGDALA
HIPPOCAMPUS
CAUDATE

THE "NEW" REGIONS

Prefrontal cortex – the executive region because it draws inputs from almost all other regions and plan actions. The prefrontal area is the region that has grown the most in the course of human evolution and which, therefore, most sharply differentiates us from our closest primate relatives

THE "OLD" REGIONS

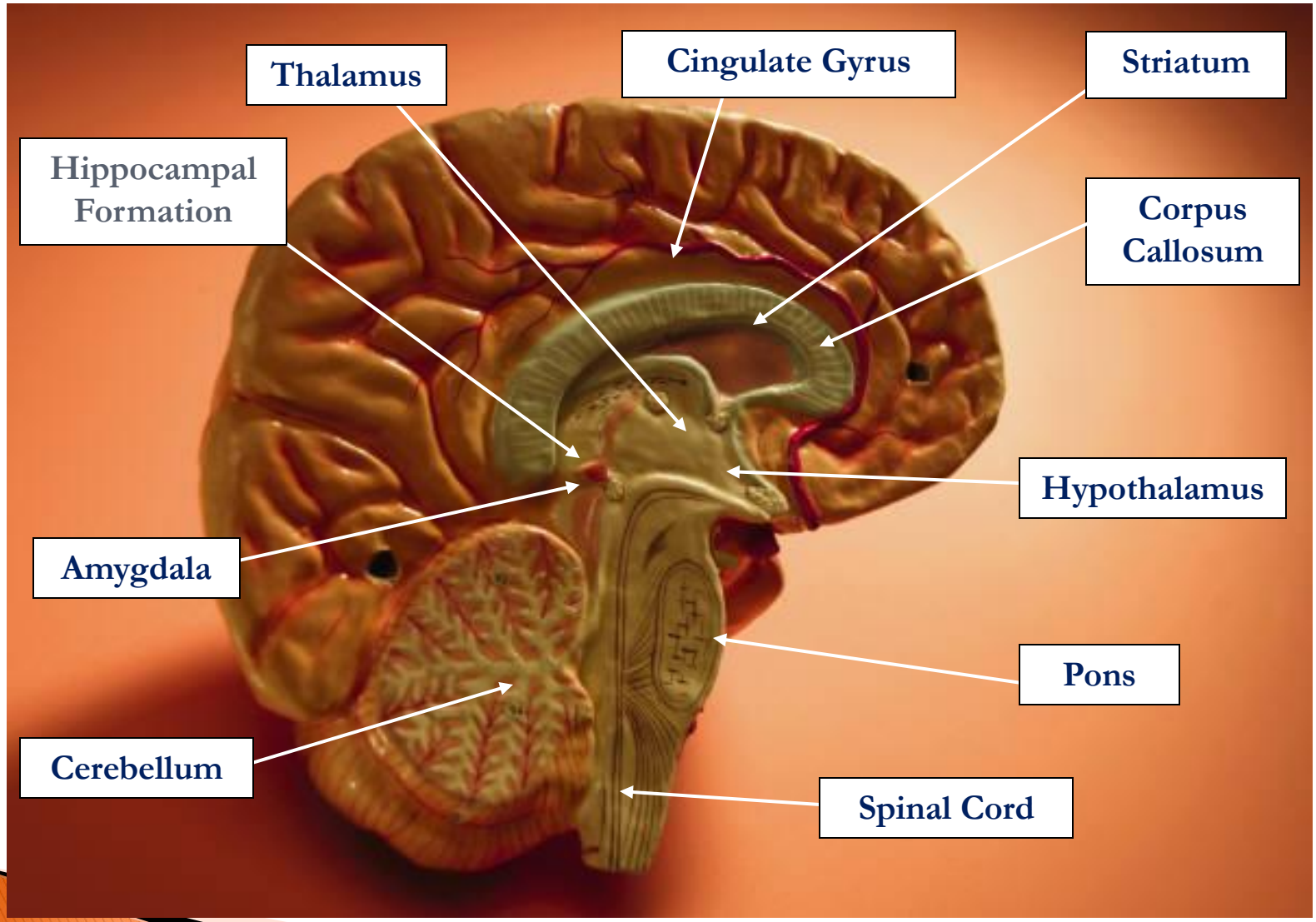
Limbic System as the main area involved with emotions

- **Amygdala** play an important role on the mediation and control of major affective activities like friendship, love and affection, on the expression of mood and, mainly, on fear, rage and aggression. It is also the center for identification of danger

- **Hippocampus** is particularly involved with memory phenomena, specially with the formation of long-term memory (the one that, sometimes, lasts forever).

- **Hypothalamus** is involved in the so-called motivated behaviors, like thermal regulation, sexuality, combativeness, hunger and thirst. It is also believed to play a role in emotion.

Limbic System



	Cognitive	Affective
Controlled Processes ▪ serial ▪ effortful ▪ evoked deliberately ▪ good introspective access	I	II
Automatic Processes ▪ parallel ▪ effortless ▪ reflexive ▪ no introspective access	III	IV

Quadrant I - deliberate whether to refinance your house, poring over present-value calculations (is the realm of economics)

Quadrant II - used by "method actors" who imagine previous emotional experiences to fool audiences into thinking they are experiencing those emotions

Quadrant III - governs the movement of your hand

Quadrant IV - makes you jump when somebody screws

Controlled processes

- conscious and introspectively accessible
- tend to be serial and to use a step-by-step logic
- tend to be invoked deliberately by the agent when her or she encounters a challenge or surprise
- are often associated with a subjective feeling of effort

Automatic processes

- operate outside of conscious awareness
- tend to operate in parallel
- are often associated with a feeling of effort
- people often have surprisingly little introspective access to automatic choices
- Ex. a face is perceived as ‘attractive’, or a verbal remark as ‘sarcastic’, automatically and effortlessly

Cognitive processes

- those that answer true/false questions
- to influence behavior the cognitive system must operate via the affective system

Affective processes

- those that motivate approach/avoidance behavior.
- include emotions such as anger, sadness, and shame, as well as "biological affects" such as hunger, pain, and the sex drive.

AUTOMATIC PROCESSES

Key principles

- **Parallelism** much of the brain's processing involves processes that unfold in parallel and are not accessible to consciousness

- **Plasticity** the brain undergoes physical changes as a result of these processes: when signals are repeatedly conveyed from one neuron to another, the connections between those neurons strengthen (Hebb 1949) . Information processing is unlikely to be reversible because the physiological processes that produce learning are themselves not reversible

- **Modularity** it draws upon multiple modules specialized to perform specific functions neurons in different parts of the brain have different shapes, structures and functions

- **Specialization** when the brain is confronted with a new problem it initially draws heavily on diverse modules, including, often, the prefrontal cortex, but over time, activity becomes more concentrated in modules that specialized in processing relevant to the task

AFFECTIVE PROCESSES

Key Principles

- ***Homeostasis*** Affective system involves detectors that monitor when a system departs from a 'set-point' and mechanisms that restore equilibrium when such departures are detected (it is highly attuned to *changes* in stimuli rather than their *levels*). Some of these mechanisms do not involve deliberate action

- ***Raw motivation*** Economists usually view behaviour as a search for pleasure . Neuroscience and other areas of psychology show that the motivation to take an action is not always closely tied to hedonic consequences (**liking vs. wanting systems**)

- ***Competition*** Affective system often plays as if the decision maker is of "two minds". It drive us in one direction and cognitive deliberations in another

- ***Erroneous sense-making*** Since quadrant I often does not have conscious access to behavior in the other quadrants, it is often tends to over attribute behavior to itself, i.e. to a deliberative decision process.

MAIN FINDINGS

- Decision making is **not a unitary process**—a simple matter of integrated and coherent maximization—because it is driven by the interaction between automatic and controlled processes.

- The extent to which **intertemporal choice** is generated by **multiple systems with conflicting priorities** is consequently the most debated issue within neuroeconomics. Most evidence favors a multiple systems perspective.

- Neuroeconomic research on **social preferences** is supportive of a **dual-systems account**, also with regard to how self-interest and fairness concerns interact to influence behavior

- Economics is intertwined with o psychology by inspiring economic models increasingly grounded in psychological reality and by addressing debates on if multiple systems operate **sequentially or in parallel** to influence behavior

IMPLICATIONS FOR ECONOMICS (1)

Neuroscience raises questions about the usefulness of some of the most common constructs that economists commonly use, such as risk aversion, time preference, and altruism.

- These characteristics are considered as stable over time and consistent across activities
- Neuroeconomics shows that they are weakly correlated or uncorrelated across situations
- Inconsistency derives from state-contingent preferences
- Intertemporal preferences are assumed to be constant for different types of investment
- The modularity of the brain implies that different types of intertemporal choices activate different mixtures of neural system (cigarette, dieting, saving, being on time) and different choices

IMPLICATIONS FOR ECONOMICS (2)

The existence of specialized systems challenges standard assumptions about human information processing and suggests that intelligence and its opposite—bounded rationality—are likely to be highly domain specific.

- Brain is composed by systems evolving to perform specific functions. Our problem-solving capacity (Wason's task) depends on be tailored to do certain tasks
- Brain modules are highly specialized, such as mirror neurons or theory of mind, i.e. there is a module controlling a person's inference about what other people believe, feel or might do
- Mentalizing is a special ability and logical deductive reasoning can only partially compensate for its absence
- Organization of labor: bundling tasks together into jobs requires un understanding of which kind of skills are general and which are neurally separate

IMPLICATIONS FOR ECONOMICS (3)

Brain-scans conducted while people win or lose money suggest that money activates similar reward areas as do other "primary reinforcers" like food and drugs, which implies that money confers *direct* utility, rather than simply being valued only for what it can buy.

- The same dopaminergic reward circuitry of the barin (mesolimbic system) is activated for various reinforcers, such as cocaine, attractive faces, sport cars, jokes and money as well
- Money provides direct reinforcement: people value money without carefully computing what they plan to buy wit it
- If gaining money provides direct pleasure, then the experience of parting with it its probably painful
- Excessive use of credit cards
- To oversubscribe flat-rate payment plans for telephone service or health clubs, which eliminate marginal costs and allows to enjoy the service without thinking about the marginal cost

IMPLICATIONS FOR ECONOMICS (4)

Research on the motivational and pleasure systems of the brain human challenges the assumed connection between motivation and pleasure, wanting and liking.

- For economists behavior is search for pleasure: to give people what they want makes them better off
- This assumption depends on knowing that people will like what they want. If likes and wants diverge, this would pose a fundamental challenge to standard welfare economics
- Neuroscience shows that to take an action is not always closely tied to hedonic consequences and decision-making involves the interaction of two separate overlapping systems, one responsible for pleasure and pain (the liking system) and the other for motivation (the wanting system)
- In later stages of drug addictions there is wanting without liking for the disconnection between the two systems
- Presumably welfare should be based on "liking." But if we cannot infer what people like from what they want and choose, then an alternative method for measuring liking is needed, while avoiding an oppressive paternalism

IMPLICATIONS FOR ECONOMICS (5)

Important implications of cognitive inaccessibility for economic decision-making

- The lack of introspective access make people unable to correct discriminatory biases on job markets
- To acknowledge the effect of gifts from pharmaceutical companies on physician's prescriptions
- Investors, consumers, entrepreneurs are overly optimistic about their chances for success and this is related to chronic cognitive inaccessibility of automatic brain processes
- Confirmation bias

A CRITIQUE OF NEUROECONOMICS
(Harrison 2008)

The heavy use of localization assumptions

1. when it is asserted that such-and-such a part of the brain lights up in relation to a particular stimulus, this conclusion is arrived at by subtraction. Much more of the brain is already busy or lit up. All the scientist can observe is the additional activity associated with the stimulus. Minor changes noted diffusely are overlooked.

2. the additional activity can be identified only by a process of averaging the results of subtractions after the stimulus has been given repeatedly: variations in the response to successive stimuli are ironed out.

3. experiments look at the response to very simple stimuli – for example, a picture of the face of a loved one compared with that of the face of one who is not loved. But love is not like a response to a stimulus because it encompasses many more things

A CRITIQUE OF NEUROECONOMICS
(Harrison 2008)

The reverse inference problem

The usual kind of inference that is drawn from brain imaging is '*if cognitive process X is engaged, then brain area Z is active*.

(1) In the present study, when task comparison A was presented, brain area Z was active.
(2) In other studies, when cognitive process X was putatively engaged, then brain area Z was active.
(3) Thus, the activity of area Z in the present study demonstrates engagement of cognitive process X by task comparison A.

This is a 'reverse inference', in that it reasons backwards from the presence of brain activation to the engagement of a particular cognitive function.

It is self-evidently not a matter of deductive logic, and indeed in introductory philosophy classes it is presented as the formal fallacy of "affirming the consequent"