

ETC5512: Wild Caught Data

Introduction to data collection methods

Lecturer: *Emi Tanaka*

Department of Econometrics and Business Statistics

✉ ETC5512.Clayton-x@monash.edu

CALENDAR
Week 1



Starts with a question

What questions do you have ... ?

- ... about a virus?
- ... forecasting the weather?
- ... about the stock prices?

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OPEN DATA HANDBOOK

VALUE-STORIES

Hong Kong/China –
open sourcing
genomes /

The screenshot shows the "Climate Data Online" page from the Australian Government Bureau of Meteorology. At the top, there's a banner with the Australian coat of arms and the text "Australian Government Bureau of Meteorology". Below the banner, the title "Climate Data Online" is displayed. A search bar is present with the placeholder "Use the Text or Map search below to view daily and monthly statistics, rainfall, temperature and solar tables, graphs and data." Below the search bar, there's a section titled "1: Selected: Daily rainfall" with a dropdown menu set to "Rainfall". Under "Type of data", there are two sets of radio buttons: "Observations" (Daily selected) and "Statistics" (Daily selected). A red box highlights the text "Daily rainfall data and graphs for a selected year. Data download for one or all years." at the bottom of this section.

The screenshot shows a mobile application interface for The Wall Street Journal. At the top, it displays the DJIA index value. Below the header, there's a search bar and a navigation menu icon. The main content area features a large headline "THE WALL STREET JOURNAL" and a promotional message: "Continue reading your article with a WSJ membership. US \$1 for 2 Months". A blue button labeled "VIEW OPTIONS" is visible at the bottom of the promotional box. The background of the app has a dark theme with some light-colored cards.

Planet Monash



How many yellow, green and red alien creatures?



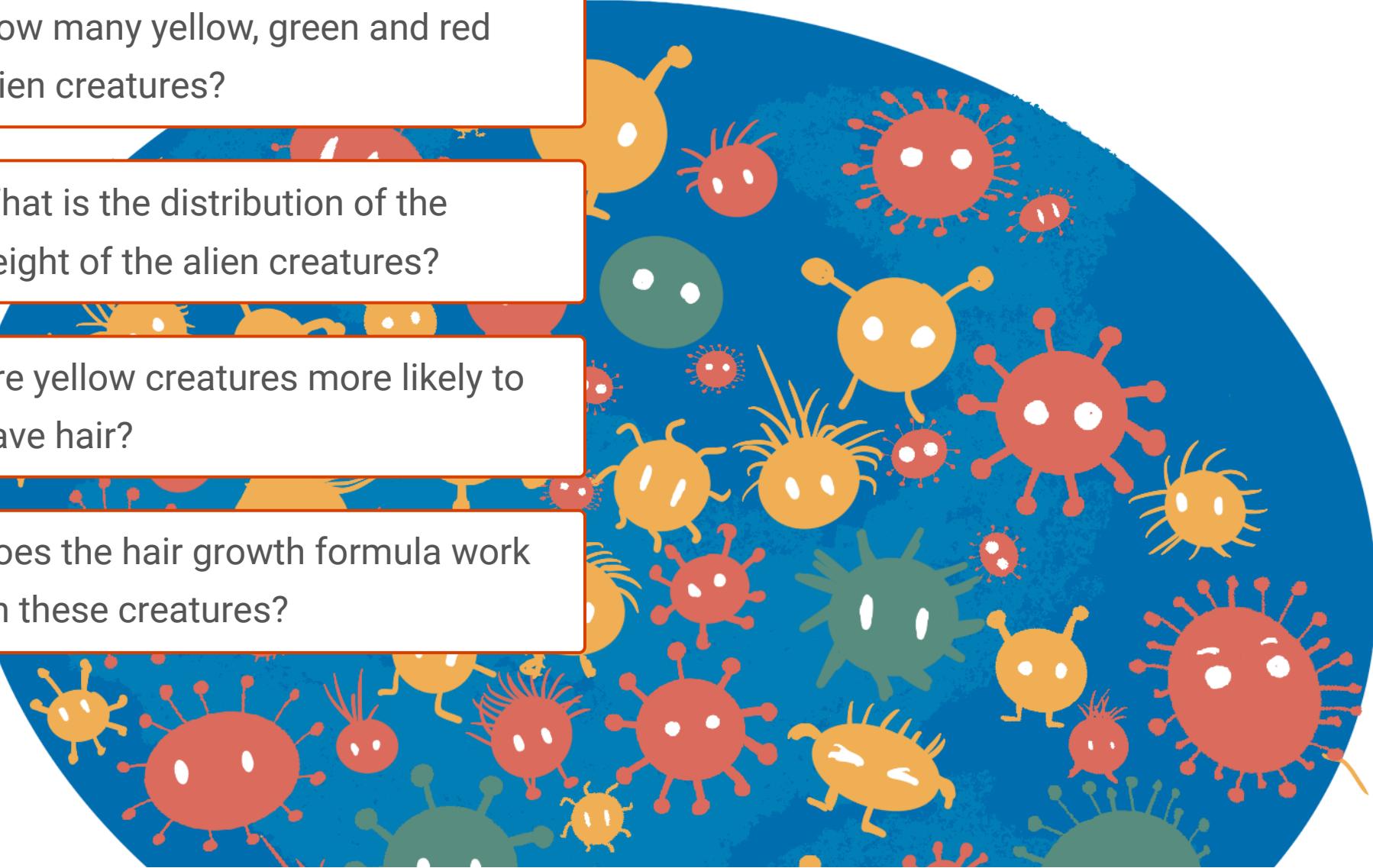
What is the distribution of the height of the alien creatures?



Are yellow creatures more likely to have hair?



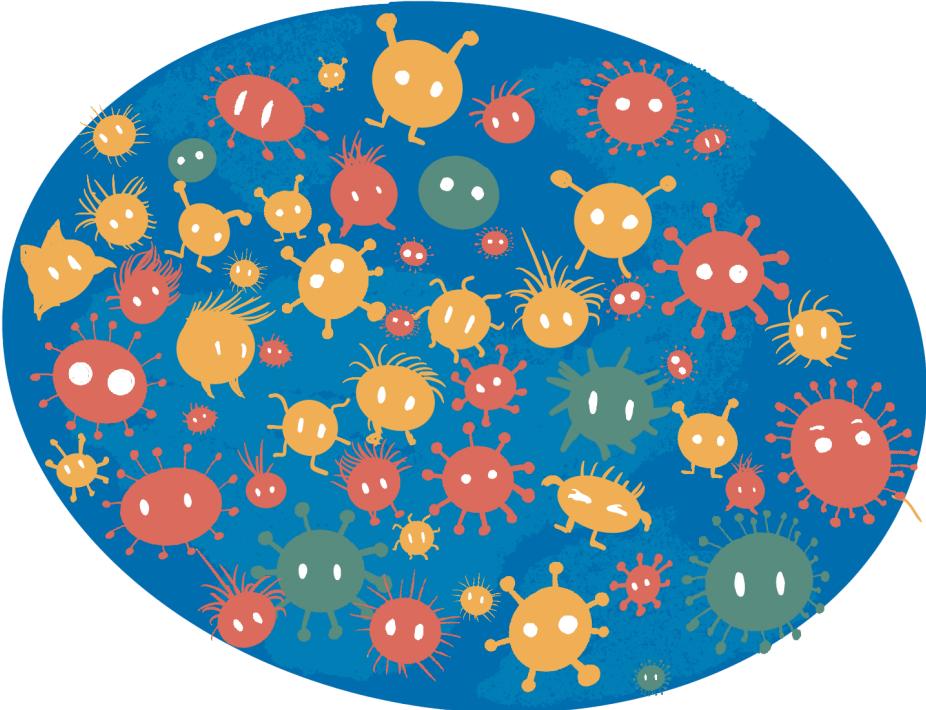
Does the hair growth formula work on these creatures?



**Now that we have a
question ...**

What's the population of interest?

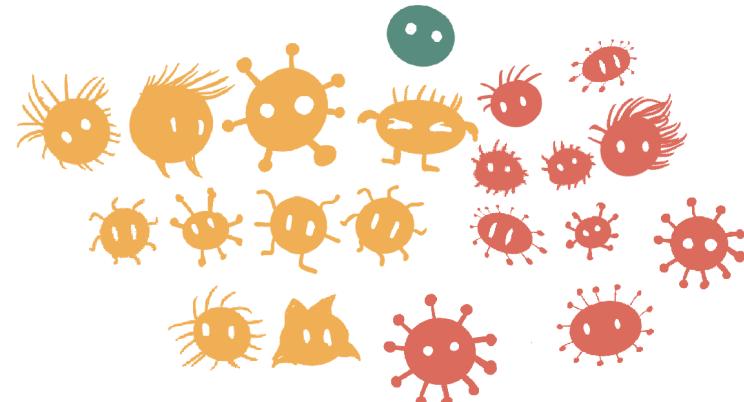
Population



Population parameters:

Green: $6/53=0.113$, Yellow: $22/53=0.416$,
Red: $25/53=0.472$

Sample



Estimates of population parameters:

Green: $1/21=0.048$, Yellow: $10/21=0.476$,
Red: $10/21=0.476$

Sampling the population

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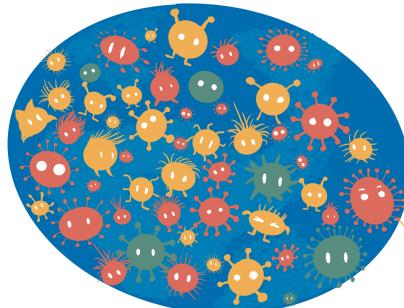
Collecting data on the entire population is normally too expensive or infeasible!

- We therefore collect data only on a subset of the population.
- **How should we sample the population?** There are many sampling schemes.



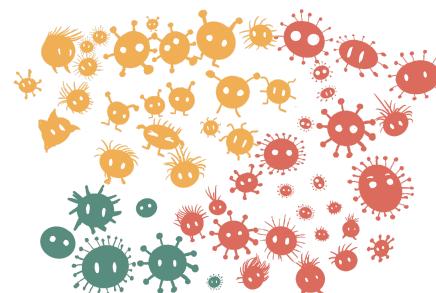
Simple random sampling

Every unit in the population has the same sample probability to be drawn.



Stratified random sampling

Units are drawn from non-overlapping sub-populations.



Goal of sampling schemes

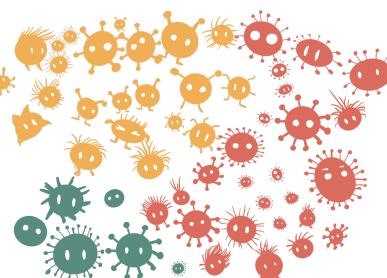


The **goal of a sampling scheme** is to get accurate information from the sample in order to answer your question.

- This involves identifying:
 - the **population of interest** (e.g. if studying about male baldness pattern, your population of interest is the biologically male population),
 - what **responses** or **covariates** to capture and how to measure it (e.g. do you collect their age? Which range of age they are in? Their hair count? The thickness of the hair?),
 - the **sample size** (how many samples do we need?),
 - any **structure** that will be in the data (e.g. population structures, repeated cross-sectional data, panel or longitudinal data), and
 - any **restrictions** (e.g. ethical concerns, limitation on collecting data).

Sampling strategies

- Sampling strategies combine knowledge about the population with statistical methods.
- For example,
 - designing so your sample estimates give (theoretically) unbiased estimates of the population parameters,
 - sample so the data will have representative of the subpopulations (e.g. stratified random sampling), or
 - oversampling or undersampling to compensate for imbalance in classes.



What might go wrong with a simple random sampling of 10 creatures from this population?

Random and non-random selections

- Units ideally are sampled *randomly*, but more than often selection are non-random.



If I survey every 10th household in a street, is that a random selection?



What do you think can go wrong if we don't sample randomly?

- What's wrong with these examples?



⌚ You want to know the attitude of the creatures about working at home.

📞 You call phone numbers listed in the order of white pages and stop when you have 20 observations.



⌚ You want to get the hair count distribution of the Plant Monash population.

📞 You sample creatures from the Society of Bald Extraterrestrials.

Reality of data collection ...

- Making an appropriate sampling design is *hard*.
 - There may be unknown or hidden structures in the population.
 - You may introduce intentional data structures, e.g.
 - Cross-sectional data,
 - Repeated cross-sectional data (e.g. case-control),
 - Panel or longitudinal data (e.g. cohort studies), and so on.
 - You may have unintended or unknown structures in the data, e.g. confounded variables.
 - It's further complicated by:
 - Non-response,
 - Missing data,
 - Mis-measured data,
 - Sample attrition, and so on. 😱

Observational studies

- Studies mentioned so far has been **observational studies**.

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- An **observational study** aims to draw inferences about a population from a sample where independent variables are *not* intentionally allocated to units within the population for the purpose of a study.
- Data considered in observational studies are **observational data**.

Examples:



Who will win the 2022 Australian federal election?
Survey households



Where are the best schools?
Government administrative data



Who are buying my products?
Customer database

Experimental studies

- A scientific claim generally need to be validated by an *experimental study*.

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- In an **experimental study**, a causal variable of interest is administered to recipients while holding other covariates at controlled settings to observe responses.
- Data from an experiment are referred to as **experimental data**.

Examples:



- ⦿ Is the vaccine effective against flu?
- ⌚ The data of whether the person who was administered the vaccine or placebo caught the flu afterwards.



- ⦿ Which fertilizer brand is most effective for wheat yield?
- ⌚ Yield data from crop field trial with plots treated with one of the three fertilizer brands.

Experimental unit

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Experimental units are recipients of the allocated treatment such that no sub-division of it can receive another treatment independently.



- Prof Android delivers their lecture by reciting word-to-word from the text in a monotone.
- Prof Alien delivers their lecture by transmitting the information directly to the students mind.
- You want to see if one of the method is more effective.
- Students in class 1, 3, 4, 7 and 10 have Prof Android.
- Students in class 2, 5, 6, 8 and 9 have Prof Alien.

What the experimental units? It's the classes.

Observational unit

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Observational units are units that you measure the response on.



Carrying on from previous example...

- Students all sit for the same exam.
- You record the exam mark for each student.

What are the observational units? It's the students.

- Note: *observational unit* is not the *observation* (the response)!

Wheat Yield Trial

CORRI	SUNLA	RAC80	VF300	TINCU	RAC80	VF655	VF519	RAC79	VG701	OSPRE	PELSA	VF300	MEERI	EXCAL
CADOU	SUNFI	RAC80	VF299	TINCU	RAC75	SWIFT	TRIDE	MOLIN	HOUTM	VF299	BT_SC	M5075	KATUN	(WWH*)
BLADE	SUNBR	RAC80	VF508	CONDO	VF508	VF299	AMERY	WI221	RAC78	VF508	BD231	RAC81	SUNFI	BATAV
BEULA	SHRIK	RAC80	VF655	RAC65	TINCU	SUNBR	RAC79	RAC81	(WWH*)	RAC82	VG503	CADOU	VF519	WW183
BATAV	ROSEL	RAC80	(WWH*)	M5097	DGR/M	PEROU	BD231	VF655	RAC77	CONDO	VG878	RAC80	RAC82	RAC65
AROON	PEROU	RAC80	(WqKP)	K2011	VG878	JANZ	KITE	WI232	RAC80	GOROK	HALBE	VG701	RAC79	RAC75
AMERY	PELSA	RAC79	WI216	WW183	VG714	MACHE	BT_SC	RAC75	RAC71	VF302	RAC80	STILE	SUNLA	OUYEN
YARRA	OXLEY	RAC79	WW147	WW147	KULIN	VF664	TINCU	VF300	RAC81	CUNNI	DGR/M	WW140	SUNBR	RAC71
WYUNA	OUYEN	RAC79	WW140	M4997	SUNLA	LOWAN	WARBL	AROON	M5097	K2011	WILGO	JANZ	M5097	HOUTM
TRIDE	OSPRE	RAC78	VF519	WI232	TASMA	WW147	STILE	BEULA	VG506	DOLLA	RAC80	VG714	RAC81	RAC81
TATIA	LOWAN	RAC77	RAC82	WI231	EXCAL	(WqKP)	M4997	RAC81	RAC77	ROSEL	RAC79	KIATA	WW147	MOLIN
STILE	LARK	RAC77	RAC82	WI221	RAC79	WW183	BATAV	RAC81	RAC81	RAC79	RAC75	SPEAR	WYUNA	CORRI
SPEAR	KULIN	RAC77	RAC81	BD231	RAC65	RAC77	M5075	CORRI	RAC80	BEULA	SHRIK	RAC78	VF664	RAC80
SCHOM	KITE	RAC75	RAC81	VG878	VF302	MEERI	SHRIK	SCHOM	KIATA	RAC81	TASMA	RAC81	RAC81	RAC65
MOLIN	KIATA	RAC75	RAC81	VG714	RAC80	WILGO	CADOU	SUNFI	BLADE	WI216	SCHOM	RAC81	TRIDE	MACHE
MEERI	KATUN	RAC71	RAC81	VG701	OXLEY	KATUN	YARRA	CONDO	PELSA	RAC77	KULIN	WARBL	WI232	PEROU
MACHE	HOUTM	RAC69	RAC81	VG506	RAC65	RAC81	CUNNI	WI216	RAC81	AMERY	KITE	WI221	RAC81	YARRA
JANZ	HALBE	RAC65	RAC81	VG503	RAC80	RAC80	OSPRE	RAC69	RAC82	RAC81	RAC80	OXLEY	TINCU	VF655
EXCAL	GOROK	WILGO	RAC81	VG127	K2011	OUYEN	WW140	LARK	RAC81	RAC77	VG127	RAC80	TINCU	VG506
DGR/M	DOLLA	WARBL	RAC81	VF302	RAC82	VG127	HALBE	WI231	WYUNA	WW147	TATIA	LOWAN	RAC81	WI231
BT_SC	M5075	TASMA	RAC81	VF664	GOROK	VG503	RAC81	ROSEL	TATIA	ANGAS	RAC69	VF655	BLADE	M4997
ANGAS	CUNNI	SWIFT	RAC81	VF655	WW147	RAC81	ANGAS	SPEAR	DOLLA	AROON	(WqKP)	LARK	SWIFT	RAC77

- A selective breeding experiment with 107 wheat varieties (or *genotypes*) were conducted in South Australia in a field with plots laid out in a rectangular array with 22 rows and 15 columns.
- The breeders want to find a variety with *high yield*.
- The **treatments** are the 107 wheat varieties.
- The **experimental units** are the 330 plots.
- The **observational units** are also the 330 plots.

Replications

CORRI	SUNLA	RAC80	VF300	TINCU	RAC80	VF655	VF519	RAC79	VG701	OSPRE	PELSA	VF300	MEERI	EXCAL
CADOU	SUNFI	RAC80	VF299	TINCU	RAC75	SWIFT	TRIDE	MOLIN	HOUTM	VF299	BT_SC	M5075	KATUN	(WWH*
BLADE	SUNBR	RAC80	VF508	CONDO	VF508	VF299	AMERY	WI221	RAC78	VF508	BD231	RAC81	SUNFI	BATAV
BEULA	SHRIK	RAC80	VF655	RAC65	TINCU	SUNBR	RAC79	RAC81	(WWH*	RAC82	VG503	CADOU	VF519	WW183
BATAV	ROSEL	RAC80	(WWH*	M5097	DGR/M	PEROU	BD231	VF655	RAC77	CONDO	VG878	RAC80	RAC82	RAC65
AROON	PEROU	RAC80	(WqKP	K2011	VG878	JANZ	KITE	WI232	RAC80	GOROK	HALBE	VG701	RAC79	RAC75
AMERY	PELSA	RAC79	WI216	WW183	VG714	MACHE	BT_SC	RAC75	RAC71	VF302	RAC80	STILE	SUNLA	OUYEN
YARRA	OXLEY	RAC79	WW147	WW147	KULIN	VF664	TINCU	VF300	RAC81	CUNNI	DGR/M	WW140	SUNBR	RAC71
WYUNA	OUYEN	RAC79	WW140	M4997	SUNLA	LOWAN	WARBL	AROON	M5097	K2011	WILGO	JANZ	M5097	HOUTM
TRIDE	OSPRE	RAC78	VF519	WI232	TASMA	WW147	STILE	BEULA	VG506	DOLLA	RAC80	VG714	RAC81	RAC81
TATIA	LOWAN	RAC77	RAC82	WI231	EXCAL	(WqKP	M4997	RAC81	RAC77	ROSEL	RAC79	KIATA	WW147	MOLIN
STILE	LARK	RAC77	RAC82	WI221	RAC79	WW183	BATAV	RAC81	RAC81	RAC79	RAC75	SPEAR	WYUNA	CORRI
SPEAR	KULIN	RAC77	RAC81	BD231	RAC65	RAC77	M5075	CORRI	RAC80	BEULA	SHRIK	RAC78	VF664	RAC80
SCHOM	KITE	RAC75	RAC81	VG878	VF302	MEERI	SHRIK	SCHOM	KIATA	RAC81	TASMA	RAC81	RAC81	RAC65
MOLIN	KIATA	RAC75	RAC81	VG714	RAC80	WILGO	CADOU	SUNFI	BLADE	WI216	SCHOM	RAC81	TRIDE	MACHE
MEERI	KATUN	RAC71	RAC81	VG701	OXLEY	KATUN	YARRA	CONDO	PELSA	RAC77	KULIN	WARBL	WI232	PEROU
MACHE	HOUTM	RAC69	RAC81	VG506	RAC65	RAC81	CUNNI	WI216	RAC81	AMERY	KITE	WI221	RAC81	YARRA
JANZ	HALBE	RAC65	RAC81	VG503	RAC80	RAC80	OSPRE	RAC69	RAC82	RAC81	RAC80	OXLEY	TINCU	VF655
EXCAL	GOROK	WILGO	RAC81	VG127	K2011	OUYEN	WW140	LARK	RAC81	RAC77	VG127	RAC80	TINCU	VG506
DGR/M	DOLLA	WARBL	RAC81	VF302	RAC82	VG127	HALBE	WI231	WYUNA	WW147	TATIA	LOWAN	RAC81	WI231
BT_SC	M5075	TASMA	RAC81	VF664	GOROK	VG503	RAC81	ROSEL	TATIA	ANGAS	RAC69	VF655	BLADE	M4997
ANGAS	CUNNI	SWIFT	RAC81	VF655	WW147	RAC81	ANGAS	SPEAR	DOLLA	AROON	(WqKP	LARK	SWIFT	RAC77

- The varieties **VF655**, **TINCURIN** and **WW1477** have a **replication** of 6, the remaining 104 varieties each have a replication of 3.
- Treatment **replications are essential** in an experiment; without any replication, no treatment variation can be measured nor distinguished from unit variation.
- More replications are desirable for accuracy, however, there is always a tension to balance between accuracy and the cost of the experiment.

Pseudo-rePLICATION



Carrying on from the teaching example...

- Suppose there were 30 students in each class.
- The treatments were the two teaching method confounded with each professor.
- There were two professors and 10 classes.
- Each professor was randomly assigned to 5 classes, so each professor manages 150 students.

What are the replications of each treatment? It's 5.



The treatment of repetition as replication in the analysis is referred to as **pseudo-rePLICATION**.

Systematic Design of Experiments

BEULA	DGR/M	K2011	M5075	OXLEY	RAC75	RAC79	RAC81	RAC81	SPEAR	TATIA	VF508	VG701	WI232	YARRA
BD231	DGR/M	K2011	M4997	OXLEY	RAC75	RAC79	RAC81	RAC81	SHRIK	TATIA	VF508	VG506	WI232	YARRA
BD231	CUNNI	K2011	M4997	OUYEN	RAC75	RAC79	RAC80	RAC81	SHRIK	TASMA	VF508	VG506	WI231	YARRA
BD231	CUNNI	JANZ	M4997	OUYEN	RAC71	RAC79	RAC80	RAC81	SHRIK	TASMA	VF302	VG506	WI231	WYUNA
BATAV	CUNNI	JANZ	LOWAN	OUYEN	RAC71	RAC79	RAC80	RAC81	SCHOM	TASMA	VF302	VG503	WI231	WYUNA
BATAV	CORRI	JANZ	LOWAN	OSPRE	RAC71	RAC79	RAC80	RAC81	SCHOM	SWIFT	VF302	VG503	WI221	WYUNA
BATAV	CORRI	HOUTM	LOWAN	OSPRE	RAC69	RAC79	RAC80	RAC81	SCHOM	SWIFT	VF300	VG503	WI221	WW183
AROON	CORRI	HOUTM	LARK	OSPRE	RAC69	RAC78	RAC80	RAC81	ROSEL	SWIFT	VF300	VG127	WI221	WW183
AROON	CONDO	HOUTM	LARK	MOLIN	RAC69	RAC78	RAC80	RAC81	ROSEL	SUNLA	VF300	VG127	WI216	WW183
AROON	CONDO	HALBE	LARK	MOLIN	RAC65	RAC78	RAC80	RAC81	ROSEL	SUNLA	VF299	VG127	WI216	WW147
ANGAS	CONDO	HALBE	KULIN	MOLIN	RAC65	RAC77	RAC80	RAC81	RAC82	SUNLA	VF299	VF664	WI216	WW147
ANGAS	CADOU	HALBE	KULIN	MEERI	RAC65	RAC77	RAC80	RAC81	RAC82	SUNFI	VF299	VF664	WARBL	WW147
ANGAS	CADOU	GOROK	KULIN	MEERI	RAC65	RAC77	RAC80	RAC81	RAC82	SUNFI	TRIDE	VF664	WARBL	WW147
AMERY	CADOU	GOROK	KITE	MEERI	RAC65	RAC77	RAC80	RAC81	RAC82	SUNFI	TRIDE	VF655	WARBL	WW147
AMERY	BT_SC	GOROK	KITE	MACHE	RAC65	RAC77	RAC80	RAC81	RAC82	SUNBR	TRIDE	VF655	VG878	WW147
AMERY	BT_SC	EXCAL	KITE	MACHE	PEROU	RAC77	RAC80	RAC81	RAC82	SUNBR	TINCU	VF655	VG878	WW140
(WqKP)	BT_SC	EXCAL	KIATA	MACHE	PEROU	RAC77	RAC80	RAC81	RAC81	SUNBR	TINCU	VF655	VG878	WW140
(WqKP)	BLADE	EXCAL	KIATA	M5097	PEROU	RAC77	RAC80	RAC81	RAC81	STILE	TINCU	VF655	VG714	WW140
(WqKP)	BLADE	DOLLA	KIATA	M5097	PELSA	RAC77	RAC80	RAC81	RAC81	STILE	TINCU	VF655	VG714	WILGO
(WWH*)	BLADE	DOLLA	KATUN	M5097	PELSA	RAC75	RAC79	RAC81	RAC81	STILE	TINCU	VF519	VG714	WILGO
(WWH*)	BEULA	DOLLA	KATUN	M5075	PELSA	RAC75	RAC79	RAC81	RAC81	SPEAR	TINCU	VF519	VG701	WILGO
(WWH*)	BEULA	DGR/M	KATUN	M5075	OXLEY	RAC75	RAC79	RAC81	RAC81	SPEAR	TATIA	VF519	VG701	WI232

- The treatments appear to be randomly ordered before.
- Why don't we order the treatments in a **systematic order** like on the left?
- Isn't this easier to manage the experiment?



Systematic designs are prone to
bias and confounding.

Randomisation

- Treatment should be allocated *randomly* to experimental units.
- This avoids:
 - **systematic bias** - e.g. all flu vaccine A tested in January (summer) and all flu vaccine B tested in July (winter).
 - **selection bias** - e.g. giving the treatment that you are testing to the sick patients and placebo to those that are healthy.
 - **other bias** - e.g. the lab technician giving the treatment to the first rat that is taken out of the cage.

Blocking

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Blocks are used to group the experimental units into alike units.

- If well done, blocking can lower the variance of treatment contrasts which increase power.
- A non-homogeneous block (i.e. units within block are *not* alike) can decrease the power of the experiment.

You can form blocks from:

- **Natural discrete divisions** between experimental units.
E.g. in experiments with people, gender make an obvious block.
- Grouping experimental units with similar **continuous gradients**.
E.g., if the experiment is spread out in time or space and there exists no obvious natural boundaries, then an arbitrary boundary may be chosen to group experimental units that are contiguous in time or space.

The Salk Vaccine Field Trial

- The first polio epidemic hit the United States in 1916 claiming hundreds of thousands of victims, especially children.
- National Foundation for Infantile Paralysis (NFIP) was ready to test the vaccine developed by Jonas Salk in the real world.
- A controlled experiment was proposed to test the effectiveness of the vaccine on grade 1, 2 and 3 children at selected school districts though the country where the risk of polio was high.
- In total two million children were involved although not all parents consented to their children to be vaccinated.

Design for the NFIP Study

Vaccinate all grade 2 children whose parents would consent, leaving children in grades 1 and 3 as controls.

- Can grade 2 children whose parents did not consent be included as control?
- What are the potential issues with such a design?
- Polio is a contact disease. Would incidences of disease be higher in grade 2?

Randomised controlled trial

An alternate vaccine randomly assigned the vaccine and placebo to children.

Vaccine Results

The NFIP Study

Group	Participants	Rate
Vaccinated (Grade 2)	221,998	25
Control (Grade 1 & 3)	725,173	54
Not Vaccination (Grade 2, no consent)	123,605	44
Incomplete Vaccination (Grade 2, incomplete)	9,904	40

Randomised controlled trial

Group	Participants	Rate
Vaccinated	200,745	28
Placebo	201,229	71
Not Vaccination (no consent)	338,778	46
Incomplete Vaccination	8,484	24

- The rate is the number of polio cases per 100,000 in each group.
- RCT and NFIP trial sampled from school districts with similar exposures to the polio virus.
- Both the not vaccinated (no consent) and placebo/control group did not receive the treatment but why is the rate of polio cases less in the not vaccinated (no consent) group?

Possible explanations

- Higher income parents would more likely consent to treatment than lower-income parents.
- Children of higher income parents are more vulnerable to polio.
- Many forms of polio are hard to diagnose and in borderline cases.

Limitations in (social) experiments

- Cooperation needed from participants
- Ethical objections
- Substitution bias
- Sample attrition
- Hawthorne effect

Basically, designing and running experiments are *hard*.

Pop Quizzes

Observational or experimental data?



The Academic Performance Index is computed for all California schools based on standardised testing of students. The data sets contain information and characteristics for 100 schools.

OBSERVATIONAL

Observational or experimental data?



The response is the length of odontoblasts in 60 guinea pigs. Each animal received one of three dose levels of vitamin C by one of two delivery methods by the technician.

EXPERIMENTAL

Observational or experimental data?



Can people really tell the difference between different flavours associated with the color of the skittles? You blind your friends so they can't see the color and collect data on their guess after giving them one skittle at a time.

EXPERIMENTAL



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Lecturer: *Emi Tanaka*

Department of Econometrics and Business Statistics

✉ ETC5512.Clayton-x@monash.edu

CALENDAR Week 1

