HUMBEHV 3ST3

Basic Concepts & Graphical Displays
Week 1

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Overview

- Part 1 - Introduction: What is Statistics?
- Part 2 - Basic Concepts: Variables & measurement scales
- Part 3 - Graphical displays & shapes of distributions

Part 2 Basic Concepts

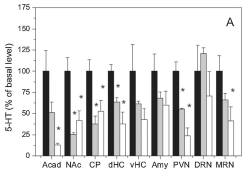
Independent Variables

- Most Psychology studies collect data in <u>designed experiments</u>
- Experiments usually involve collection of data in various experimental conditions
  - conditions differ in terms of 1 or more <u>independent variables</u>
  - ideally, participants are <u>randomly assigned</u> to experimental conditions
- Independent variables are manipulated by experimenter
  - e.g., conditions in memory experiment defined by:
    - type of items (faces vs words) being studied
    - time interval between study & test phases

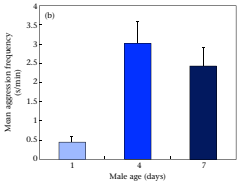
Dependent Variable

- Dependent variables are the things that are measured and constitute the data, or results, that will be analyzed.
- Designed experiments measure the effects of independent variables (X) on dependent variables (Y)
  - evaluates causal links between X & Y
  - what does it mean to say that X causes Y?
  - statistical idea of causality: when we intervene and change X, then the probability of Y occurring also is changed
    - e.g., smoking "causes" lung cancer even though not all smokers get cancer (and not all people with lung cancer are smokers)

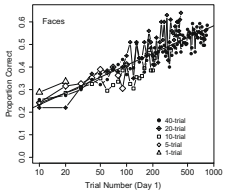
Examples of dependent variables



Serotonin levels in cortical tissue. Figure 5 in Andrews et al, 2015, Neurosci & Biobehav Rev



Aggression frequency in male fruit flies. Baxter & Dukas, 2017, Animal Behaviour



Accuracy in a face identification task. Hussain et al, 2009, Vis Research.

Examples of dependent variables include reaction time, response accuracy, number of items recalled in memory test, event-related brain potentials, heart rate, number of offspring, number of aggressive or affiliative behaviours, etc.

Hypothetical Recognition Memory Experiment

2 independent variables

2 levels on each independent variable

		Retention Interval	
		short (1 minute)	long (1 hour)
Study Items	faces	# of items correctly recognized during test	# of items correctly recognized during test
	words	# of items correctly recognized during test	# of items correctly recognized during test

2 (items) x 2 (interval) factorial design

1 dependent variable measured in 4 experimental conditions defined by combinations of independent variables

Correlational Studies

- Correlational studies measure the association between variables
- Usually, the variables are not manipulated by investigator
  - each event/subject comes with own set of variables
  - but values on variables differ across events/subjects
- Regression measures association between predictor & criterion variables
  - e.g., measure the association between annual income (criterion variable) and parent's income, years of education, race, gender (predictor variables)
- Correlation is not causation

Random Assignment

- In Psychology, designed experiments use subjects that also come with their own set of intrinsic characteristics
- These characteristics (personality, motivation, intelligence, etc.) probably affect dependent variable
- HOWEVER, whenever possible, subjects in most experiments are **randomly assigned** to experimental conditions
- So, effects of subject differences should be UNRELATED TO EFFECTS OF INDEPENDENT VARIABLES
  - big advantage of designed experiments over correlational studies

Between-Subjects Experimental Design

2 independent variables →

2 levels on each independent variable ↓

		Retention Interval	
		short (1 minute)	long (1 hour)
Study Items	faces	n = 12 Ss	n = 12 Ss
	words	n = 12 Ss	n = 12 Ss

Random assignment reduces chance that observed differences among conditions are due to differences among subjects.

48 subjects **randomly assigned** to 1 of 4 conditions (12 Ss per condition)

Within-Subjects Experimental Design

2 independent variables →

2 levels on each independent variable ↓

		Retention Interval	
		short (1 minute)	long (1 hour)
Study Items	faces	n = 12 Ss	n = 12 Ss
	words	n = 12 Ss	n = 12 Ss

Subject characteristics are the same in each condition (because each subject is tested in every condition)

12 subjects: each subject is tested in all 4 conditions

Categorical vs. Numerical Variables

- **Categorical variables** typically have a few discrete levels:
  - sex (male or female); marital status (single, married, divorced); brain area (e.g., V1, V2, V5); profession; age (e.g., young, middle-age, elderly)
  - often, though not always, they lack numeric properties
- **Numerical variables** typically have many levels (e.g., reaction time, body weight, income, age (years)) though not always (e.g., number of offspring).
  - have obvious numeric properties: the levels are ordered, differences between levels are meaningful, etc.
- In truth, "categorical" and "numerical" are at ends of a continuum
  - some variables possess both categorical & numerical properties
  - e.g., age, handedness

Between-Subjects Experimental Design

Note that 'Retention Interval' could be categorical or numeric independent variable

		Retention Interval	
		short (1 minute)	long (1 hour)
Study Items	faces	recognition memory accuracy	recognition memory accuracy
	words	recognition memory accuracy	recognition memory accuracy

categorical independent variable

# of items correctly recognized is a numeric dependent variable

Measurement Scales

- nominal, ordinal, interval, & ratio
- type of scale determines the kinds of mathematical operations (addition, subtraction, multiplication, division) and statistical methods that can be applied to the data to yield results that make sense
- important to distinguish between
  - i) measurements of stimuli, subjects, & behaviour;
  - ii) psychological phenomena that underlie the measured quantities
    - e.g., the difference between sound intensity & loudness
    - e.g., the difference between light wavelength & colour

Nominal Scale

- Nominal (Categorical) Scale examples:
  - eye colour: blue, brown, green, etc.
  - gender: male, female
  - political party affiliation: Liberal, Conservative, NDP, None
- Levels of nominal variable have no obvious numeric properties

Ordinal Scale

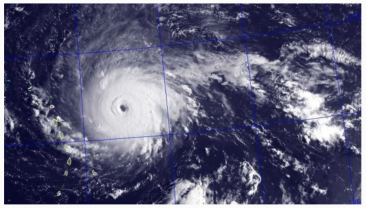
- Ordinal Scale examples:
  - age: child, adolescent, young-adult, middle-age, elderly
  - musical expertise: none, novice, amateurs, experts
  - Likert scales… Rate your response to "X":
    - 1) strongly agree; 2) agree; 3) neutral; 4) disagree; 5) strongly disagree
- <u>Order</u> of levels is meaningful
- Differences between levels may not be meaningful

Saffir-Simpson Hurricane Scale (SSHS)

example of ordinal scale

Why even a record-breaking hurricane can't hit Category 6

'Once you say catastrophic and there's near complete damage, why do you need a 6?'



- **Category 1 (119-153 km/h)**: Very dangerous winds will produce some damage: Well-constructed frame homes could have damage to roof, shingles, vinyl siding and gutters. Large branches of trees will snap and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.
- **Category 2 (154-177 km/h)**: Extremely dangerous winds will cause extensive damage: Well-constructed frame homes could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.
- **Category 3 (178-208 km/h)**: Devastating damage will occur: Well-built frame homes may incur major damage or loss of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.
- **Category 4 (209-251 km/h):** Catastrophic damage will occur: Well-built frame homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
- **Category 5 (252 km/h or higher)**: Catastrophic damage will occur: A high percentage of frame homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

Interval Scales

- Numeric variables usually with many levels
- but, interval scales lack a true, meaningful zero:
  - e.g., time of day [zero point is arbitrary]
  - e.g., IQ [zero doesn't imply zero intelligence]
- consequently, <u>differences</u> between levels are meaningful:
  - difference btw IQs 100 & 105 is same as 115 & 120
- but <u>ratios</u> are not particularly meaningful:
  - temperature: 10/5 deg C not equal to 40/20 deg C
- Scores on most standardized psychological tests use interval scales

Ratio Scales

- Numeric variables:
  - reaction time (RT), proportion correct, body weight
- ratio scales have a true, non-arbitrary ZERO on the scale
- differences & ratios between levels are meaningful
- addition, subtraction, multiplication, & division are valid mathematical operations

Physical vs. Psychological Measurement

- dependent variables often are indirect measures of psychological constructs
  - e.g., <u>ratings</u> of happiness vs. true, internal happiness
- typically, we treat dependent measure as interval or ratio variable <u>without assuming</u> that psychological variable exists on interval or ratio scale
- **<u>but then our conclusions are about the measure, not the underlying psychological variable</u>**
  - we <u>operationally define</u> the psychological variable as our measure
  - a person's "happiness" **<u>is</u>** her self-reported rating of happiness
- sometimes this limitation is OK, sometimes it is a problem
  - e.g., should we equate IQ with "intelligence"?

Part 2 Summary

- Variable types
  - independent vs dependent
  - predictor vs criterion
- Data types: continuous vs discrete
- Random Sampling & Random Assignment
- Measurement Scales: nominal, ordinal, interval, ratio
  - type of scale determines mathematical/statistical operations that make sense
  - physical vs psychological measures
    - e.g., sound intensity vs loudness