Neurophilosophical Foundations 3

The Artifact Problem

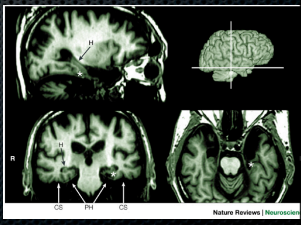
- Techniques to procure evidence alter the phenomenon about which scientists are trying to get evidence
  - Are the resulting observations merely a reflection of the alterations the investigator has made?
- Scientists confronted with observations made with new instruments are often very suspicious that they are artifacts
  - At the outset the signal is often very weak and variable--variations in the technique produce quite different responses
  - The procedures by which the instrument works are not sufficiently understood
    - We still don't know why Golgi's silver stain affects only some neurons
    - Are there is considerable disagreement about the source of increased blood flow detected with fMRI

Practical Solution to the Artifact Question

- Does the technique/instrument generate well-defined or determinate results?
  - If one isn't tracking anything, one would not expect a clear pattern in the results
- To what degree do the results from the technique/instrument agree with results generated by other means?
  - Would not expect perfect overlap since the new technique/ instrument is intended to generate new information
  - But in the domains where they overlap they should agree (or the new technique is calibrated so that it does agree)
- To what degree do the results cohere with what our theories led us to expect?
  - We believe results that seem plausible given what we think we know

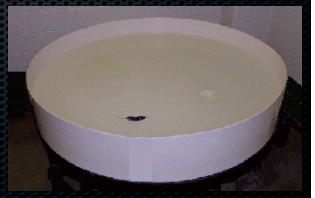
Lesion Studies: Two Examples

- Challenge 1: Knowing just what is lesioned
- Tan (Leborgne)
  - Broca met Tan late in his illness and could not examine his brain until after he died
    - By then the damage was widespread and Broca had to argue as to its likely origin
- HM (Henry G. Molaison)
  - HM suffered from serious epileptic seizures which Scoville sought to reduce by removing the hippocampus from which they seemed to originate
    - For the next 40+ years of his life HM acquired no new episodic memories
  - Although Scoville's aim was to resect the hippocampus, MR scans in 1998 indicated some of the hippocampus was initially spared (but atrophied) and nearby areas were damaged



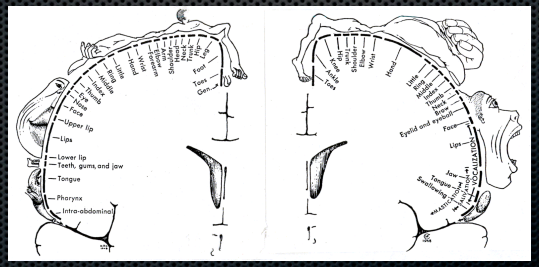
Lesion Studies

- Challenge 2: What operations were due to the lesioned area?
  - Other areas may be secondarily altered
  - Neuroplasticity may result in some “recovery” of function
  - What operation involved in the lost ability is directly affected?
- Tan
  - Broca spoke of the faculty of articulate speech
  - In the 1970s the deficit was interpreted as a deficit in syntax
  - There is huge variability in patients with damage in Broca’s area
- HM
  - Are episodic memories stored in the hippocampus?
  - Or is the hippocampus only involved in regulating access?
  - And are other functions performed by the hippocampus?



Stimulation Studies

- Just as eliminating a functioning component should change behavior in a determinate manner, so should adding more of it into the mechanism
- Challenge 1: Is what is added working in the same as the endogenous component?
- Challenge 2: Just what does the added component contribute to the mechanism?

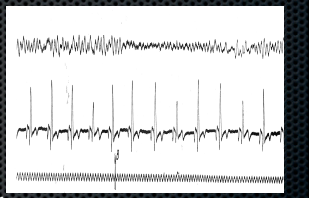


Delgado’s Bull Experiment

- Delgado claimed he found a center that inhibited agression
- Valenstein: Delgado really activated a pathway that controlled movement

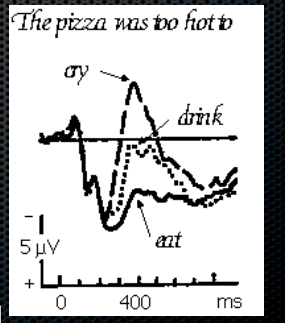
Electrophysiological Recordings

- Electroencephalogram (EEG): Electrodes placed on the skull detect ongoing electrical signal
  - Berger (1930) distinguished large amplitude, slower waves during rest (8-12 Hz alpha rhythms) and lower-frequency, faster waves after stimulation (12-30 Hz beta rhythms)
  - Subsequent discovery of both higher-frequency (>30 Hz gamma rhythms) and lower-frequency (4-7 Hz theta and 0.1-4 Hz delta rhythms) oscillations
    - Much of the focus directed at the lower-frequency rhythms associated with stages of sleep
- These oscillations were interesting even as researches were uncertain as to their origin
- But until recently they did not seem to have much to do with cognitive activities--BUT THAT HAS CHANGED DRAMATICALLY



Evoked Response Potentials (ERPs)

- By time-locking the EEG signal to the presentation of a stimulus and averaging over many trials, researchers could extract a detectable signal
  - Thought to reflect the brain's processing of that stimulus
    - N400 (discovered at UCSD by Marta Kutas) thought to reflect violations of semantic expectations
- ERP studies can provide high resolution information about timing of activity
  - But little information about where the signal is coming from
    - As there is no general solution to the inverse problem--inferring from what is recorded at different electrodes to the source of the signal

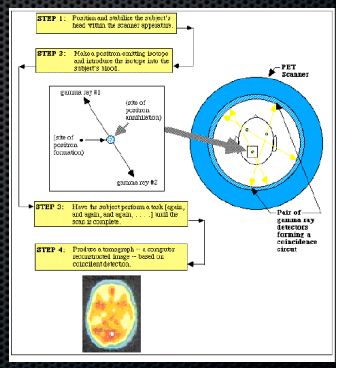


Single-Cell Recording

- Once the technique of inserting an electrode next to a neuron and recording its electrical behavior was developed it became the workhorse of sensory (especially visual) neuroscience
- Challenge 1: Finding the full set of stimuli that elicit response in a given neuron
- Challenge 2: Determining what that neuron is contributing to the processing of a given stimulus
- Challenge 3: Activity of individual cells may not be the relevant brain activity
  - Cannot detect what is going on in other cells and how timing of the responses in multiple cells might encode information

Neuroimaging: PET

- Positron emission tomography (PET)
  - Employs a radioactive compound to provide a signal
    - 2-deoxyglucose which is transported to cells like glucose but not metabolized
      - Builds up in cells as they recruit glucose for energy
    - Labeled H_2O which is carried by the bloodstream
      - Registering the increased blood flow as energy is needed
  - The products of the radioactive decay (gamma rays generated as an emitted positron collides with an electron) are detected by a scanner when they arrive simultaneously
    - Computerized tomography is used to generate a three-dimensional image from which slices in any direction can be viewed



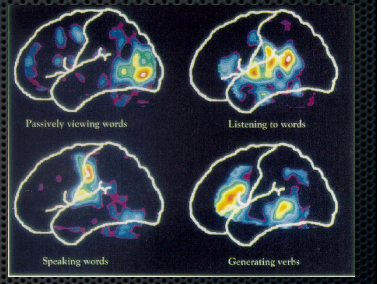
Neuroimaging: MRI and fMRI

- Magnetic Resonance Imaging (MRI)
  - In a strong magnetic field, hydrogen nuclei align the axes of their spin
    - The energy from a radiowave pulse perturbs this alignment
    - When the pulse ends, nuclei return to the low-energy aligned state
      - And release radiowaves with a specific frequency
- Structural MRI uses the difference in frequency from atoms in grey and white matter to construct an image
- Functional MRI (fMRI) detects changes in deoxyhemoglobin resulting from changes in blood flow that *exceed* oxygen required by neurons
  - Blood oxygen level-dependent (BOLD) signal
- The question of why blood flow exceeds that required to provide oxygen to neurons is still a matter of serious dispute

Neuroimaging: Relating Signal to Cognition

- Just as with single-cell recording, what one can infer from the results of a PET or fMRI scan depends on the input stimulus/task
- Researchers must find a means of relating inputs/task to the signal
  - During any task there will be activity throughout the brain (it is not dead when no task is presented)
- One of the most widely used strategies for relating task to detected activity is subtraction
  - An approach first developed by Donders in the 19th century for reaction time studies
    - Compare two different task conditions and subtract the time required for one from that required for the other
  - In neuroimaging, compare two tasks conditions and subtract blood flow produced by one task from that produced by another (baseline) task

Neuroimaging: The Verb-Generate Task



- Four subtraction conditions
  - Passively viewing words - resting
  - Passively listening to words - resting
  - Speaking viewed words - passively viewing words
  - Generating and speaking verb in response to viewed words - speaking viewed words
- Last subtraction resulted in increased activity in the left prefrontal cortex, anterior cingulate, right cerebellum
  - The researchers contended that the left prefrontal cortex reflected semantic processing
  - This was one of the first studies to highlight the anterior cingulate, but they and others assumed it was involved in executive control

Neuroimaging: Answering Skeptics

- A variety of skeptics have raised doubts about the informativeness of neuroimagiing studies
  - Variability across studies: Different researchers, doing studies expected to generate the same results, show activity in different areas
    - Results reflect more the manipulations of the study than the underlying phenomenon (recall Golgi)
  - Holistically oriented critics claim that the idea of localization is built into the methodology
    - One assumes that the task is performed by a localized component and looks until one finds such

Neuroimaging: Answering Skeptics

- Why are neuroimagers so confident in their results?
  - The images reveal definite patterns, not just a hodgepodge of activations
- Results cohere with results from studies using other techniques
  - Reading activated visual areas and speaking activated motor areas
  - But generating verbs activated lateral prefrontal areas and not Wernicke's area in the temporal lobe
    - Frith et al. (1991) found activation in both Wernicke's and prefrontal areas
      - And interpreted only Wernicke's area as involved in semantic processing
      - Each group tries to answer the interpretations of the other
- Results fit within a theoretical framework: two pathways of processing, one direct and one through semantic associations