Error, Bias and Objectivity in Experimental design

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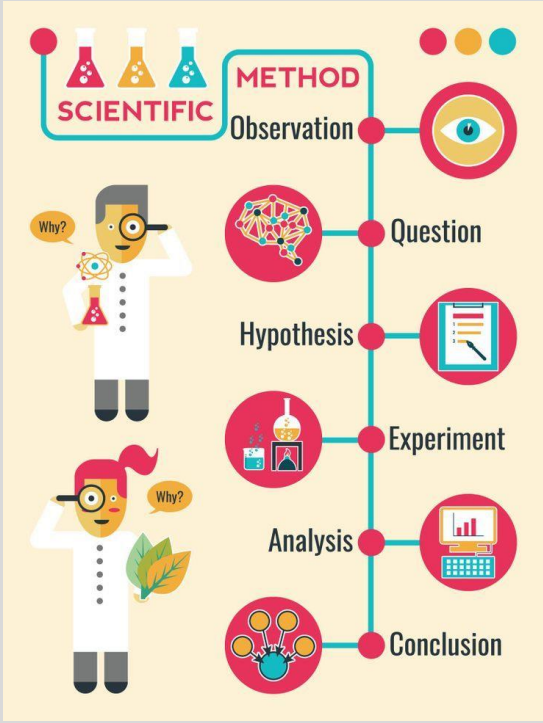


What does it mean to be objective in science?

- Experimental design should reduce error or bias by:
  - Remove pre-conceived ideas
  - Avoid bias by poor experimental design

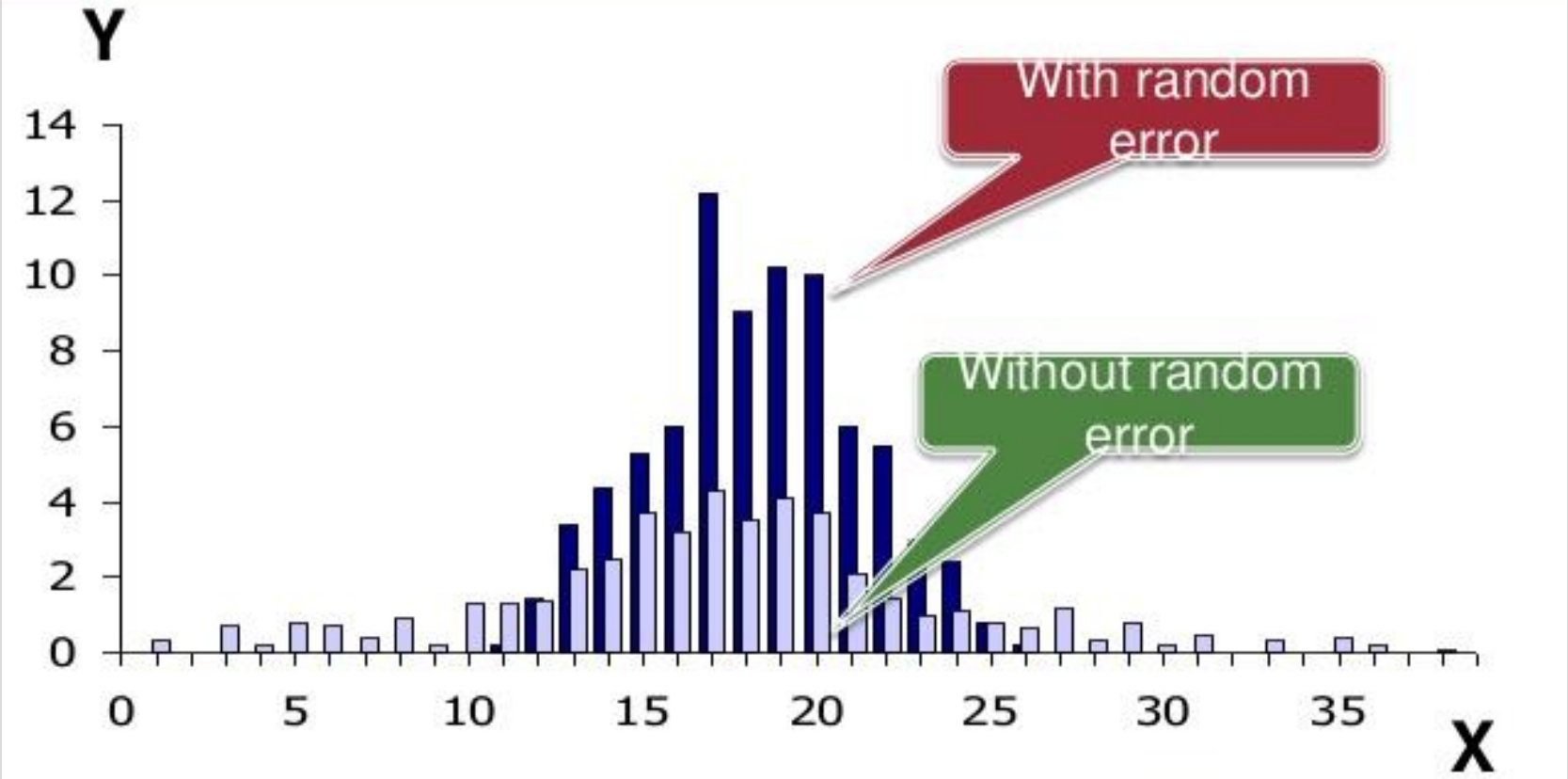
Types of error in experimental design

- Random error
  - Chance variation in a ‘population’
  - Equally misclassifies treatments and controls

Good experimental design

- Systematic error
  - Misclassifies treatments in one direction and controls in another
  - Selection bias
  - Confounding variable bias

RANDOM ERROR



Random error doesn't affect the average, only the variability around the average

https://cirt.gcu.edu/research/developmentresources/research_ready/experimental/error_bias

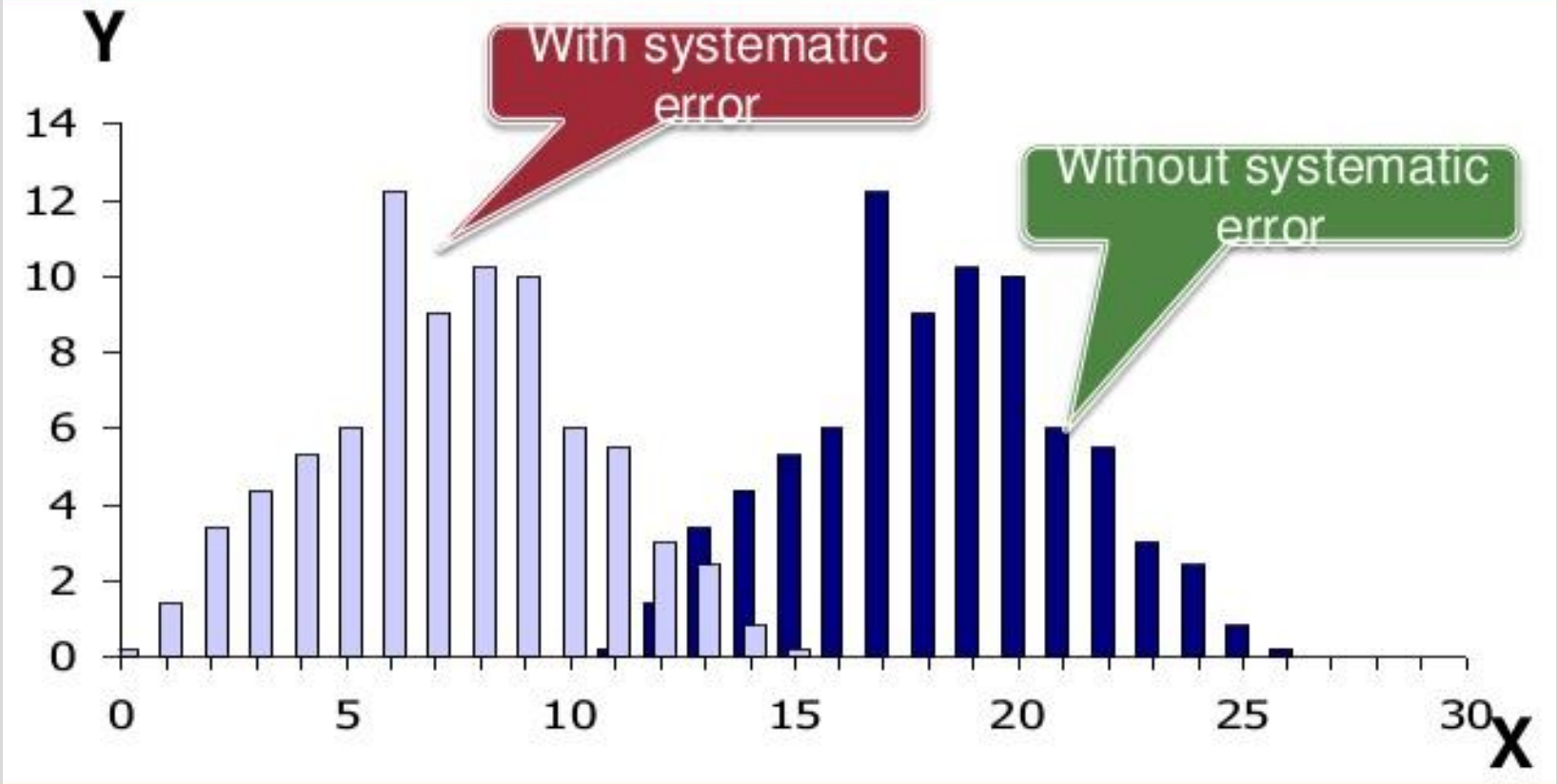
Random Error

- Low precision of outcome

- Outcome is not precise but is true
  - Imprecise measuring
  - Small sample size

- Decreases with
  - Increasing sample size
  - Repeating test on different sample of population

SYSTEMATIC ERROR



Systematic error does affect the average, called as bias

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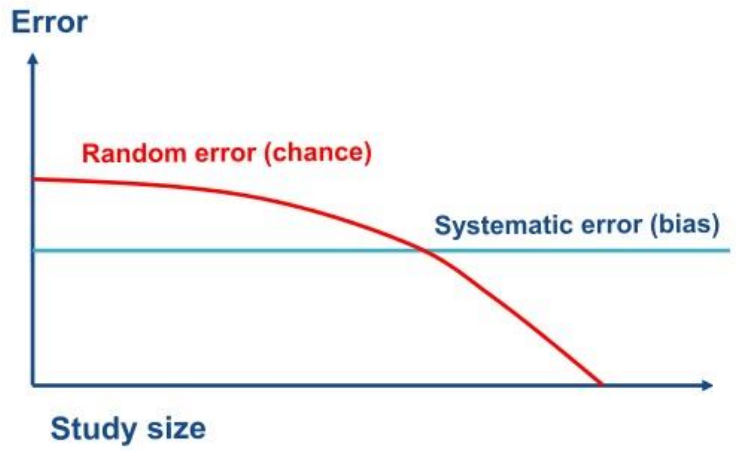
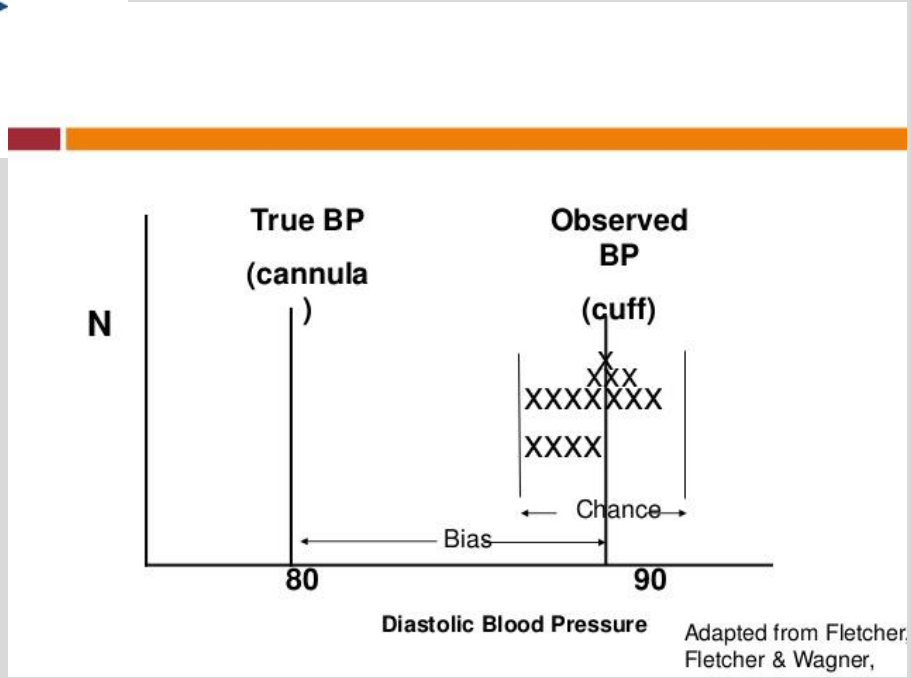
Systematic Error

- Low validity of outcome
- Outcome is **not true**
  - Selection bias
  - Confounding variable
- Decreases with:
  - Knowledge of test system
  - Understanding of potential areas of bias

ERRORS





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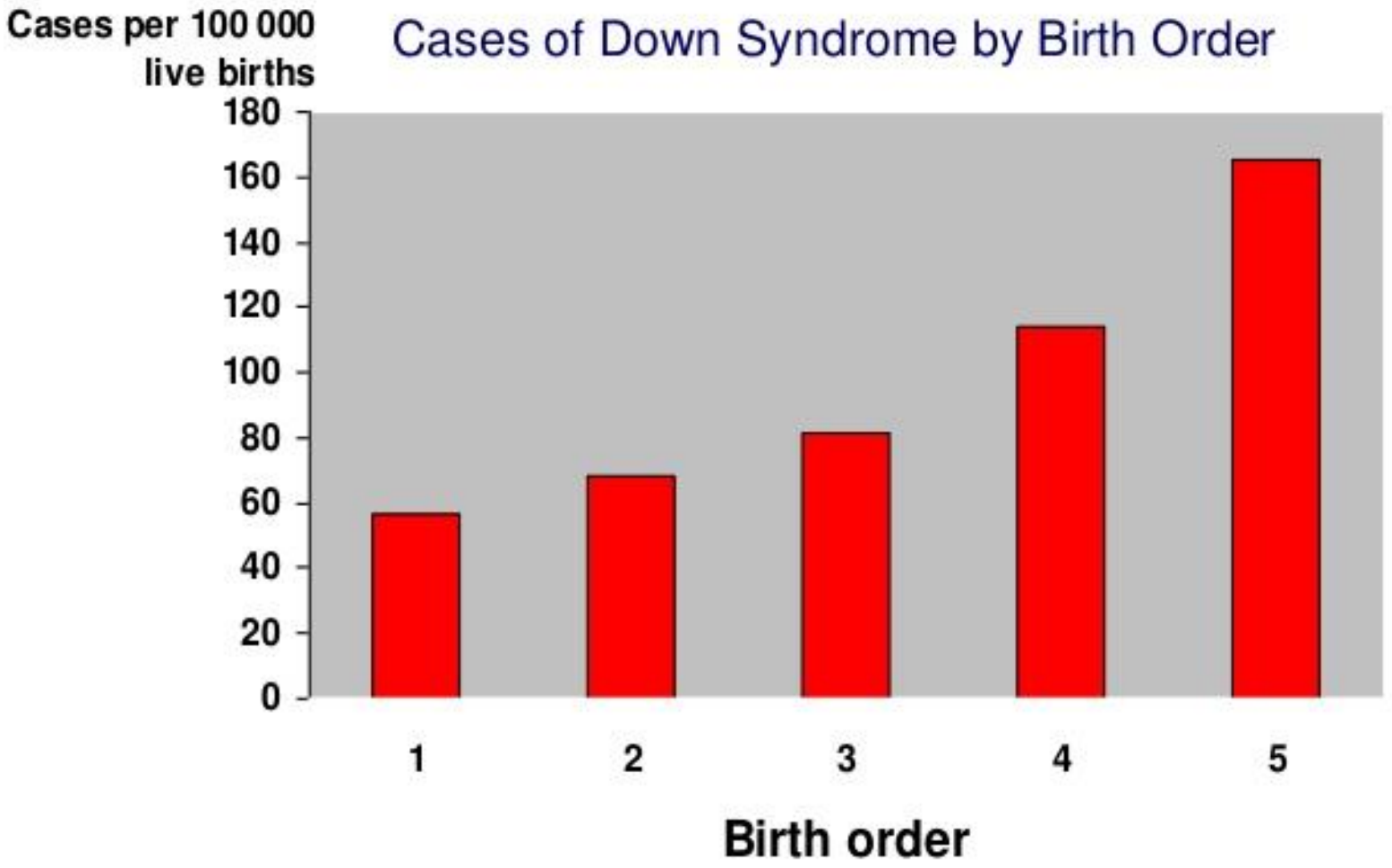
Systematic Error: Confounding variable bias

- The effect of the explanatory variable on the response variable is distorted by the responses association with other factors

EXAMPLE OF CONFOUNDING



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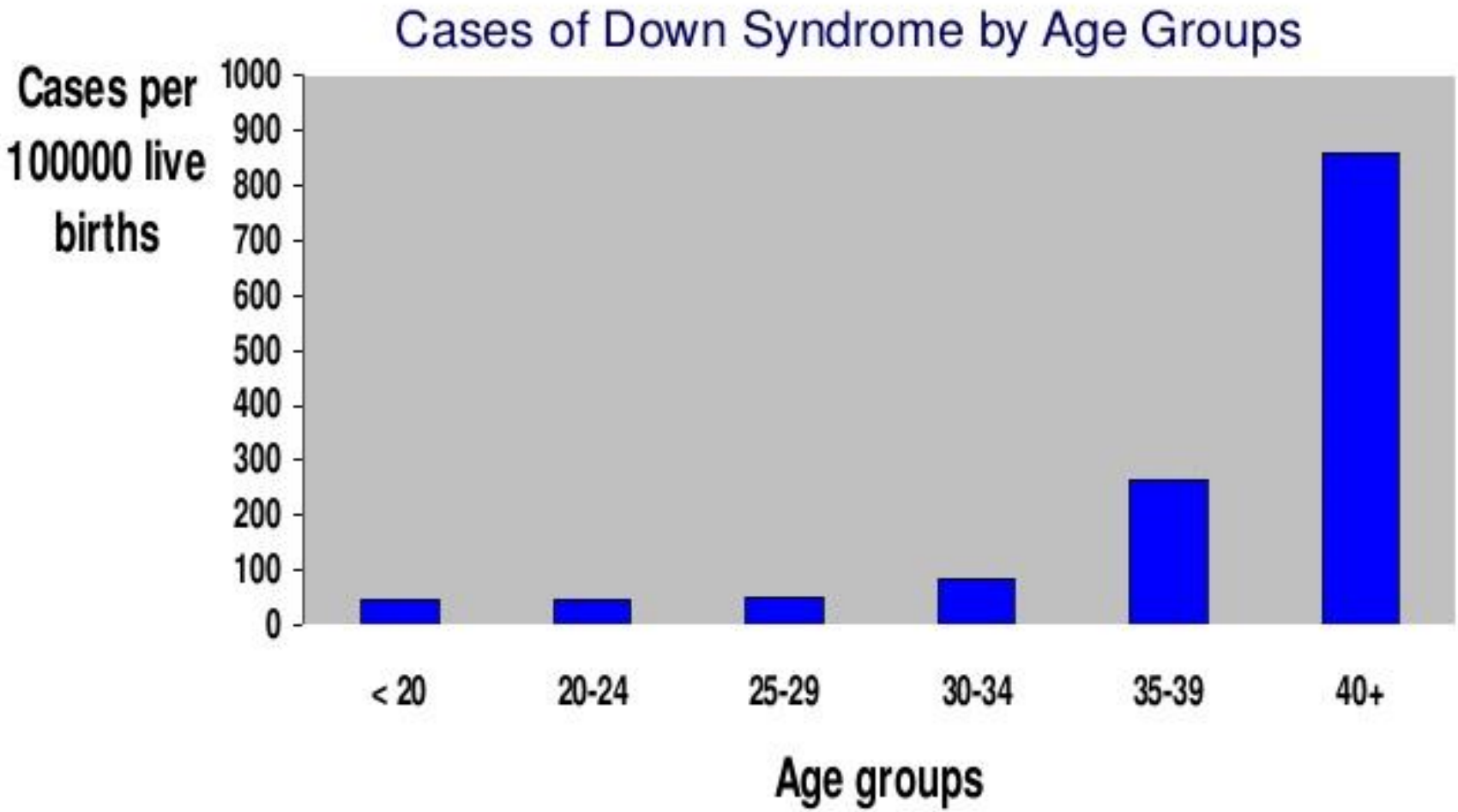

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Experimental design: Confounding variables

- Knowledge of study system
- Sound hypothesis
- Control/exclude for confounding variables
- Measure confounding variables

Systematic error: selection bias & information bias

- Selection bias:
  - Are study subjects similar in all respects apart from explanatory variable?
  - Control for as many factors/confounding variables as possible

- Information bias:
  - Is information about outcome collected in the same way for all treatments & control?
  - Good & rigorous experimental design

Avoiding bias

- Knowledge of the system
  - Select correct explanatory variables
  - Identify cofounding variables
- Random sampling of the population
- Blinding
- Knowledge of potential experimenter bias
  - Double blinding

What are the implications of unaccounted for error?

- You may conclude something is true when it is not

Type I error

- You many conclude something is not true when it is

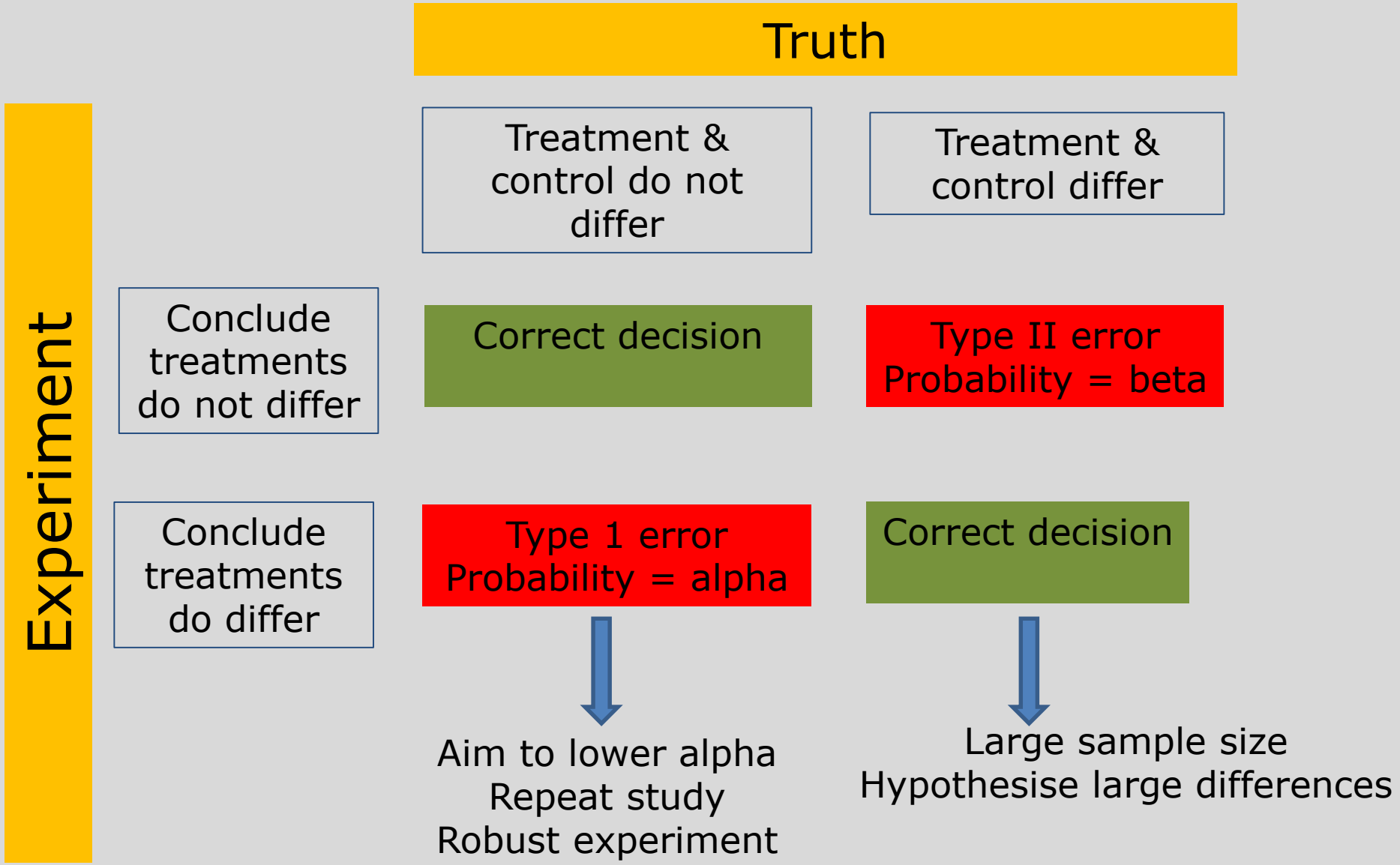
Type II error

Type I & Type II Errors

- Type I – the probably of rejecting a true null hypothesis

- Type II – the probably of failing to reject a null hypothesis even though it is false

Type I & Type II Errors



Bias may occur at any stage

- Literature review
- Experimental design
- Data collection
- Analysis
- Interpretation of results & conclusions
- Publication

Group work – bias & error

- Design a simple, practical scientific experiment
  - Set hypothesis/hypotheses
  - Choose dependent and independent variables
  - Construct experimental and control groups
  - Consider sampling approach
  - Highlight sources of bias at all stages of research
- In pairs
- Choose a topic from the list of examples (some more workable than others!), or devise your own
- 30 minutes preparation time
- 2-3 minute presentation (PowerPoint if preparation time permits)

<u>Example topics</u>

1. Alder trees thrive in waterlogged conditions
2. Dogs only see in black and white
3. Listening to classical music increases intelligence
4. Women are better multi-taskers than men
5. Driving on the left is safer than driving on the right
6. Red smarties taste best
7. Elvis is alive

Supervisor discussion topics

- For your broader discipline and your specific project:
  - Identify sources of random and systematic bias
  - Identify ways to reduce these
  - Identify implications if you don't reduce error
    - Academic
    - Wider Impact

- Consider & identify examples of these for every stage of the research process

Resources & Acknowledgements

- https://cirt.gcu.edu/research/developmentresources/research_ready/experimental/error_bias
- https://courses.lumenlearning.com/boundless-psychology/chapter/bias-in-psychological-research/
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2917255/
- https://www.thoughtco.com/difference-between-type-i-and-type-ii-errors-3126414