Quantitative research

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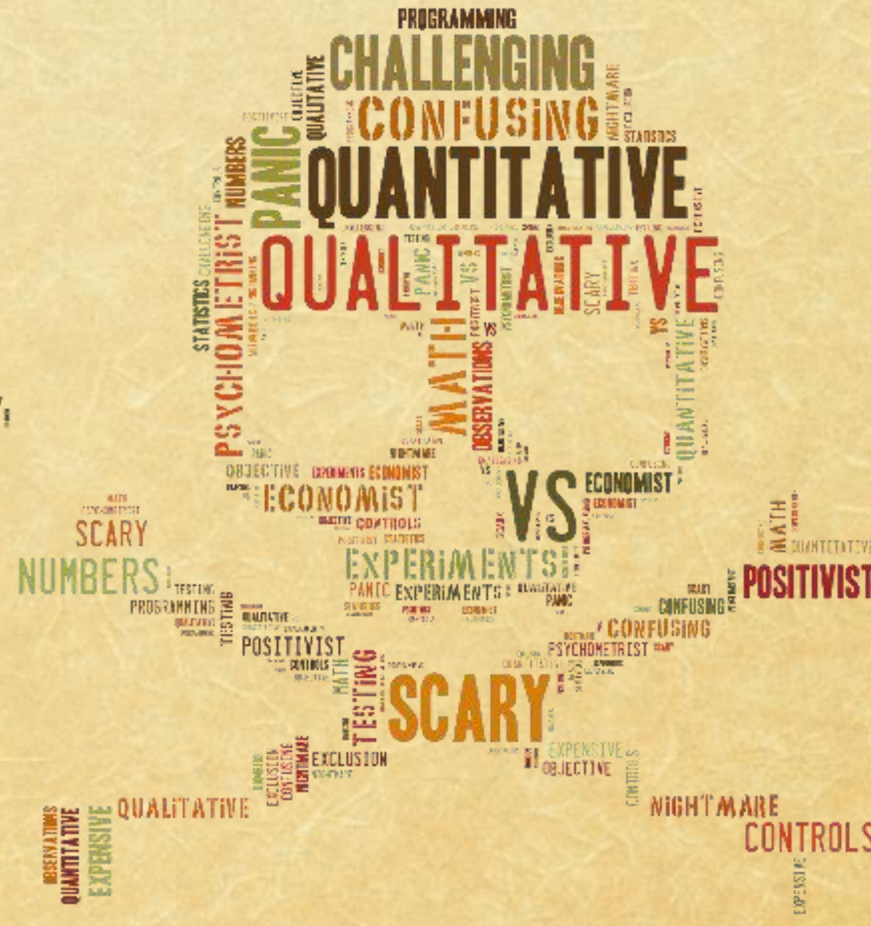
JET EDUCATION SERVICES

Introduction and word association



Contents

- Theory
- Three basic designs
- Research process
- Popular experimental techniques
- General statistics

Detours with
terminology

Theory

Set of propositions which describes the nature of relationships between predefined constructs/variables
Can be implicit or explicit

Theory building

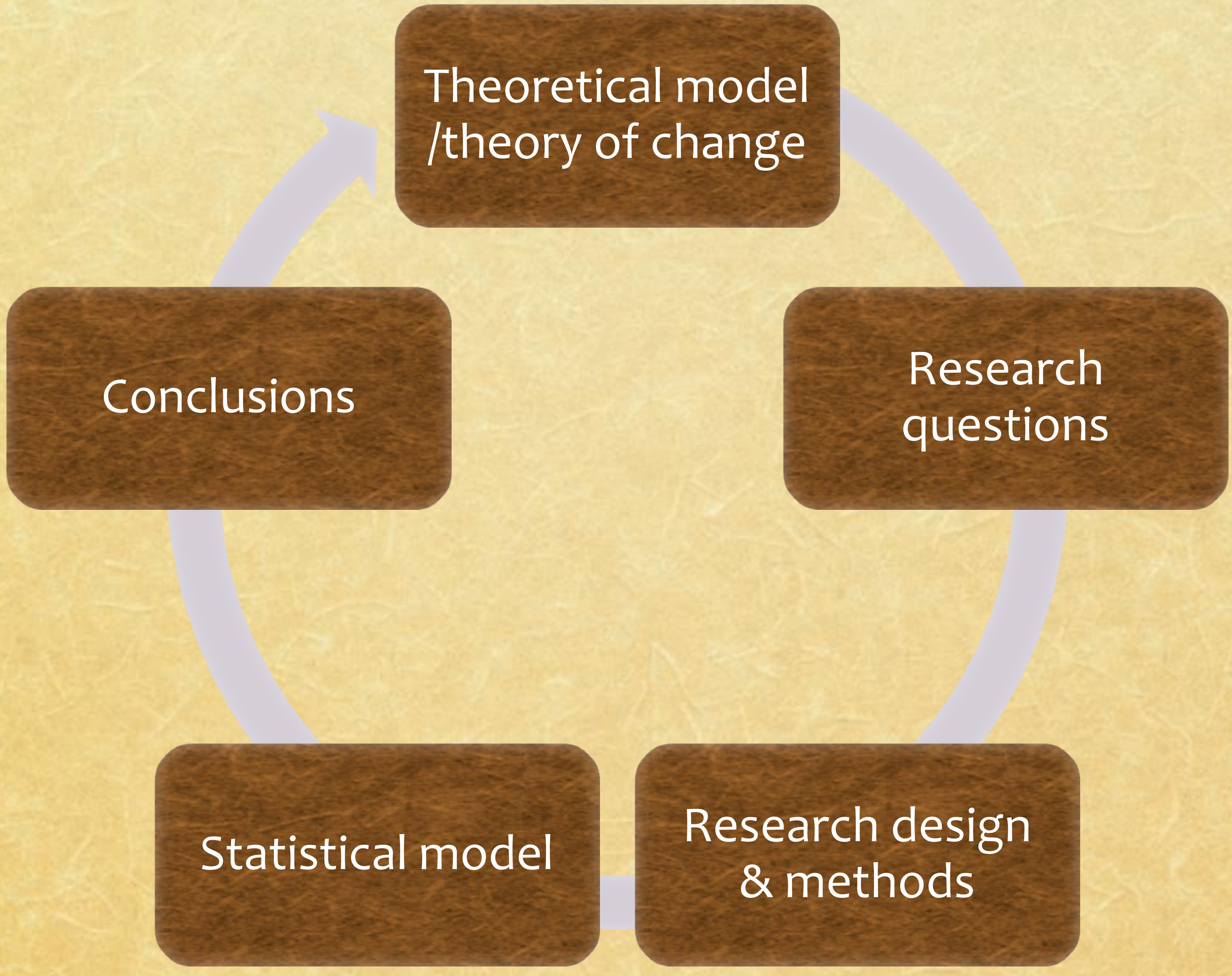
- Description
- Taxonomy/categorisation of phenomena
- Relational rules: how variation in one construct affects other constructs

Theories, models and paradigms

Theory testing

- Parsimony – no redundancies
- Explanatory power
- Flexibility
- Internal consistency
- External validity – power of prediction
- Falsification
  - Circular reasoning
  - Tautology


Related theories,
concepts, processes
Paradigm


Theoretical model /theory of change
Research questions
Research design & methods
Statistical model
Conclusions

Theory

Why is knowing the theory important?

- Different types of theory/different understandings of change are suited to different types of research methodologies, including mixed methods

- Research methodologies differ in at least four dimensions:
  - **Type of data elicited** – intrapersonal, interpersonal, societal, etc.
  - **Technique of data elicitation** – direct elicitation, indirect elicitation, amount of control
  - **Type of survey design for monitoring change**
    - Longitudinal – follows same people over time, data collected at least twice in a period
    - Cross-sectional – data collected from people under different conditions
    - Sequential – data collected from people under specific conditions, but at different times
  - **Data may be treated as quantitative or qualitative**

Detour

Population – collection of all individuals of interest in a study

Parameter – characteristic of a population

Sample – set of individuals selected from the population and intended to represent the population in the study

Statistic – characteristic of a sample

Case or unit of analysis – respondent of interest

Time of measurement – collective term for all factors that might influence the study at the time of data collection

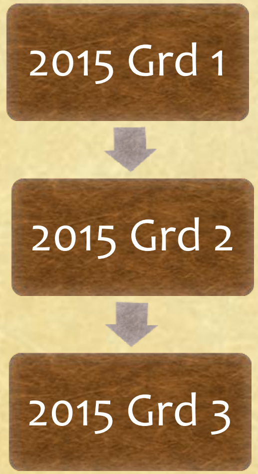
Every type of design holds some aspect constant while varying others

Longitudinal

- Constant is the sample of subjects
- Time of measurement and chronological age vary

Potential problems

- Learners may leave or join the school
- Distinguishing intervention effects from normal development and/or growth



Cross-sectional design

- Time of measurement stays constant
- Chronological age and sample vary

Potential problems

- Distinguishing between intervention effects and effects due to variations in the sample and age

Sequential design

- Chronological age stays constant
- Time of measurement and sample vary

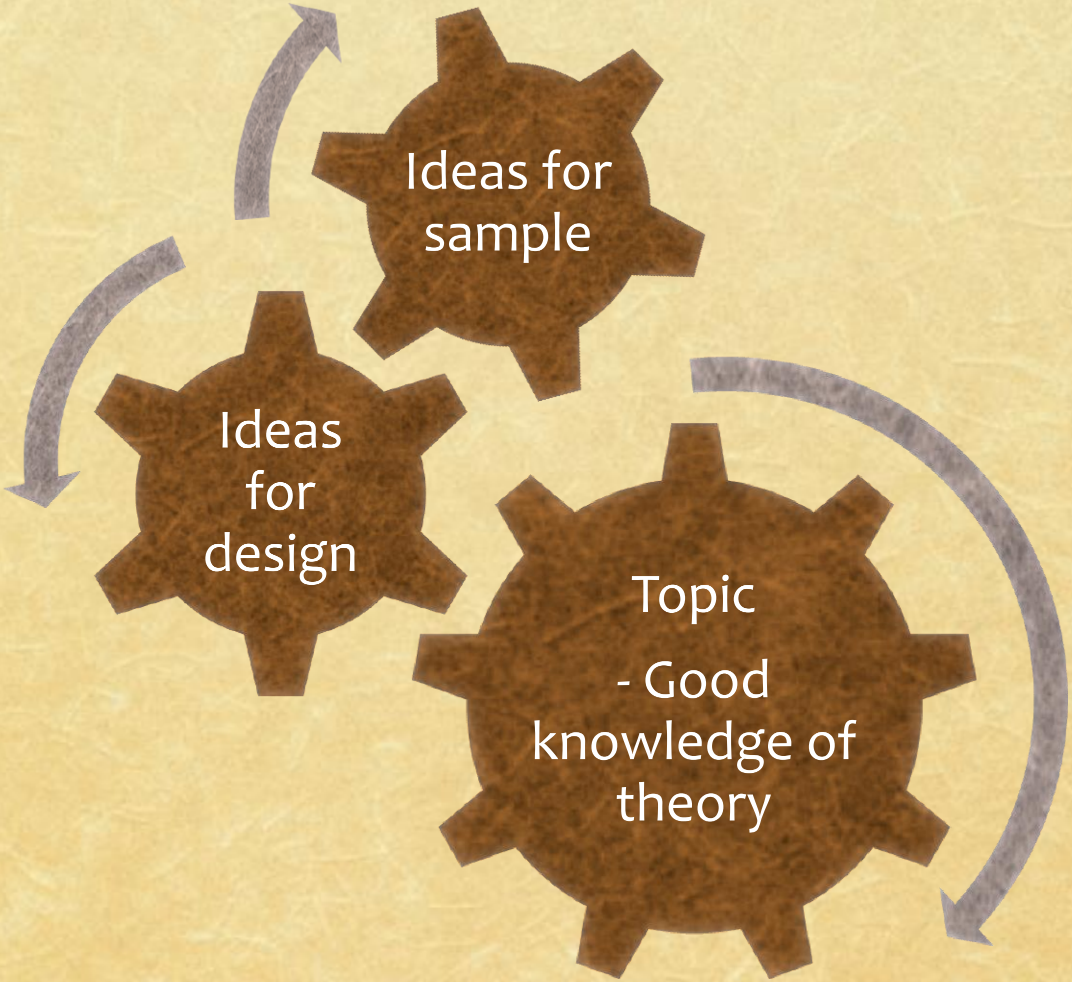
Potential problems

- Distinguishing between intervention effects and effects due to variations in the time of measurement and the sample

One design inherently better than the other?

- Every type of design holds certain aspects constant while varying others in order to determine what drives the change in outcome
- Combine designs to compensate for weaknesses in specific design

- Remember research designs and methods are only tools for testing a theory - they are not inherently good or bad
- **Your use of designs and methods is good or bad: Ethics !!!**


Ideas for sample
Ideas for design
Topic
- Good knowledge of theory

Formulating research questions

- Must be specific (target population and context)
- Must be testable
- Must be feasible
- Must be answerable

Then:

- Provide operational definitions for concepts in research questions, e.g. fluent reading is….. (find definition in literature)

Detour

Variable – any construct/characteristic or effect

Dependent variable – effect or construct under investigation

Independent variable – any variable that causes changes in the dependent variable

Hypothesis

- When inferring something about a population from sample data, you would generally translate research questions into a hypothesis
- A hypothesis is a theoretically generated prediction about how the independent variable will affect the dependent variable
- Null hypothesis (H_0) – state of no change or effect
- Alternative hypothesis (H_1) – state of change or effect
- You cannot prove a hypothesis: you can only disprove it

Examples of hypothesis

E.g. in a reading intervention

H_0: mean of intervention = mean of control

H_1: mean of intervention ≠ control (two tailed)

H_2: mean of intervention > mean of control (one tailed)

A mean is the average

Samples

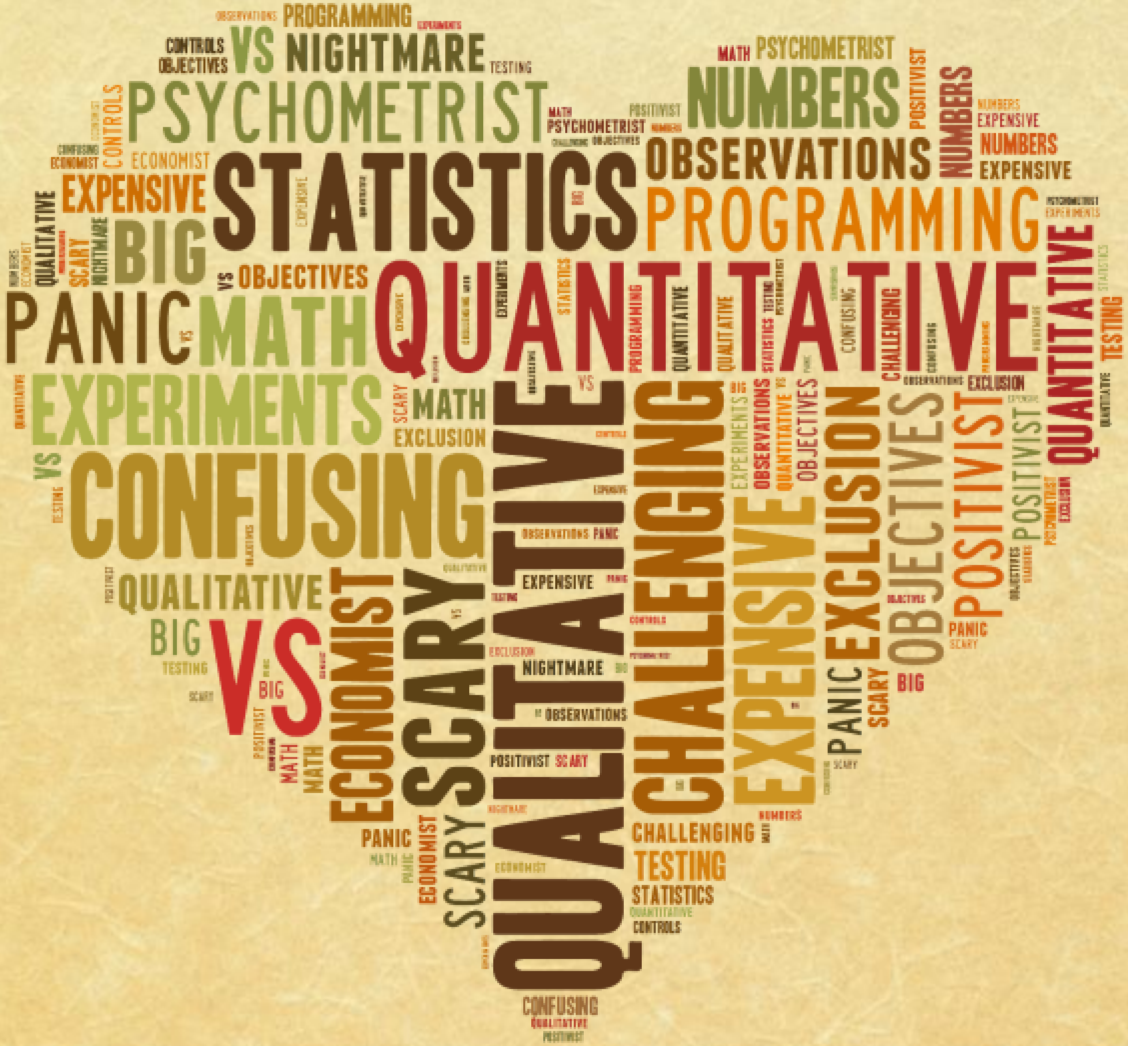
- Think about subjects required
  - Type of subject (need for parental permission?)
  - How many subjects?
  - Will subjects be paid or incentivised?
  - Ethical regulations: informed consent and assent
- Sources of bias (sample may be skewed or unfairly effect results)
  - Selection
  - Attrition – drop-out during study
  - Subject non-compliance
    - Purposeful non-compliance – recruitment of subjects?
    - Accidental non-compliance – instructions to subjects?

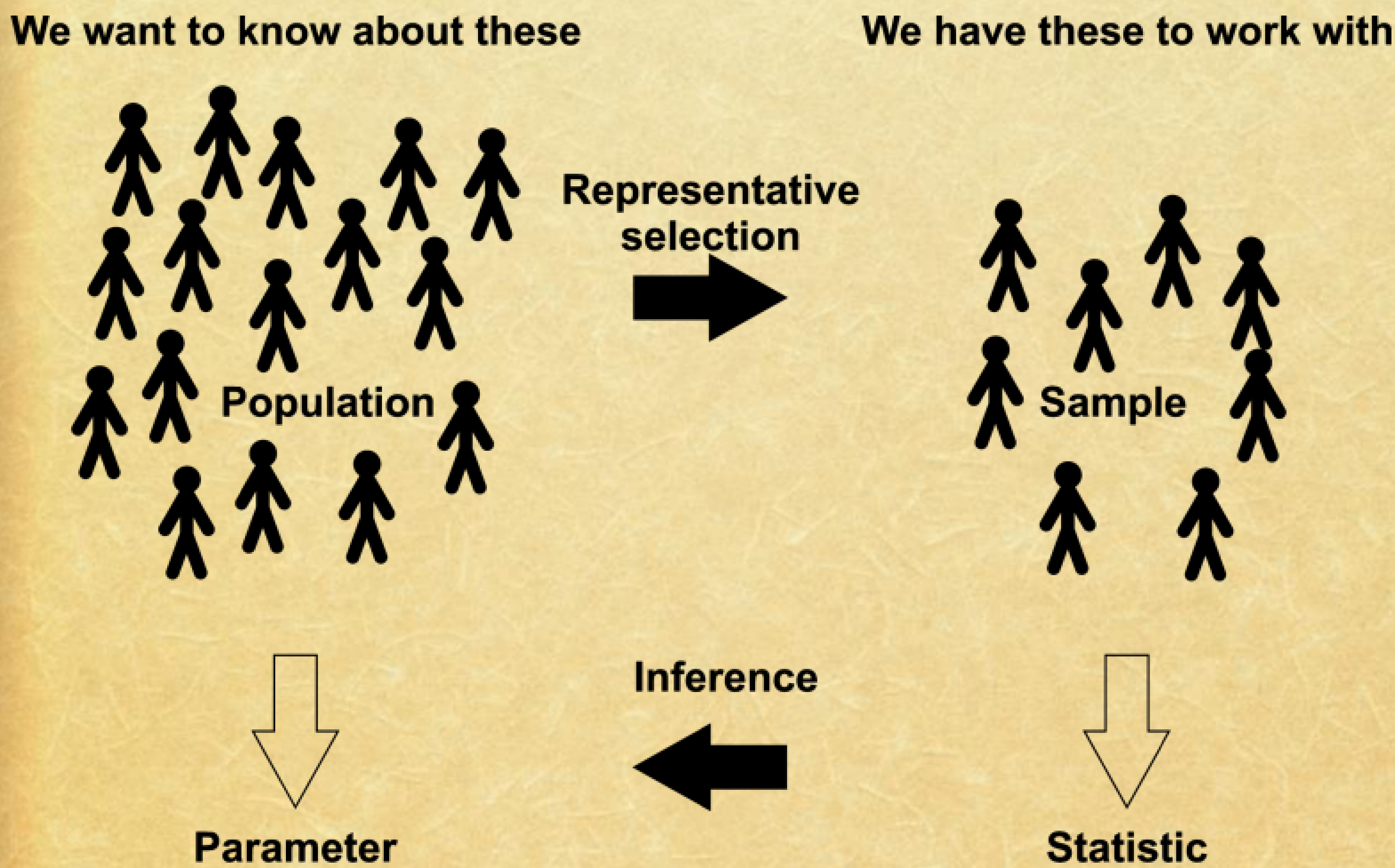
Detour

Sample – set of individuals selected from the population and intended to represent the population in the study

Measurement error – when you calculate a statistic based on sample information it is likely that your sample is not completely representative of the population. This is the difference between the true population parameter and your sample statistic: it is called measurement error.

Standard error – standard error is the standard deviation of the sampling distribution of the statistic: it is a parameter.

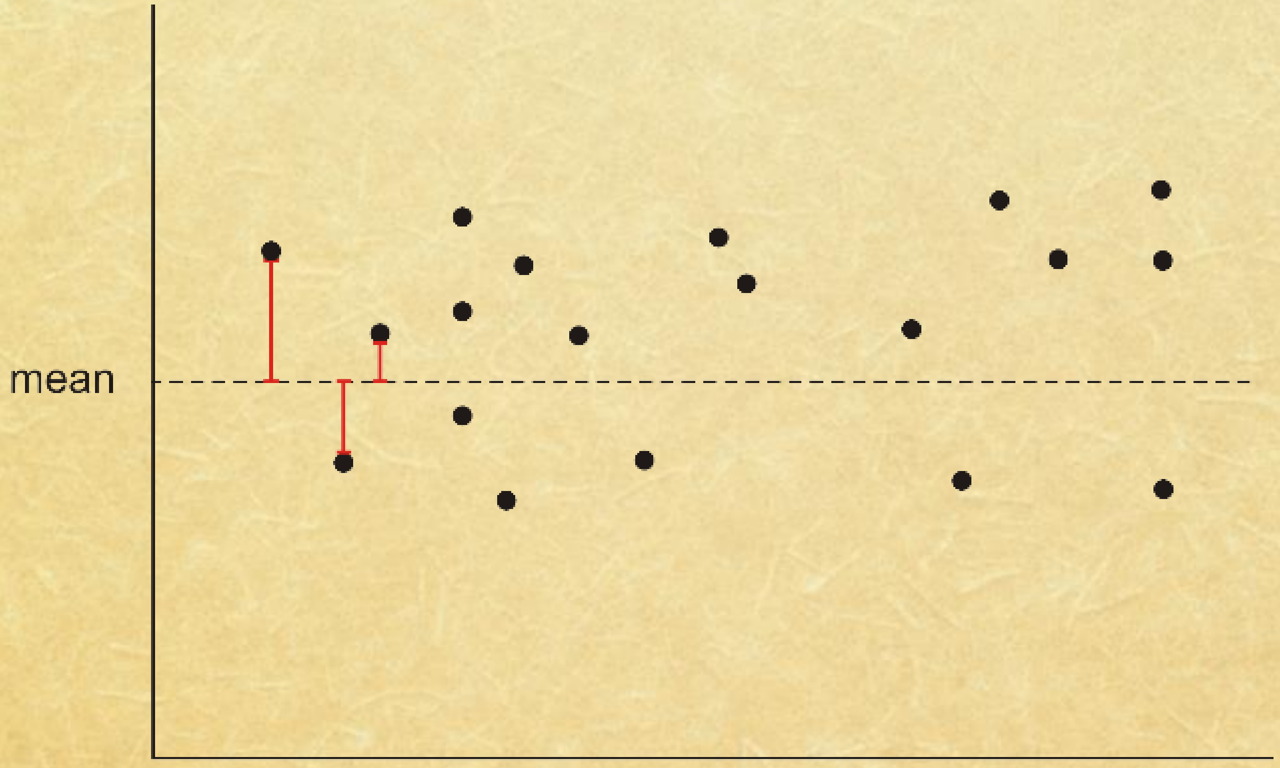

QUALITATIVE
QUANTITATIVE
STATISTICS
CONFUSING
CHALLENGING
EXPENSIVE
PROGRAMMING
PSYCHOMETRIST
EXPERIMENTS
NUMBERS
OBSERVATIONS
MATH
PANIC
SCARY
ECONOMIST
EXCLUSION
OBJECTIVES
POSITIVIST
VS
BIG
NIGHTMARE
TESTING
CONTROLS



We want to know about these
We have these to work with
Representative selection
Population
Sample
Inference
Parameter
Statistic

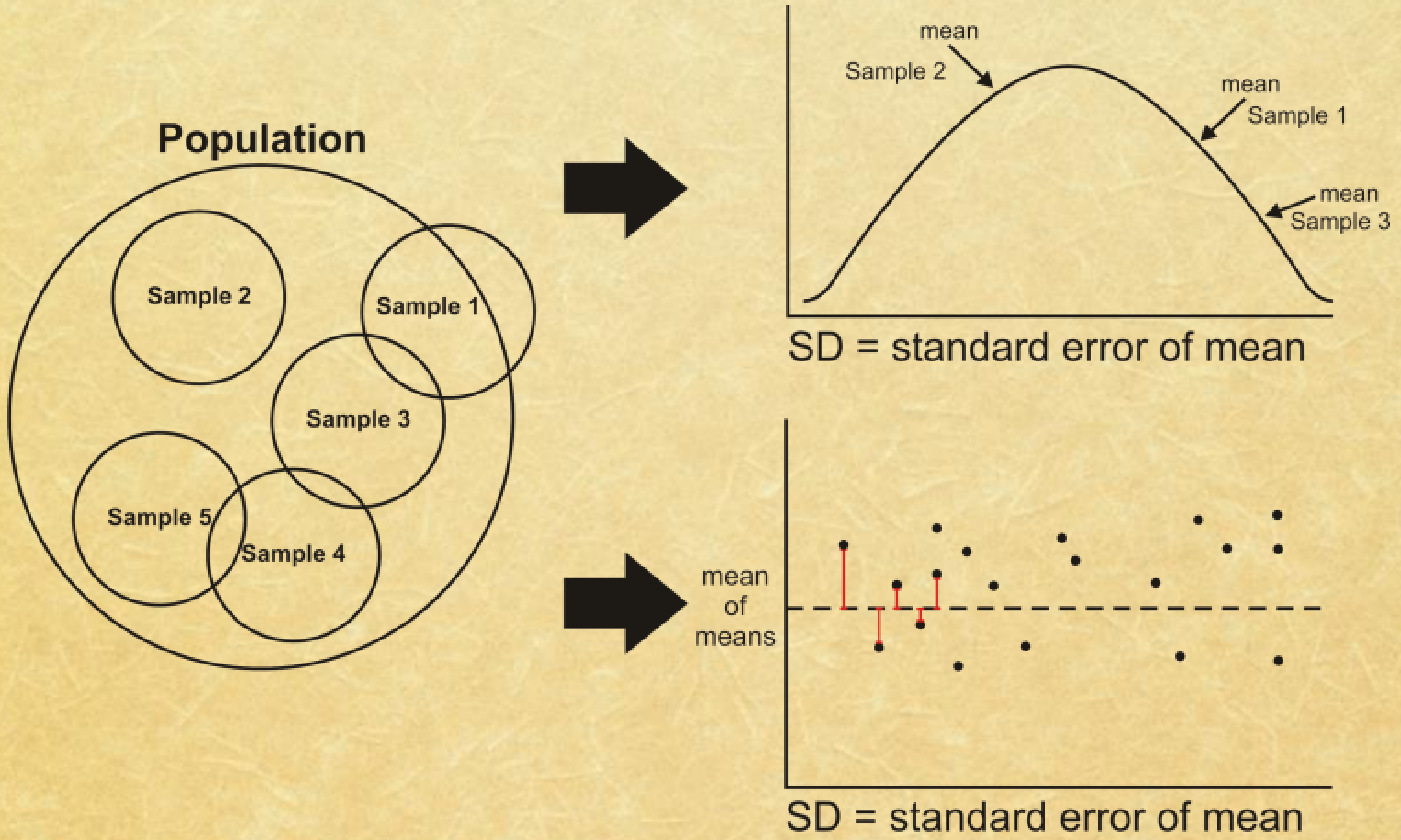
Standard error

- If you draw many random samples from the same population you will get slightly different means for each sample
- If you plot all these means on a graph then the standard deviation of the distribution of means will be the standard error of the mean
- This helps you to determine how confident you can be in estimating the population mean from any one sample mean



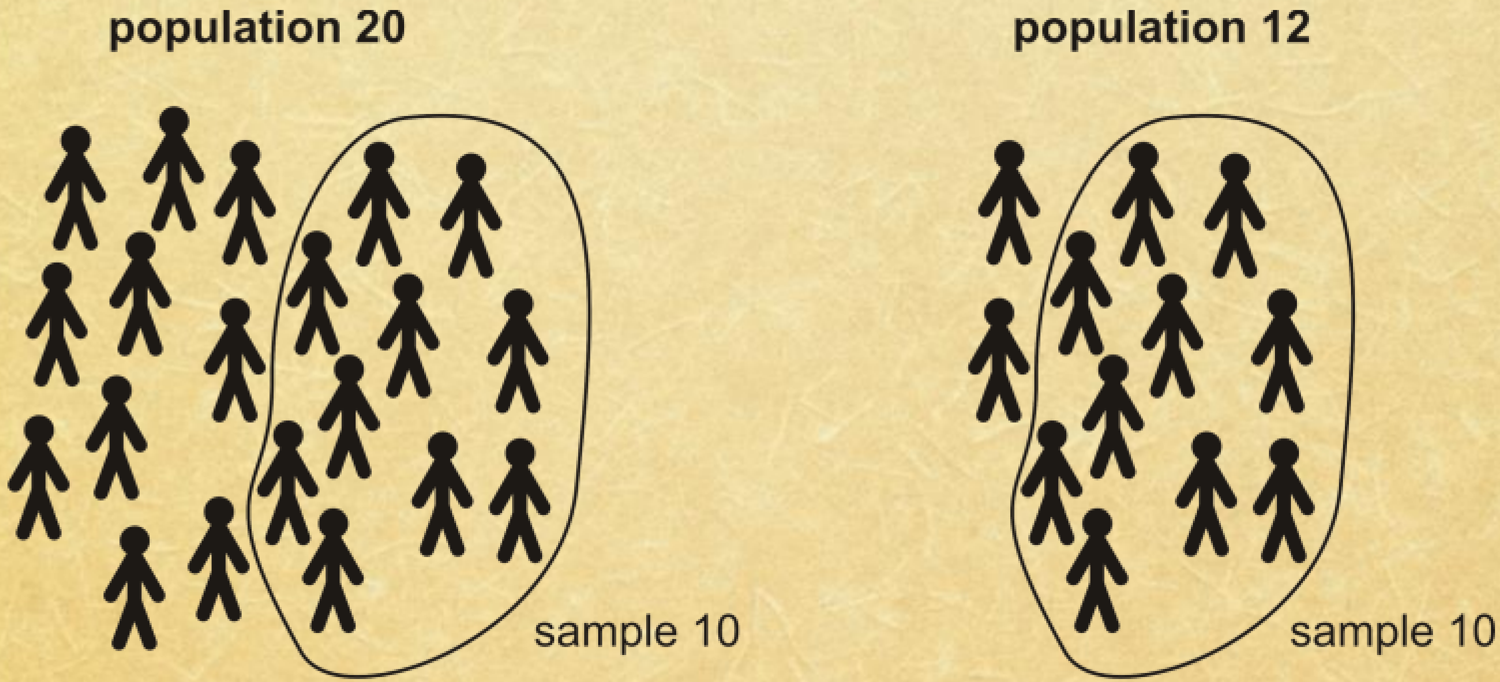
$$\text{variance } (s^2) = \frac{\Sigma(x-\bar{x})^2}{n-1}$$

$$SD = \sqrt{s^2}$$



Population
Sample 2
Sample 1
Sample 3
Sample 5
Sample 4
mean
Sample 2
mean
Sample 1
mean
Sample 3
SD = standard error of mean
mean
of
means
SD = standard error of mean

Is bigger better?



Is bigger better?

- If the sample is correctly drawn, bigger relative to population size is better

$$SE_m = \frac{\text{Estimated SD}}{\sqrt{n}}$$

$$\text{e.g.} = \frac{10}{\sqrt{25}} = 2 \qquad \text{but} = \frac{10}{\sqrt{100}} = 1$$

- The bigger the sample gets, the smaller the standard error becomes

Sample size

$n = (z*s/E)^2$

Where n is the sample size,
z is the standard value for the level of confidence chosen in SD units (95% is 1.96)

s is the estimated standard deviation in units of measurement (find in articles on similar studies with similar populations)

E is the allowable error in units of measurement

Sampling strategies

Simple random sample (probability sample)

- Everyone in population has the same probability of being included in the sample
  - Lottery
  - Random number generator (demonstration)
  - Manually using a sampling interval and seed number
- Advantage: uses all conventional statistical techniques
- Disadvantages: can be cumbersome in big populations and may miss the characteristic you are researching

Sampling strategies 2

Stratified random sample

- Divides population into strata or subpopulations
- Everyone in a specific stratum has the same probability of being included in the sample
- Must know what proportion each stratum represents in the population
- Advantage: Likelihood of including all key groups in sample is high: statistical advantage of random sampling
- Disadvantage: can be cumbersome to get information about strata and a population list for each one

Sampling strategies 3

Quota sampling

- Specifies the type of subjects to include and their quotas in the population
- Once quotas are specified, you approach subjects that meet the criteria for inclusion
- Advantages: Likelihood of including all key groups in sample is high; no population list is needed, only information about the subpopulation's proportion in the population
- Disadvantages: Selection bias; filling quotas can be difficult; must test for representativeness before using certain statistical procedures

Sampling strategies 4

Theoretical sampling

- Specifies the type of subjects that will provide best insights
- Select those subjects (example?)
- Advantages: Likelihood of getting information from subjects is high; this minimises costs
- Disadvantage: Selected subjects might not give a balanced view

Data collection strategies

- Questionnaires
- Rating scales
- Testing/assessment
- Interviews (structured or unstructured)
- Observations
- Focus groups

Common mistakes in data collection

- Collecting too much information
- Collecting too little information
- Lack of evidence that data collection method and instruments are valid and reliable
- Problems with instruments:
  - Double-barreled questions
  - Including your assumption in the question
  - Using jargon
  - Leading questions
  - Double negatives

Examples

I assume you know that Wernicke's area is involved in understanding language?

Do you think that the wonderful science of the brain should be included in teacher training?

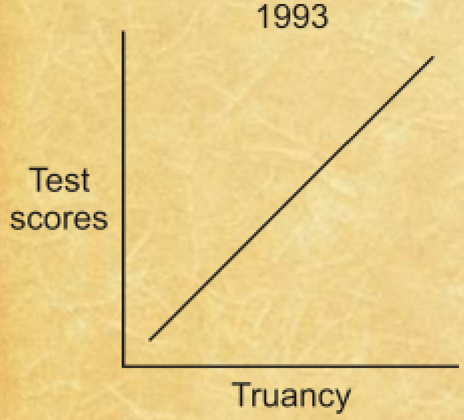
Do you think that subject knowledge and teaching strategies should be included in ITE?

Don't you think that not too many people know the difference between PCK and CK?

Correlations and causality

- Correlation means …

- Correlation does not imply causality, e.g.



Experimental techniques

- Test causality using the difference test
- Two groups are treated in the same way except in one respect: thus only the independent variable varies between the two groups
- Any differences in achievement of the two groups are attributed to the different treatment
- **Danger:** Confounding – other unintended variables may influence the dependent variable, e.g. the case of other interventions by other service providers in schools

Popular experimental techniques

Between-subject designs:

- Subjects assigned to two groups – intervention and control
- Danger: Selection effects
- Solutions:
  - Randomisation – distributes differences randomly between groups; rule of large numbers = higher likelihood distributions will be equal
  - Matching – increases sensitivity, but may be difficult to achieve

Popular experimental techniques

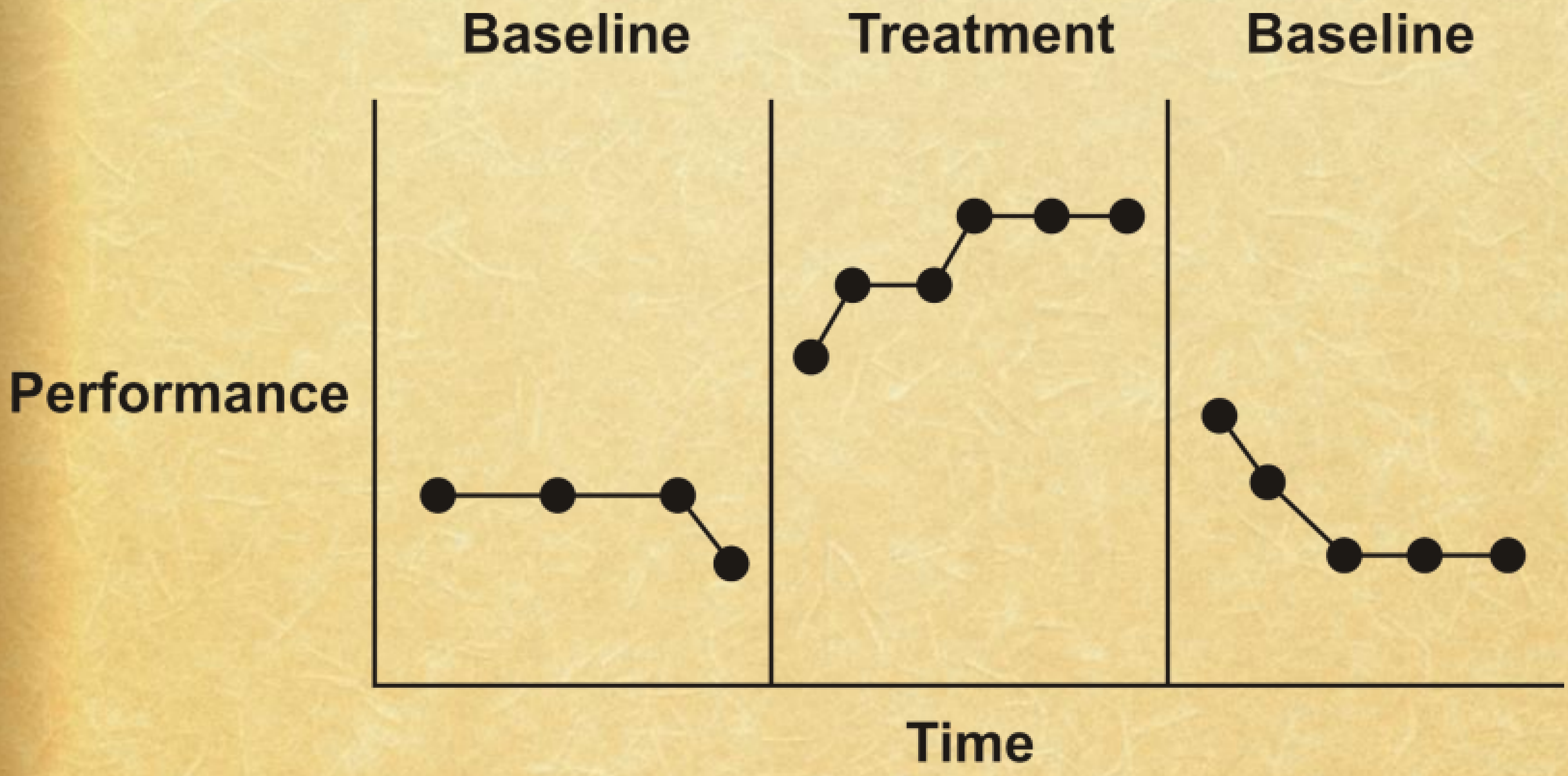
Within-subject designs:

- Subjects act as own control
- Danger:
  - Carry-over effects: gaining task related skills that spill-over into next treatment or subject reinterprets the meaning of the investigator’s intentions, e.g. Piaget/teddy and number conservation
  - Order effects e.g. teddy condition first, higher probability of correct response in adult condition
- Solutions:
  - Counter-balancing – distributes order of treatments randomly among subjects (more than two treatments becomes unwieldy)
  - Latin square design (demonstration)

Problems with group experimental designs

- Sample sizes needed
- Finding the subjects for controls
- Maintaining an uncontaminated control group
- Obscuring individual outcomes in group means
- Generalisation from group experiments to individual cases
- Ethical issues

Single case experiment



Sod's law

- No coherence in research process, e.g. data collected does not answer research question
  - Back-mapping to research questions and theory
- Problems with data collection instruments/process
  - 3Ps: Planning, piloting, peers
- Data is messy or missing
  - 3Cs: Control, check, check again
  - Meta-data files or research journal
- Expected change not found (no change, too small, too big or wrong direction) or different results with different methods (in mixed-method design)
  - Back-mapping to research questions and theory – was your expectation reasonable?
  - Check sample size, instruments and data collection
  - Check error and confidence levels
  - Check if it might be due to method/s used
  - Collect more data or increase time period using same method/s
  - Collect more data using other method/s

Detour

Statistic – characteristic of a sample

Raw score – original data as collected, before any manipulation

Sample size (n) – number of respondents in sample

Central tendency – a single score that best describe the scores in a dataset

Dispersion – variability of scores

Some basic statistics

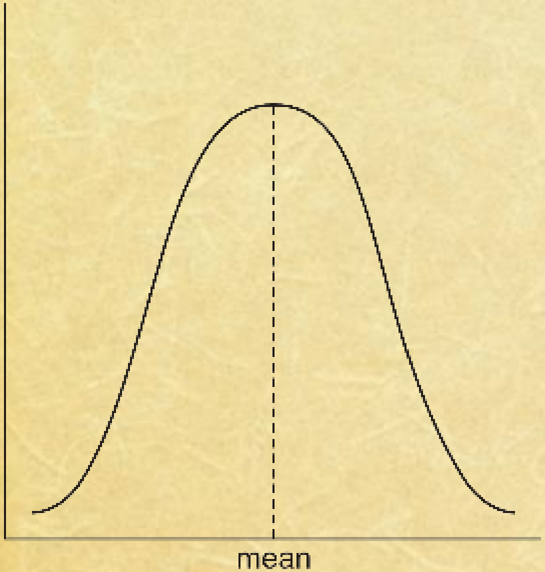
- Levels of measurement
  - **Nominal** – categorical measurements: should be mutually exclusive and exhaustive
  - **Ordinal** – rank order, distance between values unknown
  - **Interval** – rank ordered, distance between values equal
  - **Ratio** – rank ordered, distance between values equal and with a true zero point
- Level of measurement influences which statistics are appropriate
  - **Nominal –** frequencies and percentages, pie or bar graph
  - **Ordinal –** mode or median, minimum or maximum, range, pie or bar graph
  - **Interval and ratio –** mean, mode or median, minimum or maximum, range, standard deviation, histogram, box plot, stem and leaf

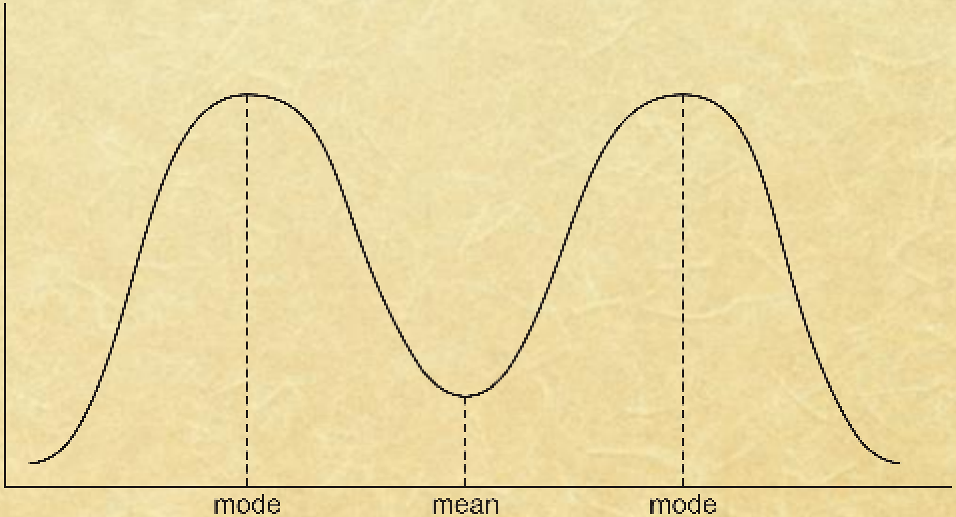
Types of statistics

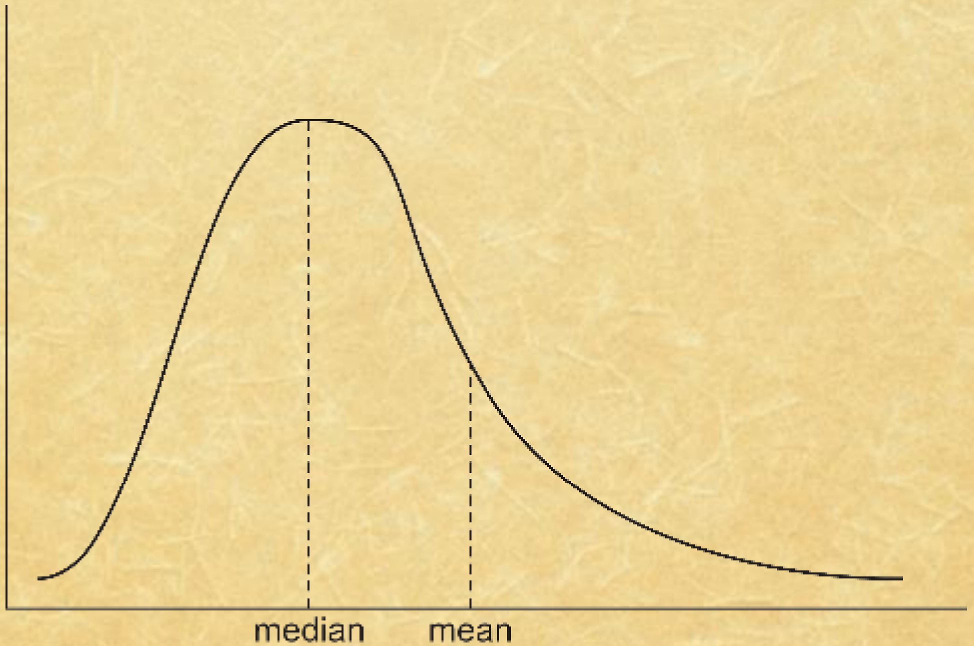
- **Descriptive** – describes the sample
- **Inferential** – infers something about the population
- **Statistical procedures:**
  - Parametric – assumes a normal distribution: more robust, many procedures, needs interval level data (some argue for ordinal level data… you decide based on how serious making the wrong conclusion might be)
  - Non-parametric – does not assume a normal distribution: less robust, fewer procedures, can be used with ordinal level data

Central tendency

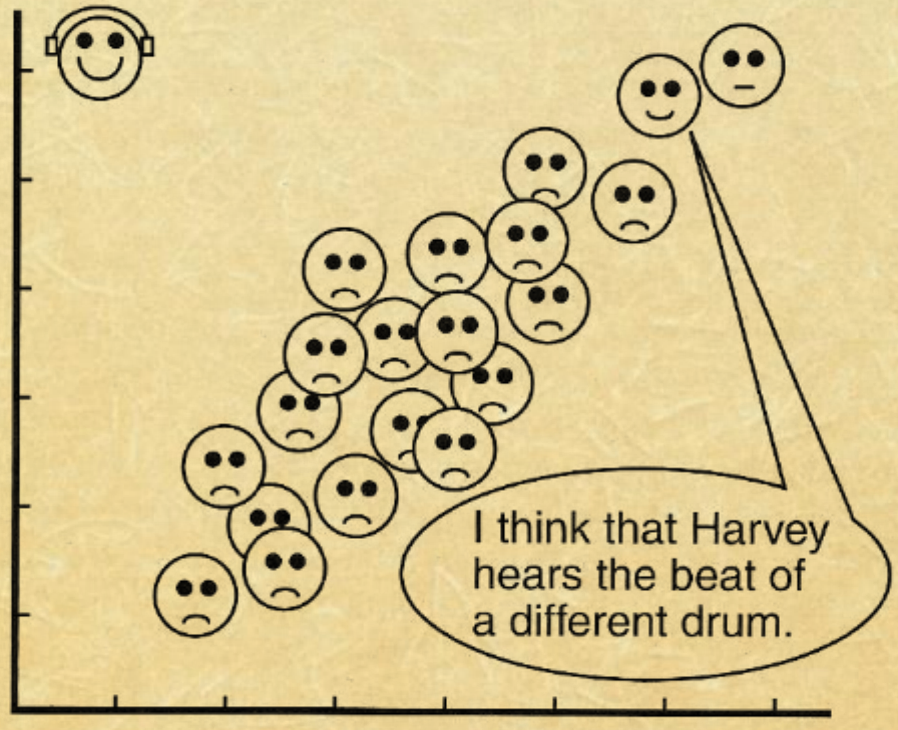
- **Mode** – value appearing most frequently in set of scores
  - Unimodal
  - Bimodal – two scores that occur with the same frequency
- **Median (md)** – middle point if scores are arranged in order of magnitude
  - 50% of scores below the median
  - If distribution is skewed, then the median is a better measure of central tendency than the mean
  - If distribution is small , then the median is a better measure of central tendency than the mean
- **Mean** – average
  - Sensitive to outliers, especially in small samples


mean


mode
mean
mode


median
mean

Outliers



Scatterplot: n = 21; r = +0.63

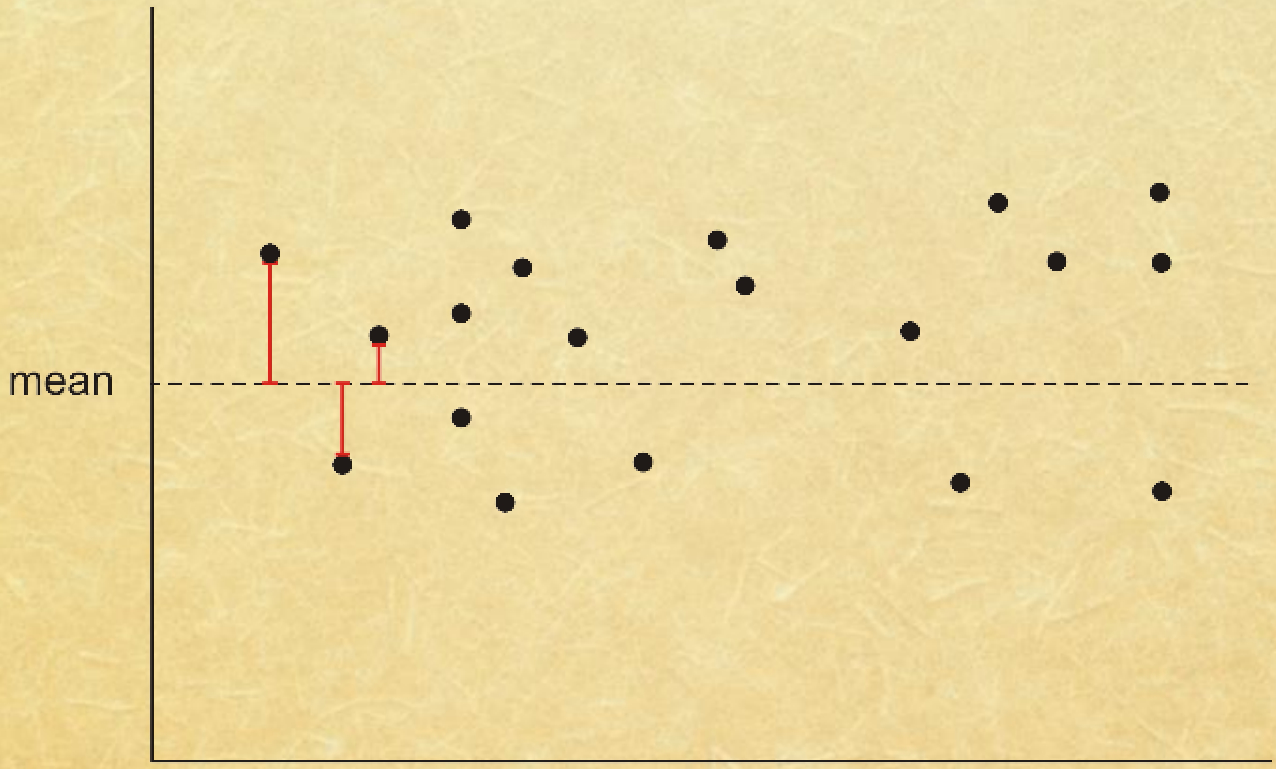
The Outlier

"I could have done better, but I didn't want to depart too far from the accepted norm.

Courtesy of Germaine Vanselow, Cartoonist: Bill Vanselow.

Dispersion

- **Minimum** – smallest value in the set
- **Maximum** – largest value in the set
- **Range** – difference between the smallest and largest value
- **Variance** – amount of spread around the mean, expressed in unit of measurement squared (sum of diff between value and mean for each case, divided by n -1)
- **Standard deviation (SD)** – square root of variance, expressed in unit of measurement
  - Generally we want a mean to be at least twice as big as the SD



$$\text{variance } (s^2) = \frac{\Sigma (x-\bar{x})^2}{n - 1}$$

$$SD = \sqrt{s^2}$$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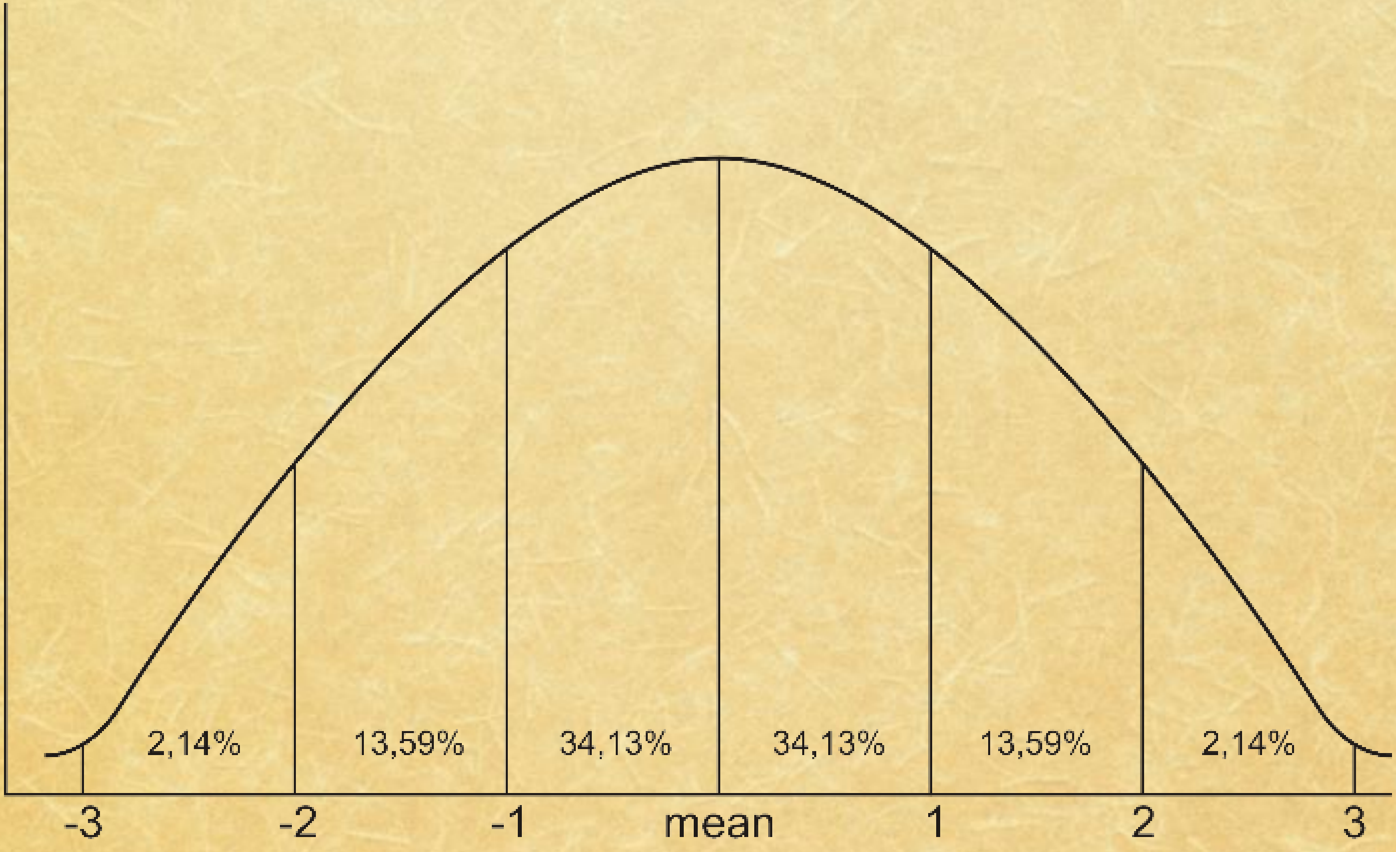
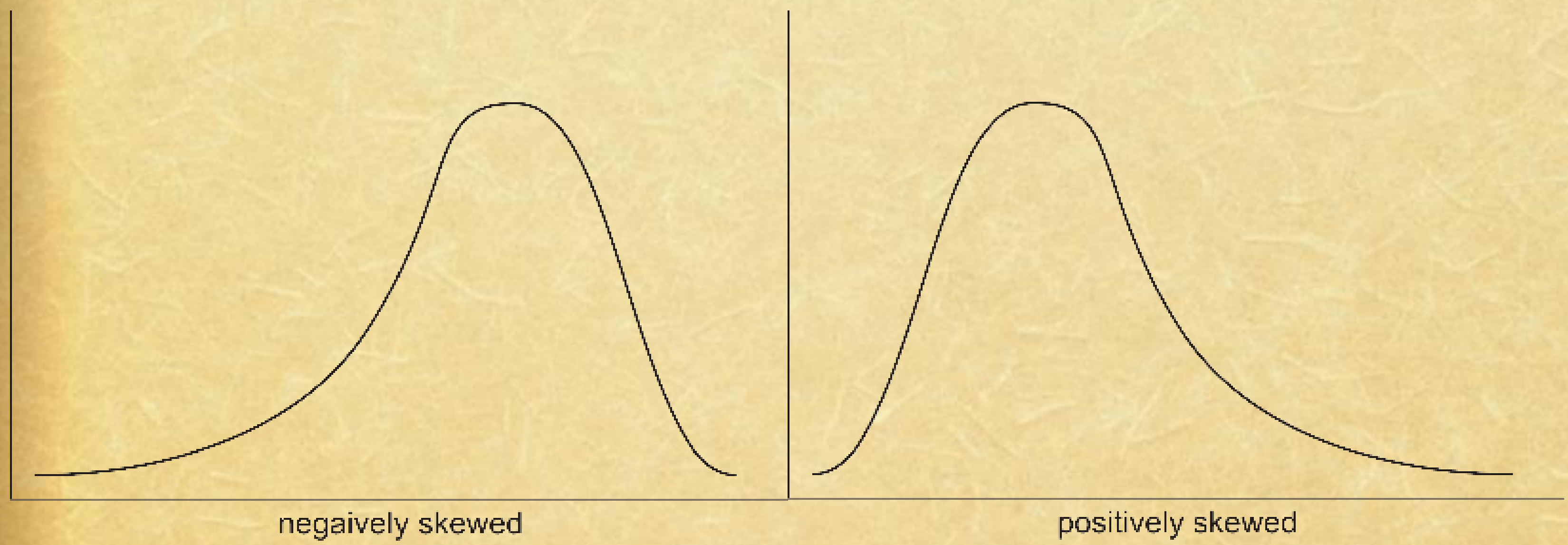
Normal distribution

- Gaussian distribution – Carl Gauss, 1809



Skewed distributions



- Refers to the tail of the distribution
- If data refers to achievement on a test,
  - negatively skewed means the test was too easy
  - positively skewed means the test was too difficult

Practical tips and demonstrations

- Data collection
  - Always record as much data as possible… rather too much than too little
  - Always go for random sampling if at all possible
- Data management and filing
  - Label all (electronic and hard copy) files with date and sample information
  - Count and count again at every step
- Data capturing in Excel
  - Headings (always start with letter)
  - List of codes and meanings
  - Use data validation function
  - Label missing values and data collection errors
- Data cleaning using filters in Excel
  - Check counts
  - Check for invalid codes
  - Check for blank blocks
  - Check min and max values for each variable
- Meta-files