Research Methods, Measurement, and Basic Statistics

Intro Psychology

Georgia Tech

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Today

- Research Questions in Psychology
- Terminology
- Methods
- Statistics

Old (?) Techniques

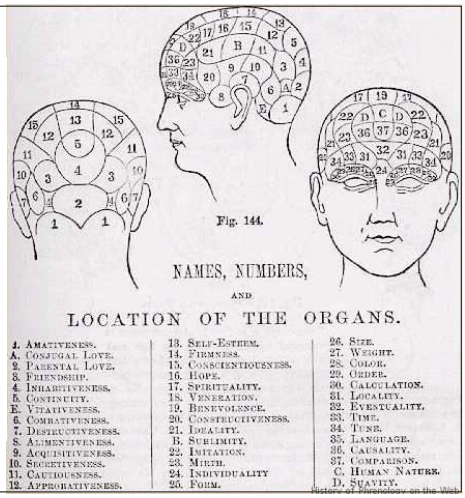
- For example, **Phrenology**

"[Before phrenology] all we knew about the brain was, how to slice it..." R. Chenevix (phrenologist), 1828.

Phrenology was a science of character divination, faculty psychology, theory of brain and what the 19th-century phrenologists called "the only true science of mind." Phrenology came from Viennese physician Franz Joseph Gall (1758-1828). The basic tenets: 1.The brain is the organ of the mind. 2. The mind is composed of multiple distinct, innate faculties. 3. Because they are distinct, each faculty must have a separate seat or "organ" in the brain. 4. The size of an organ, other things being equal, is a measure of its power. 5. The shape of the brain is determined by the development of the various organs. 6. As the skull takes its shape from the brain, the surface of the skull can be read as an accurate index of psychological aptitudes and tendencies.

- Phrenology:

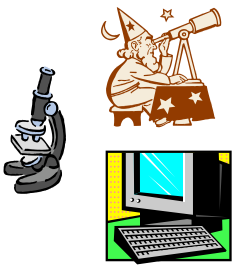
I. Amativeness (*physical love*).
II. -- philoprogenitiveness
III. -- inhabitiveness
IV. -- adhesiveness.
V. -- combativeness.
VI. -- destructiveness.
VII. -- constructiveness.
VIII. -- covetiveness.
IX. -- secretiveness.
X. -- self-love.
XI. -- approbation
XII. -- cautiousness.
XIII. -- benevolence.
XIV. -- veneration.
XV. -- hope.
XVI. -- ideality.
XVII. -- conscientiousness.
XVIII. -- firmness or determinateness
XIX. -- individuality
XX. -- form.
XXI. -- size XXII. -- weight
XXIII. -- colour XXIV. -- space
XXV. -- *order?* XXVI. -- *time?*
XXVII. -- number XXVIII. -- tune.
XXIX. -- language.
XXX. -- comparison.
XXXI. -- causality.
XXXII. -- wit. XXXIII. -- imitation.



History of Phrenology on the Web

Intro to Modern Techniques

- What is the same?
- What is different?
- What are the questions ***we*** want to answer?



Research Approaches

- Observational
- Behavioral
- Psychophysical
- Neurophysiological

Observation

- Naturalistic observation
  - In biology known as a field study, in astronomy, the only method available
  - Useful in complex social situations
  - Very limited in conclusions that can be drawn, in particular causation.

Observation

- Case Study
  - Observation or experimentation on a single entity (human, animal, social group, etc).
  - Often the only option
    - e.g., patients with rare form of brain damage
  - Extremely limited.
    - Hank, a schizophrenic has a domineering mother and a submissive father. No way to tell whether this is coincidence or a causal factor.

Observation

- Clinical Case Studies
  - Out of billions of people, highly improbable things happen to some people's brains and these turn out to be ***very*** interesting

Observation

- Clinical Case Studies
  - Phineas Gage – iron tamping rod used to pack black powder ignited the powder blowing it into his head.
  - He lost consciousness and had convulsions but eventually recovered, was able to walk, talk, etc.
  - Never quite the same…

Behavioral / Observational

- Survey
  - Look for relationships between variables by asking many people a series of questions.
  - Measure the **prevalence** of an answer in the population or look for **relationships** between different answers
    - Did you cohabit before getting married?
    - Have you been divorced?

Study: Those who cohabited less enamored of marriage

The Associated Press

WASHINGTON

People who live together before tying the knot might be more apt to fail in marriage than couples who move in after exchanging vows, two sociologists say.

The researchers said their findings contradict the idea that the experience would better prepare people for marriage and thus reduce divorce.

Professors William Axinn of the University of Chicago and Arland Thornton of the University of Michigan concluded that couples who live together are less committed to the institution of marriage and that "cohabiting experiences significantly increase young people's acceptance of divorce."

Their study, published in the August edition of the quarterly "Demography," covered 867 families of mothers and their children interviewed over a period from 1962 to 1985.

Census Bureau figures showed that in 1990, 2.9 million unmarried couples were living together, up 80 percent from 1980. Also in 1990, there were 142 divorced adults for every 1,000 married adults, three times the ratio in 1970.

Behavioral

- Survey findings:
  - People that cohabitated are also more likely to report a divorce
  - Note: No information about whether cohabitating *causes* divorce
  - Misunderstanding and mischaracterization of such survey results is rampant in media.

The Experiment

- Experimental Method
  - Control of most variables and explicit manipulation of variables of interest.
  - Only method that allows one to determine true causation.

Experiment Variables

- Variables – obviously the things that can change value...

Independent variables – things that we control, manipulate, change

Dependent variables – what is measured (answers on a survey, accuracy, response time...)

Experiment Example

- Does a background in calculus help when learning statistical methods?
- Independent variable?
- Dependent variable?
- Design?

Quasi-Experiment

- Some independent variables cannot be manipulated (or really hard to manipulate)
  - Compare patients with frontal brain damage to intact normals

Tradeoffs

- "Cost" versus "Benefit"
- True experiments are expensive, difficult, or sometimes just unethical
- Other designs easier but always come at the cost of strength of your conclusions

Psychophysical Approach

- Phenomenological method
- Recognition
- Detection

  e.g. Fechner, *Elements of Psychophysics* (1860)

  – Thresholds
    - Method of limits
    - Method of adjustment
    - Method of constant stimuli
  – Difference Threshold (JND) $\frac{\Delta S}{S} = K$
    - Weber's Law:

Physiological Approach

- Early Approach: Physiology as Anatomy
  – Aristotle
  – Others (e.g., Galen, Hippocrates)
    - Galen
    - Descartes
    - Galvani
    - Kepler

Physiological Approach

- Neurons & electrical signals
  – Mueller: "doctrine of specific nerve energies"
  – Development of study of:
    - Nerves, neurons, dendrites, axons…
    - Pathways
    - Receptors
  – Recording electrical signals
  – Brain chemistry

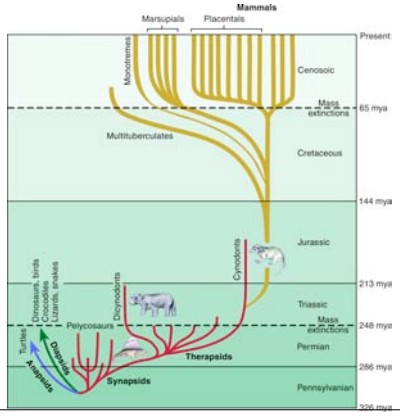
Physiological Approach

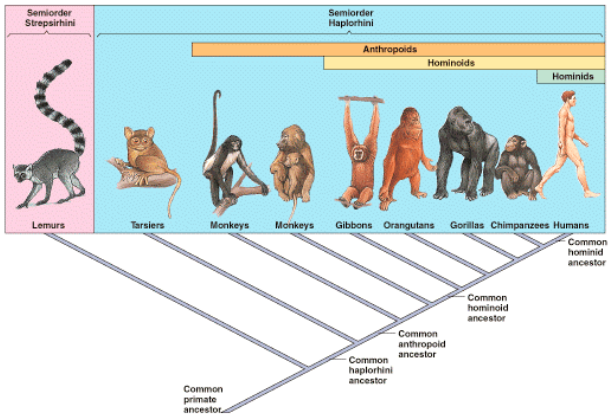
- Functional structure (not anatomical) of brain
  – e.g., pathways (but not anatomical)
  – from electrical and chemical studies of functions
- Brain activity (related to structure)
  – Evoked potentials -- electrical (EEG)
  – Neuroimaging (PET, fMRI)

Methods in Neuroscience

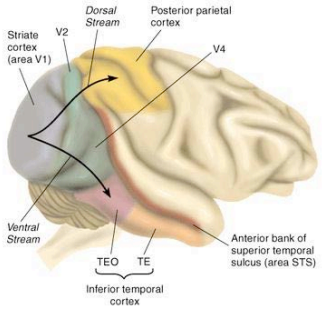
- A note on animal models
- We are animals
- Biological psychology depends on the theory of evolution

Mammalian Evolution



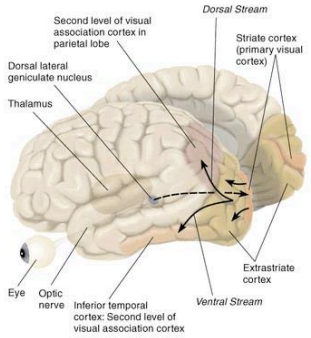


► Areas of Visual Cortex in the Rhesus Monkey Brain



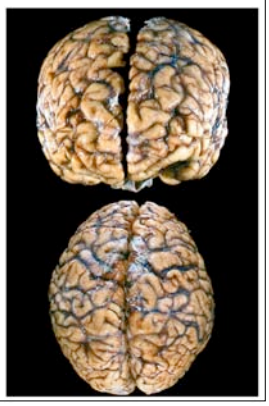
Source: Adapted from Zeki, S.M. *Journal of Physiology*, 1978, *277*, 227–244.

► The Human Visual System



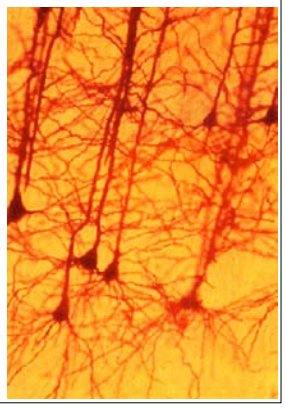
Brain as Center of Thought

- Study of the human as a perceiving "machine" led to the conclusion that the brain was center of thought and perception
- Early anatomists tried dissection to determine (1)structure, then (2) function
- Modern efforts much more effective !



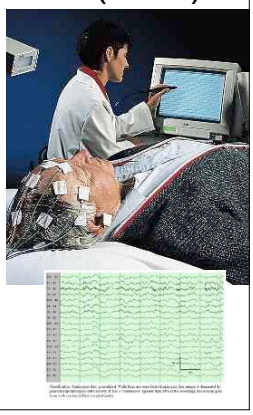
The Neuron Doctrine

- Neurons & their synapses are the fundamental entities in brain functions, including the mind and consciousness
- All the functions of the brain must ultimately be understood in terms of neurons and their interactions
- Note: Neurons are electric in nature



Event Related Potentials (ERP)

- During activity neurons emit **electrical signals** which can be measured
- Geometric and temporal analysis of signals show location and time of specific activity, related to particular sensory experience
  - e.g., see stimulus
- Non-invasive
- Good temporal resolution
- Poor spatial resolution



Electroencephalography (EEG)

- Method for measuring ERPs

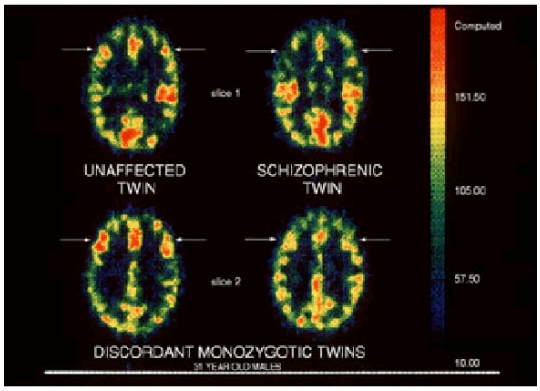
Blood is Thicker than Electricity…

- Blood flow is necessary to keep those neurons firing
- If blood flow is correlated with brain activity, and it is regionally distinct, temporally distinct, and process-related, we can use blood flow as a metric of activity

Positron Emission Tomography

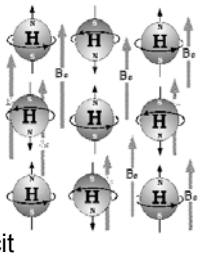
- Positron Emission Tomography
  - Radioactive $^{15}O_2$ inhaled
  - Emission of positron+electron pair from blood
  - Detectors around head can triangulate activity location
  - More blood, more activity, more emissions
- Functional, not structural images of brain in action
- Moderate spatial resolution
- Fairly slow response
  - Not "real time"

PET: Regional Activity



Magnetic Resonance Imaging (MRI)

- Protons in brain tissue have magnetic fields
- Apply external field, and protons align themselves to the field
- Disturb alignment with RF pulse, and detect the MR radiation from the protons
- Delivering the right pulses can elicit MR samples from a specific region (voxel) of the brain

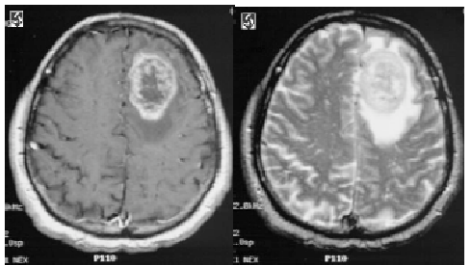


MRI Scanner

- Produce magnetic field, RF pulses, and measure MR signals
- Range from 1-9 Tesla
- 1.5 Tesla
  - = 300 X strength of a fridge magnet
  - = 30,000 X Earth's magnetic field

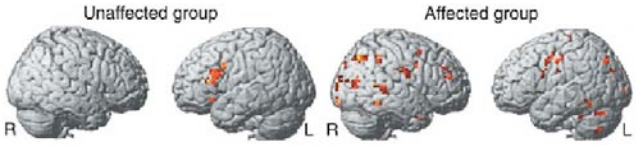
Getting an Image

- Structural image, little/no timing info
  - Can adjust to "see" different tissue types



functional MRI

- Blood Oxygen Level Dependent (BOLD)
  More brain activity --> more blood flow --> different MR signals
- Best of both worlds: Dynamic picture of brain as it is active overlaid onto structure
  - Hence, "functional" MRI



Other Techniques

- Combined fMRI and ERP !
- Optical imaging
- Electrode insertion
- Camera insertion
- Live patient brain stimulation

The Factor of Time (All Techniques)

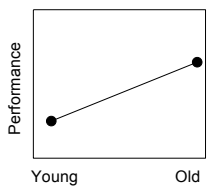
- "Developmental" Methods
  - How does an individual (e.g., children) or process (e.g., language) change over time?

Developmental Studies

- Cross sectional designs – get measures from groups that differ in development

  Example: Age differences in mathematical abilities (calculation) (Greary, 1993)

120 college freshman and 89 adults 65 to 82

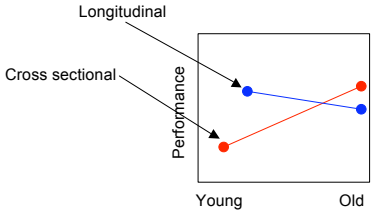


So, performance increases with age...

But, mathematical education has also changed.

Developmental, cont'd

- Longitudinal designs – measure same individuals at multiple points in time.



In fact, it declines but in cross sectional design, young and old also had very different educational experiences.

Breather

Measurement and Statistics

- The goal of research is, in the end, **knowledge**. This comes from **information**, which, in turn is founded on **data**
  - Note: *Data* are plural; *datum* is singular
- How do we measure things, and analyze what we measure, in order to generate, in the end, knowledge?

Attributes of Measures

- **Validity**: measures accurately reflect what they are supposed to reflect
- **Reliability**: measures are consistent

Basic Statistical Concepts

- Population versus sample
  - Question about drug use in college students.
  - Survey 500 college students from 5 Universities
  - Population – all college students
  - Sample – the 500 students actually surveyed.

Random Sampling

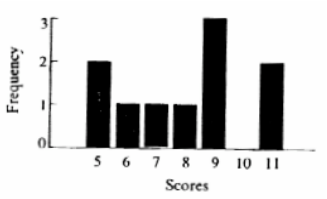
- Everyone in the population has an equal chance of being surveyed (or measured or whatever)
- If UGA students were more likely to be surveyed than GT students, then it's **biased**

Random Assignment

- Is my class really better than all of the other Intro classes?
  - Suppose my course ratings >> the other sections…
  - Is it me, or is there anything different about students taking afternoon course versus morning course?
  - Or are both things having an effect?
- Because students select which group (class) they are in, there could be any number of pre-existing differences between sections.
- Randomly assigning students to a class would (mostly) remove prior differences between groups

Frequency Distributions

- Histogram



A.2 ***Histogram*** *In a histogram, a frequency distribution is graphically represented by a series of rectangles. The location of each rectangle on the x-axis indicates a score value, while its height shows how often that score value occurred.*

Normal (Gaussian) Distribution

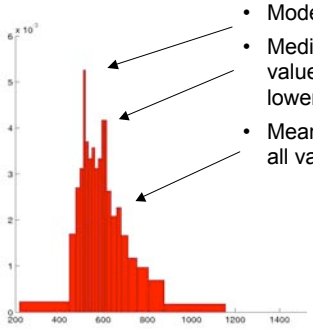
- Almost magical distribution that describes the distribution of many human characteristics and behaviors in the population.

A.3 ***Normal distribution*** *Values taken from any normally distributed variable (such as those presented in Table A.4) can be converted to z-scores by the formula z = (score − mean)/(standard deviation). The figure shows graphically the proportions that fall between various values of z.*

Table A.4 NORMALLY DISTRIBUTED VARIABLES

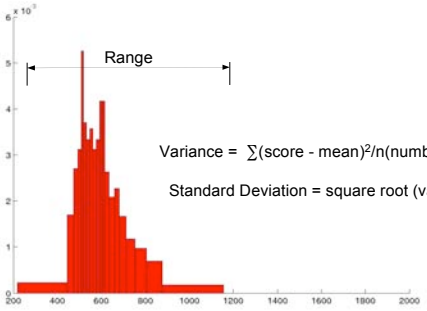
Variable	*Mean*	*Standard deviation*	*−2*	*−1*
IQ	100	15	70	85
SAT	500	100	300	400
Height (women)	160 cm	5 cm	150	155

Measures of Central Tendency



- Mode – most common value
- Median – point at which half of values are higher and half are lower
- Mean – arithmetic average of all values

Measures of variability

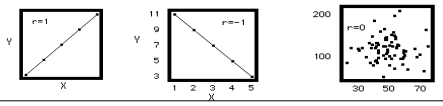


Variance = $\sum$(score - mean)^2/n(number of scores)

Standard Deviation = square root (variance)

Relationships (the stats kind)

- Correlation – how related are two variables
  - Does a value of one variable tell you anything about the value of another variable?
  - Does knowing a person's income tell you about their probable political affiliation?
  - What does knowing someone's major tell you about other aspects of the person?
- Pearson's r – mathematical statement of relationship between to variables
  - Range is negative 1.0 to positive 1.0



Correlation Does Not Mean Causation

- Negative correlation between # of people on platform and time until train
- Jogging and aggression
- Marijuana and heroin use

- Correlation is simple – causation is difficult
- Extremely common confusion in media reports.

“Significance” in Statistics

- A way of reporting the amount of trust you can put in any “finding” in your data
- “Statistically significant” generally is used to mean that it is unlikely that a “finding” (measurement) that big occurred by chance, so “believe” the finding
  - e.g., difference between two group means
- Complex issues. Never forget that this is a science based in large part on probabilities

Upcoming

- Biological Basics, Biological Basis
- Sensation and Perception