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TOPIC: SCIENCE AND STATISTICS
Lect 1 The Attitude of Science

a) Understand that critical thinking skills should be used with care and respect
b) Distinguish between scientific viewpoints and viewpoints based on opinion, taste or belief
c) Identify and understand the logical errors: 'Argument from authority' and 'Ad Hominen'
d) Distinguish between open-mindedness and unbounded credulity
e) Understand the 'attitude' of scientific investigation

a) Understand that critical thinking skills should be used with care and respect
- Dependent on whether something can be tested with an experiment or not
  - Can = science have strong view on it
  - Cannot i.e. determine whether a course of action is right or wrong = seek guidance from moral philosophers, holy text or social norm
- Must accept non-scientific debate with great tolerance and humility that a question can have many valid questions

b) Distinguish between scientific viewpoints and viewpoints based on opinion, taste or belief
- **Stephen Jay Gould: Science and religion as "non-overlaping magisteria"**
  - i.e. they were both worthy of our time and respect and were not in conflict because they were asking and answering different questions
  - Religion can no longer dictate scientific knowledge
- **Difference between acquired knowledge from revelations** (taught by your parents/ teachers)**, emotions/intuitions/opinion and science method**
  - i.e. the difference between the realm of opinion (plants versus zombie) and magisterium of science (vaccination)
  - *However attitude on science is dependent on the knowledge you attain*

e) Understanding the attitude of scientific investigation (the scientific method and the attitude of science)
- **Attitude of science ("Baloney detection")**
  - Theories are just the best we have at any given time
  - It is the mechanisms for evaluating claims which ensures the strength of science
  - Operates with the assumption that our current understanding is imperfect
  - If criticism is not possible then progress cannot be made
  - Science is motivated to bring down/challenge the big theories
  - Science must be content with uncertainty
  - Science needs to be transparent and open to criticism
  - The lack of authority i.e. not absolute truth
  - Have independent confirmation of the "facts"
  - Encourage substantive debate on the evidence by knowledge proponents from all POV
  - Argument from authority carry little weight
  - Spin more than one hypothesis
  - Quantify (i.e. prove with a measure/numerical quantity)
  - Question whether the hypothesis can be falsified
  - ***Reliance on carfully designed and control experiments is key***
- **The scientific method;**
  - Process of ***criticising and evaluating*** evidence and proposing and testing alternative explanations

- **Research:** Spot bias, industry intervention, logical error, lack of evidence, lack of peer review, lack of replication, poor research design, emotive claims etc…
- **Evidences needs to be;**
    - objective
    - replicable
    - peer reviewed
    - applicable up to date
    - scientific
- **Example of the phantom limb (specific localisation of brain function + proving old theories wrong)**
    - An arm or legs that lingers in definitely in the minds of patient long after it has been lost in accident or removed by surgeon
    - 1940s-1950s Wilder Penfield stimulated specific regions of the patients brain with an electrode - found a narrow strip from the top down both sides of the brain where his electrode produced sensation localised in various part of the body
        - "Sensory homunculus" - greatly distorted representation of the body on the surface of the brain
    - Debate of nature vs nurture - the extent to which aspects of our mind are laid down by genes and the extent to which they are modified by experience
    - Proof of the phantom limb
        - Magnetoence Phalography (MEG) - relies on the principle that if you touched different body parts laid out in the Penfield map can be measured as changes in magnetic fields in the scalp
        - Connection i.e. between the arm and face, genitals and feet
    - ***Discovery - large scales changes in the organisation of the brain could occur in adult humans (i.e. connection can be modified over distances spanning a centimetre or more) —> contradicts the fixed nature of connections in the adult human brain —> PLASTICITY IN THE BRAIN***

c) Identify and understand logical errors "Argument from authority"and "Ad Hominen"

- **Appeal to authority**
    - Logical fallacy
    - If you believe in something is true because someone important said/endorces it
- **Ad Hominem**
    - Logical fallacy
    - Disagree with what someone says but attack them for being disreputable rather attacking their claim or evidence
- Argument from adverse consequence (i.e. God's system of punishment and reward)
- Appeal to ignorance - the claim that whatever have not proved false must be true (*The absence of evidence is not evidence of absence!)*
- Observational selection
- Statistics of small number

d) Distinguish between open mindedness and unbounded credulity

- A willingness to explore new ideas does not mean you have to accept them unconditionally
- Approach promoted by science - goes through "evidence filter" before accepting
- **Pseudoscience:** no faith that leading theory is the best (WHAT NOT TO DO!)

- People who believe in pseudoscientific "supernatural" concept who tell individuals to be "more open minded" - typically based on highly flawed thinking and inaccurate understanding of what open mindedness is
- Believing in super natural (unexplained event X) will lead one to;
  - Misinterpret evidence
  - Make causal invalid connection
  - Eliminate alternative explanation prematurely
  - Rehearsing your own prejudice = CLOSE-MINDEDNESS

Readings:
Book Chapter: "The Fine Art of Baloney detection" from the book Demon Haunted World by Carl Sagan
Non -overlapping magisterial wiki and the article by Stephen Jay Gould
V.S. Ramachandran. Phantoms in the brain: human nature and the architecture of the mind (Chapter 2: Knowing where to scratch)
Youtube video - open mindedness by Qualia Soup
Examples of logical fallacies: http://www.skepdic.com/

Lect 2 The Power of a Name: Measurement and Constructs

a) Understand the need for precision in scientific constructs and concepts
b) Consider how each concept or construct we use in psychology needs to be conceptually defined or established
c) Identify logical errors: "Reification" and "the pragmatic fallacy"
d) Appreciate the notion of falsifiability
e) Understand what an "operational definition" of a variable is, and why it might not always be ideal

a) Understand the need for precision in scientific constructs and concepts
b) Consider how each concept or construct we use in psychology needs to be conceptually defined or established

- **A construct:** an idea or theory often expressed as a single word buy containing lots of assumptions and conceptual meaning
  - i.e. Different between *pre scientific constructs* (energy) and *scientific constructs* (***A more accurate/specific approximation of reality*** i.e. DNA)
  - Need for precision in *psychology* due to the ambitiousness of some psychological construct i.e. motivation (how do we measure them? how do we know if they're real?)

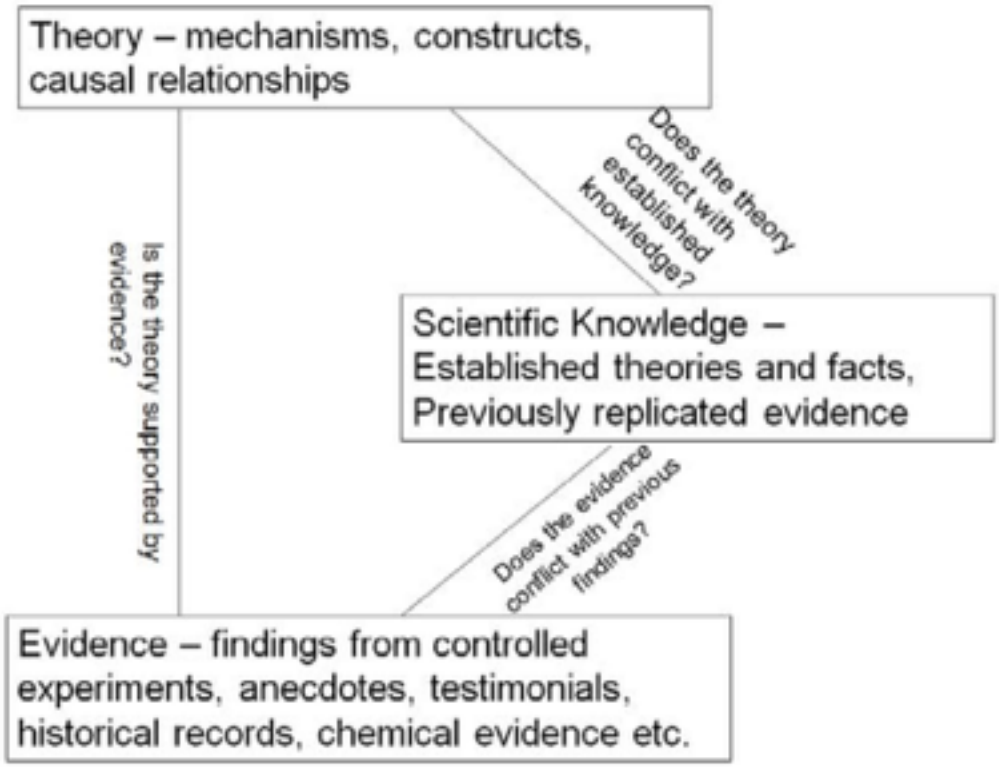
c) Understand what an operational definition of a variable is, and why it might not always be ideal

- **Construct:** a conceptual definition and an operational definition
- **Conceptual definition has an operational definition**
  - *Conceptual definition:* involves describing a construct in terms of what is and what it is not and how it might relate to existing theories
  - *Operational definition:* (of an construct) is an explanation of how a construct might be measured/observed
    - ie. Construct (theory) - motivation, then Operational Definition (observation) = rate of button pressing
  - ***Do not confuse operational definition with the construct* (i.e. operational definition might be a good/bad way to observe a construct i.e. self report scale - ***subjective appraisal, direct measurement)***

d) Identify logical errors: Reification and "The pragmatic fallacy"

- **Reification:**

    - logical error
    - occurs when a purely analytic or abstract relationship is treated as if it is a concrete entity
    - It can occur when an adjective is treated like a noun i.e. evil (Geroge Bush)
- **Vitalism**
    - Vitalistic thinking - everything relates to a purpose (i.e. a mountain is for walking)
    - Adults who use more “vitalistic thinking” more likely to believe in i.e. luck/ghosts - Lindeman and Saher 2007
    - Misunderstanding of energy = endorse these
        - China (chi/qi), Japan (Ki), Western Europe (Animal spirits - the flow of animal spirits carried our thoughts, but after 1828 vitalism begin to disappear in the west - due to formation of first organic compound)
    - Another related error when conceptually creating constructs is a failure to consider ***falsifiability*** (i.e. create something that can never be assessed or measured thus it can never be disproven)
- **The Pragmatic Fallacy**
    - logical fallacy
    - Something is true because it works
    - When conceptual reality is crudely tied to efficacy
    - i.e. Placebo effect
    - i.e. Evidence (acupuncture works) = theory (i.e. an invisible force called Chi flows through our bodies and must be unblocked) —> cannot be falsified
    - ***Theory need to interact with knowledge and evidence)*



e) Appreciate the notion of falsifiability

- **Falsifiability**
    - Everything must be able to be assessed or measured to tell if it is real or disprove it

    - If there is no way contrary evidence can disprove a theory, then the theory is not scientific
    - Construct, theories and individual prediction can all be unfalsifiable which means progress cannot be made with them and they are arguably beyond the realm of science
    - Science in not “blind empiricism” (based on experience)
    - Freud’s theory is not scientific (i.e. its not falsifiable)
- **Important of falsifiability (need for scientifically validated data)**
    - Deep sleep therapy used from 1962-1979
    - 26 patient died

f) Additional information - Using electronically data to advance our understanding of the human behaviour by steadying it (The Kosinski, Stillwell and craepel 2013 paper)

- ***Unless the study is founded on a considered approach to construct - we might find we get better and better at predicting behaviour but not any closer to understanding it***
- Digital records of behavior, Facebook Likes, can be used to automatically and accurately predict a range of highly sensitive personal attributes including: sexual orientation, ethnicity, religious and political views, personality traits, intelligence, happiness, use of addictive substances, parental separation, age, and gender.

Readings

- * Lindeman, Majaana: Vitalism, Purpose and Superstition
- * Kosinski, M., Stillwell D.J., Graepel T (2013) Private traits and attributes are predictable from digital records of human behavior. *Proceedings of the National Academy of Sciences (PNAS).*
- https://explorable.com/operationalization

Lect 3: Research Design

- **Research Design**
    - Need to distinguish between different types of design
    - Anecdotes and case studies
    - Correlation Studies
    - Quasi-Experiments
    - True Experiments
- **External validity:** random sampling
- **Internal validity:** random allocation
- **Blinding**
- **Other terminology**
    - **i**ndependent variable
    - dependent variable
    - control condition

a) Identify the flaws inherent in the “anecdotal” evidence and why a “case study” provides more meaningful data

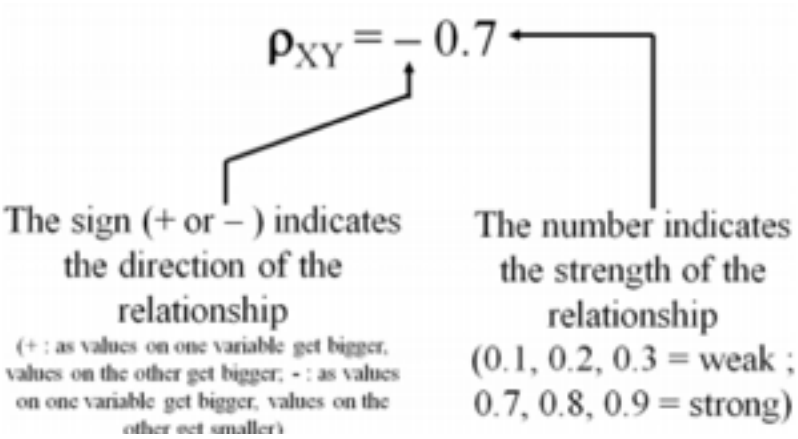
- **Anecdotal Evidence (Flaws)**
    - ***Interpreted stories*** about a single occurrence in the past and are usually of no scientific value
    - Small sample size
    - Built in bias (only relevant info to interpretation is reported)
    - Can change with each telling
    - Often of a single instance - cannot be replicated by a non-prejudice observer

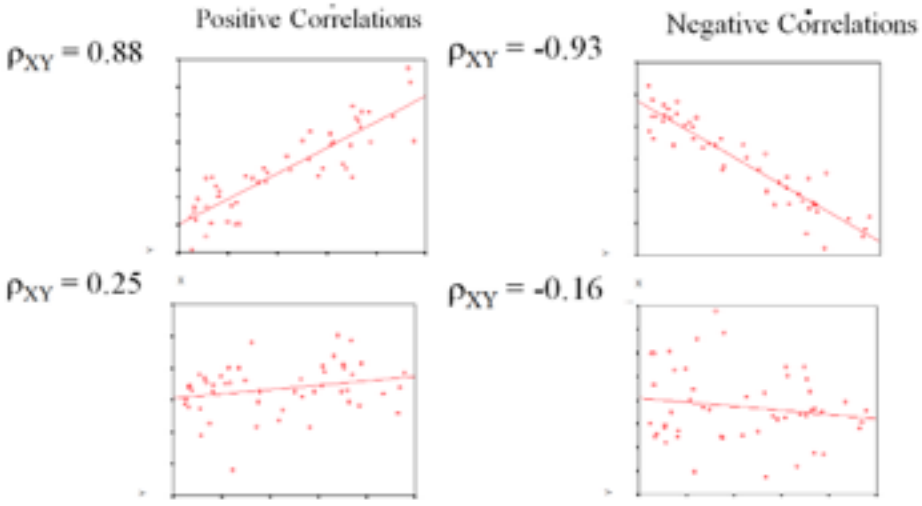
- Usually contains an interpretation
- i.e. “I got better” thus “I am living proof that X works”

- **Case study (Preferred)**
  - More systematic - as they arise from an earnest attempt to understand (all details - relevant or not are recorded in a scientific manner)
  - Scientific humility - attitude of wanting to discover rather than confirm (objective)
  - Often only way to study extremely rare conditions

b) Understand a correlation coefficient and be able to interpret its meaning in a research paper

- **Correlation Coefficient**





- **Correlation Study**
  - At least ***two variable*** are measured from each case/person with a view to calculating relationship between variables i.e. ***Height and IQ***
  - Cannot infer ***causation*** (i.e. wealth and richer people near the sea) i.e. do not have a control condition, no control over any variable/all variable are dependent variable
  - Pattern expressed as a correlation coefficient (*See above)*
  - Scatter plots: the signs give the direction of the slope, and the magnitude show clustered the cases are along the line *(see above)*

c) Appreciate the need for a control condition in ruling out alternate explanations

- **Control Condition**
  - ***First essential requirement in inferring causation***
  - Exist to rule out other causes such as time, fatigue, immune system
  - Hamburger example (i.e. McDonald or a
  - Experimental condition - only one controlled feature - if changes found in this and not control then can attribute to manipulation
- **Independent variable (IV):** Presumer cause, manipulated by the researcher
- **Dependent variable (DV):** measured to see if IV have effect (often a behaviour or response)

d) Be able to distinguish between 'true experiments', 'quasi-experiments' and correlational studies, and understand the pros and cons of each

Examples of strengths and weaknesses of various research methodologies

Methodology	Major strength	Major weakness
Correlational	Can be used to examine complex relations among many variables.	Can't draw conclusions about causality.
Experimental	Can draw conclusions about causality.	Often does not represent true learning environments in real classrooms.
Quasi-experimental	Can simulate an experiment in a true classroom setting.	More difficult to justify causal conclusions than in true experiments.
Qualitative	Can provide detailed, in-depth analyses of the contexts of learning environments.	Very time-consuming, both in terms of data collection and analysis.
Longitudinal	Can examine changes in variables over time.	Very costly, and subjects may drop out over the course of the study.
Cross-sectional	Efficient and rapid way to examine developmental differences.	Not nearly as accurate as longitudinal designs; cohorts may differ, and these differences may be mistaken for true developmental differences.
Design experiments	Occur in actual classrooms; experiments are constantly altered based on actual occurrences in the classrooms.	Very time-consuming; sometimes quite difficult to examine causality.
Microgenetic research	Allows for in-depth analyses of development in strategy usage over time.	Very time consuming; often uses very small samples.
Single-subjects	Provides detailed data about changes in a specific variable in one individual learner at a time; can be particularly useful in developing interventions for learners with special needs.	Difficult to generalize to larger populations.
Action research	Involves real classroom teachers investigating questions that are directly important to practicing educators.	Often does not meet the stringent criteria of other designs, and results may not be acceptable to the scientific community.

	True experiment	Quasi experiment	Correlation studies
Definition	2 variable - IV, DV	An attempt is made to control at least one of the independent variable - but other variable which are important in drawing inferences cannot be manipulated or are not manipulated (i.e. gender)	At least 2 variable are simply measured in a correlation study (the experimenter does not intervene in any way) Correlation coefficient: Strength or direction of relationship
Random allocation of independent variable	All independent variable of interest are controlled and able to be randomly allocated (undifferentiated groups of people)	At least one variable of interest cannot be randomly allocated (i.e. **study of pre-existing groups)**	None
Characteristics	• Strong casual inference made (random allocation makes all variation between the groups cancel out) • Only variation not canceled out - systematic difference between level of independent variable	• Pre existing groups weakens any casual inference • THUS if you find difference in DV between people belonging to one pre-existing group over another, you cannot say with certainty what caused that difference • **Matching** - trying to equate pre-existing groups with a control group (systematic difference caused by that variable can be ruled out)	See above

***How to determine between each of the above: How many variables were randomly allocated*

e) Other terminology

- **Independent variable (IV) - stimulus variable**
  - ***Presumed cause*** *in research*
  - ***Manipulated*** *by experimenter (*i.e. control over a variable - participants being randomly allocated)
- **Dependent variable (DV) - response variable**

- ***Measured*** by the experimenter to see if independent variable has any effect (i.e. behaviour of interest)

f) Use the concepts of 'random allocation' and 'random selection' to distinguish between different kinds of research design and understand 'external validity' and 'internal validity'

- **Random allocation**
  - occurs when participants in a study arrive at the study **not belonging to any level of the independent variable** and can be given/administered or placed into a level/ condition of the independent variable by a random process.
  - ***Complete control over the independent variable*** to be randomly allocated is necessary
  - ***Hard to random allocated*** - treatment, lifestyles, education, experience, diet
  - ***Impossible to randomly allocate*** - sex, brain damage, psychological disorder, sexuality, family, location, religion, race, income
  - ***Hard to allocate (i.e. already have pre-existing differences/already belonging to a group) = it is a quasi-experiment*
- **Random selection: COMPLETELY IRRELEVANT**
- **External validity**
  - **The extent to which findings can be generalised to the population at large**
  - **Depend on**
    - Sample size
    - How the sample was chosen (Random sampling, self-select, biased?)
    - Where and how the experiment was conducted (artificial testing location, how real did the participants think it was)
    - Variation of effects being studied (effects varies very little from person to person, a large sample might not be needed, if effect varies greatly across cultural group - they need to be represented in the sample)
- **Internal Validity**
  - The extent to which changes in the DV can be attributed to changes in the IV (maybe effected by compounding variables)
  - If strong causal inference made - internal validity is high and vise vers
  - True experiments - high
  - Correlation studies - low

g) Understand the importance of 'blindness' and 'replication' in scientific research

- **Blindness**
  - Essential in research
  - Both researchers and participants should be blind to which condition is being administered - "double blind"
  - Participants and researchers knew conditions they were allocated to = undermine result —> participants would guess what is expected, research may not randomly allocate correctly or incorrectly record data
- **Replication** (need to be replicated)
  - Same findings found by independent party following the same method

- Readings*
- *Taylor, James. Efficacy and safety of Echinacea in treating upper respiratory tract infections in children: A randomized controlled trial.*