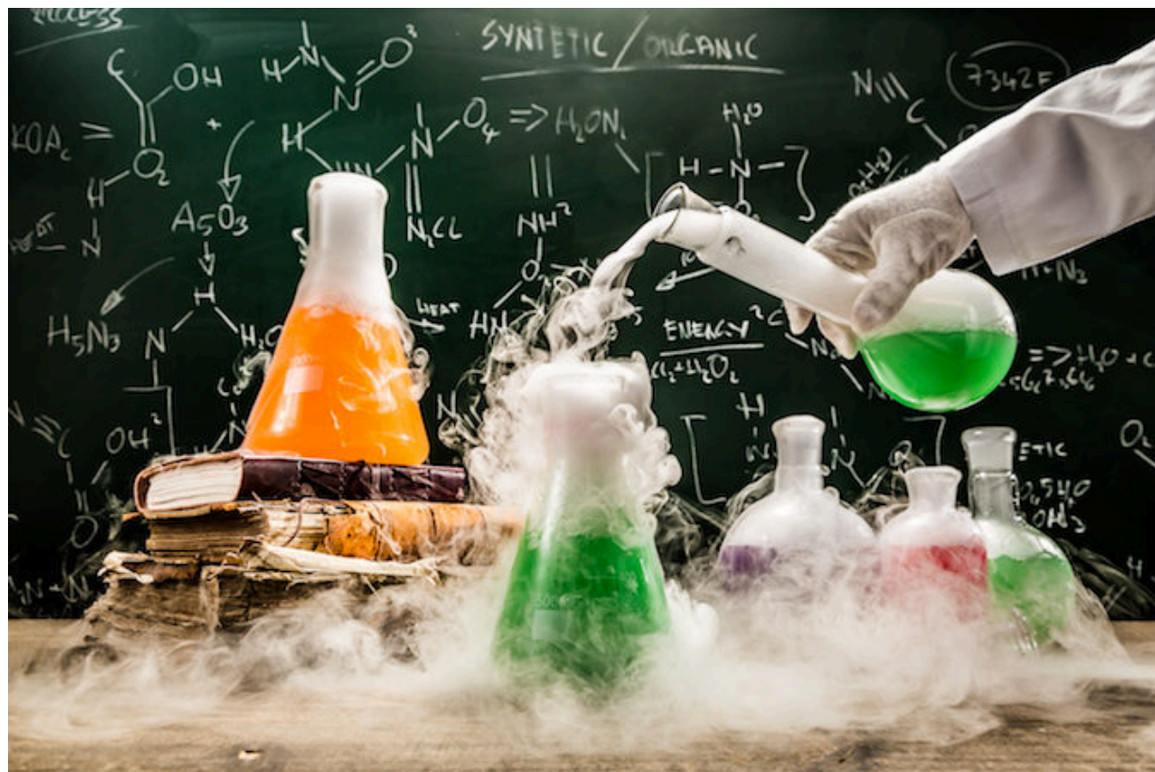
Project Evaluation

F21RP - Research Methods and Project Planning

(based on slides by Oliver Lemon, Judy Robertson, Helen Hastie, Frank Broz and Tom Methven)

Learning Outcomes

- Why do we need to evaluate?
- How can we evaluate?
  - Case Studies, Testing
  - Experimental Design
  - Empirical Evaluation
  - Human Evaluation



Q: Why bother evaluating?

A: The stakeholders (aka you/supervisor/clients/users) of the project need to know if your method/algorithm/model/system

- is successful
- is *comparable/better/worse* compared to the competition

$\mathcal{Q}$: How do you formulate your evaluation?

$\mathcal{A}$: By defining your research questions (usually in the Introduction).

- These are the main things you want to investigate in your project. For example:
  - *How do compressed representations improve performance on a machine learning task?*
  - *How do users respond to different dialogue flows?*
  - *How does technology effect the consumption of visual art?*
  - *How do different visualisations of uncertainty affect the trust of the user of an autonomous system?*

$\mathcal{Q}$: How do you answer your Research Questions?

$\mathcal{A}$-1: By stating a thesis.

- A thesis statement is a short, direct sentence that summarises the main points or claims of your project.
  - For example:
    - *Using transfer learning based on large pre-trained models, we can achieve reliable text generation systems using significantly less data.*

AND optionally

$\mathcal{A}$-2: By formulating one or more hypotheses.

- A hypothesis is a statement that can be proved or disproved.

Jablonski, Judith. What is the difference between a thesis statement and an hypothesis statement? Online Library. American Public University System. Jun 16, 2014.

$\mathcal{Q}$: How do you support your thesis?

$\mathcal{A}$: By developing, supporting, and explaining it via examples and evidence.

- Examples include:
  - Case studies of a system
  - Qualitative analysis
  - Software Evaluation

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$\mathcal{Q}$: How do you prove/disprove your hypotheses?

$\mathcal{A}$-1: By designing and conducting a controlled experiment

- Examples of experimentation include:
  - Empirical Evaluation (automatic metrics)
  - Human Evaluation

$\mathcal{A}$-2: By designing and conducting a usability study

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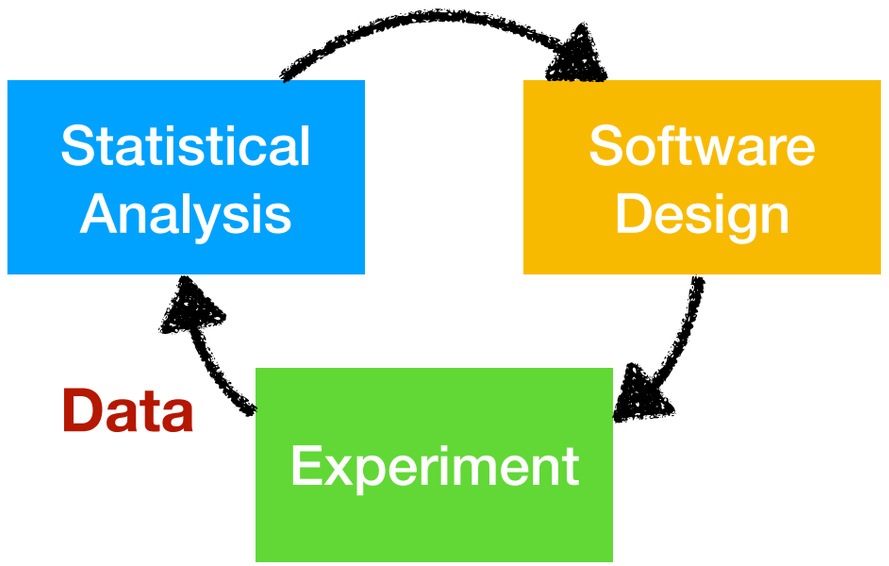
Experimental Design

Experiment and Design

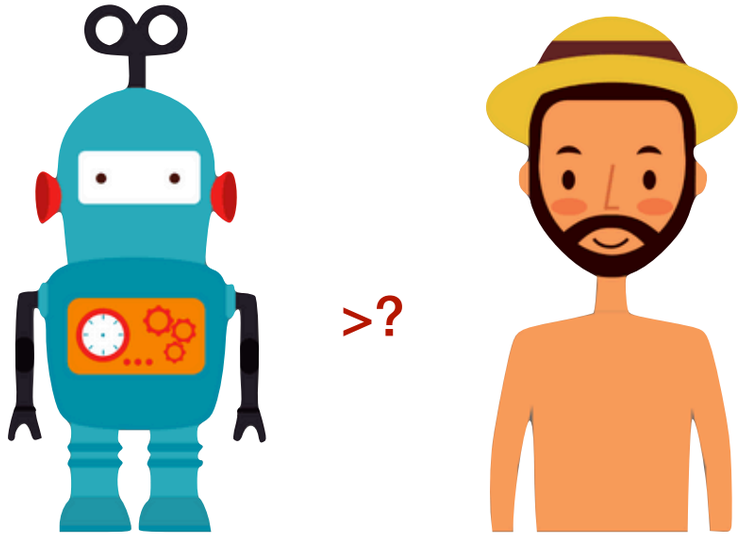
- Conventional software design cycle:



Examples:
- System
- Algorithm
- Model
- User Interface

Claims require 2 ingredients

- “My system / method / design / algorithm is good”
  - …good compared to what?
- “My system ... X is better than system ... Y”
- Is Y a strong competitor?
  - Not a ‘straw man’ but a sensible alternative approach
  - Ideally the current state-of-the-art approach
  - We call this a “baseline” for comparison
- What does “better than” mean?
  - Need to define metrics that measure “goodness”
  - E.g., speed, user satisfaction, task completion, energy usage, BLEU score ....



2 ingredients generate data

- Baselines
  - Comparison systems / methods / techniques control condition
- Metrics
  - Ways of measuring performance of your approach and the baseline(s)
- When you run experiments, you will apply the metrics to your system and the baseline(s)
  - …this will generate data that you need to analyse!

Why does it matter?

- Interpreting claims that you read:
  - “Method B is better than method A”
  - “Average task completion with system B is higher than with system A”
  - E.g., “Users of System A preferred it to System B 23% of the time, $p < 0.05$”
  - E.g., “System A is significantly faster than System B”
  - “Our results are significant”
- Making your own experimental claims:
  - E.g., “My new algorithm X means that users can complete tasks in only 52% of the time that they needed previously ($p<0.001$)”

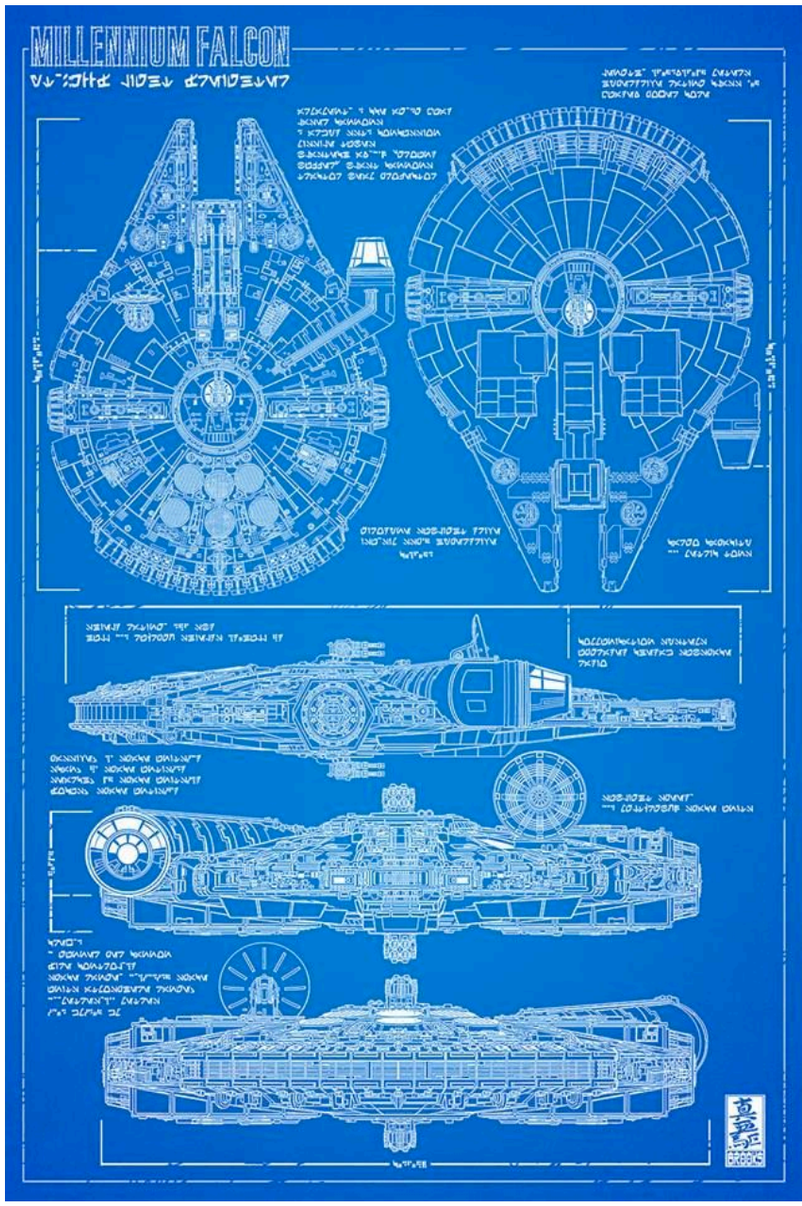
Experimental Method

- Experiments are required where:
  - You want to know the difference between two or more features or methods
    - *Which screen layout is easier to use?*
    - *How does my algorithm affect speed and accuracy?*
  - You want to see what happens when you make a change or series of changes to a design parameter
    - *At what font size does text become unreadable ?*
  - You want to see how the changes you've made to a method affect overall performance
    - *Do your changes make the system faster/more usable?*

Working artefact

- An experiment enables the researcher to observe the effect of manipulating one or more variables

- Requires an artefact: a simulation, prototype, or a fully implemented system



Experimental Design

1. Determine

   (a) the research questions of the project

   (b) the hypotheses being tested

2. Design the experiment(s)

3. Run the experiment AND/OR user study [takes a lot of time!]

4. Analyse measured data AND/OR questionnaires using statistical tests

5. Summarise and present the result

1(b). Hypothesis

???

- A statement of fact that you are going to try to prove/disprove

- An educated guess as to why something happens

Hypothesis: Examples

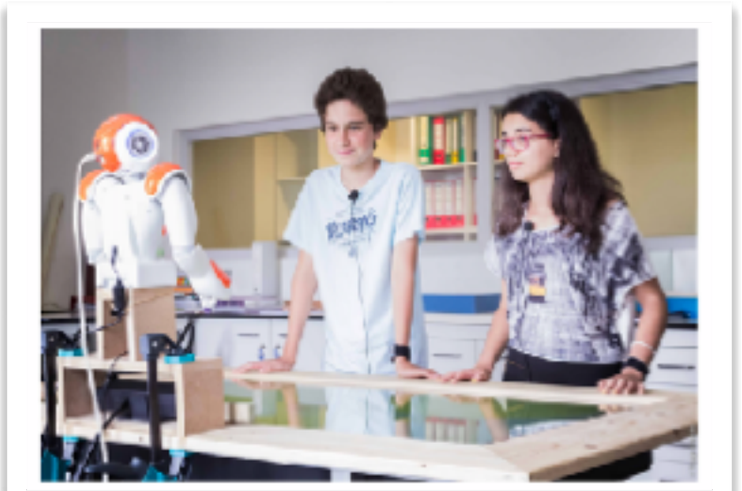
- Most of the time they are written like this:
- If _____ [I do this] ___ then ___ [this will happen]

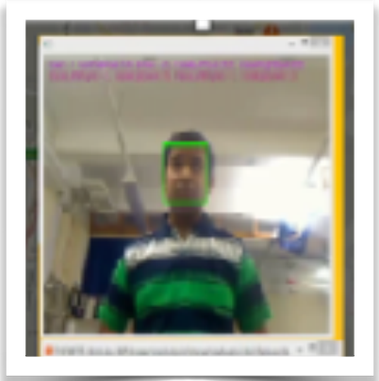
- For example:
  - *If I change the robot voice from male to female, then this makes the system perceived as more friendly*
  - *If users use voice instead of text input, then this will be more efficient for texting messages*

Hypotheses: more examples

- *Empathic robots are better teachers than non- empathic robots*

- *Robots with memory make better teachers than robots without memory*





Hypotheses: even more examples

- *Representation X allows faster convergence of the SARSA algorithm than representation Y, on task T.*

- *E.g. Users prefer dialogue flow A to standard flow B, measured by the PARADISE metrics.*

2. Design the Experiment: Principles

- Three basic principles of experimental design

(a) Replication

(b) Importance

(c) Control/Validity

2(a). Replication

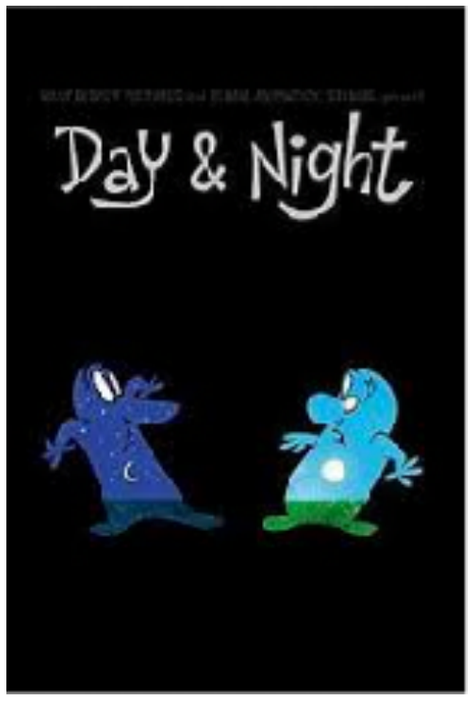
- Careful measurements allow you to replicate your experiments

2(b). Importance

- An experiment can be replicated and controlled but not worth it if it's not important

2(c). Controlled Environment

- Some variables correlate but don't necessarily cause effects
- Need to isolate the variables that cause effect



Designing Experiments: Recipe (Automatic Evaluation)

1. Create a controlled environment
2. Define parameters and hyperparameters
3. Decide about measurements of metrics
4. Execute model

Designing Experiments: Recipe (Human Evaluation)

1. Create a controlled environment

2. Create scenarios and tasks

3. Decide about measurements of metrics

4. Prepare questionnaires

5. Recruit subjects (5 - 10000000000000)

Ensuring a Controlled Environment

- Isolating the cause: control condition

Everything else must be the same

Ensuring a Controlled Environment

- Hypothesis: "*If mobile phones are used then more tumours will occur*"
- Cause: mobile phones
- Effect: tumours

One condition where **mobile phones** are **present**

One condition where **mobile phones** are **absent**

What else do you want to keep constant?

???

Everything else must be the same

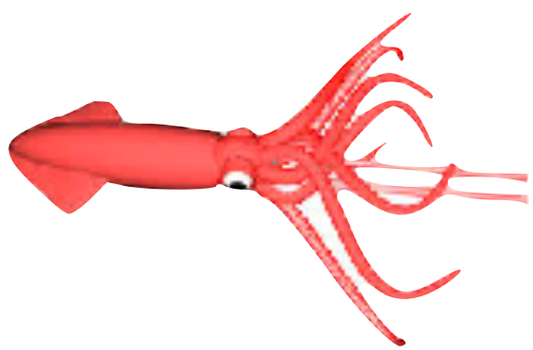
Ensuring a Controlled Environment

- Isolating the cause: control condition

Everything else must be the same

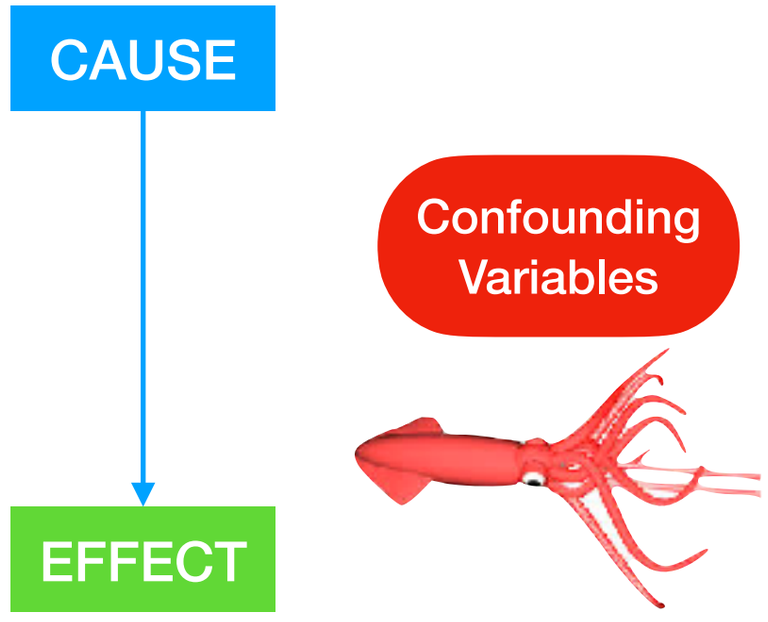
Confounding Variables: Tertium Quid

- Examples of confounding variables
  - Type of phone
  - Brain health
- Killing the Tertium Quid
  - Well thought-out and well executed experiment
  - Balanced experiment
  - Randomisation



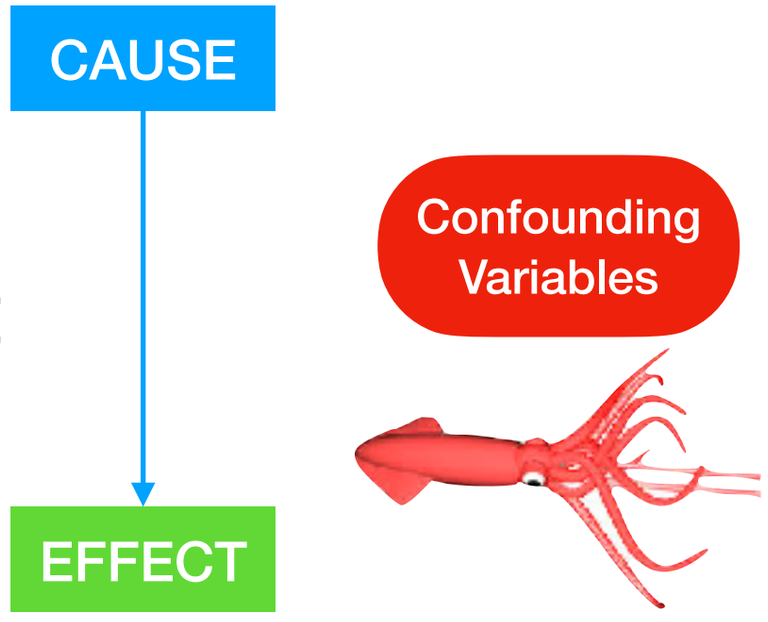
Independent/Dependent Variables (Automatic Evaluation)

- Independent Variable
  - Variable that is manipulated
    - e.g., type of training loss, encryption mechanism
- Dependent Variable
  - Variable that is measured
    - e.g., F-1 score



Independent/Dependent Variables (Human Evaluation)

- Independent Variable
  - Variable that is manipulated
    - e.g., phone use, type of diet
- Dependent Variable
  - Variable that is measured
    - e.g., brain tumours, blood pressure



Experimental Hypotheses

- A Hypothesis is:
  - Your prediction of outcome, in terms of the IV and DV

- Null hypothesis: that there is no difference between experimental conditions (i.e., changing the IV does not lead to any real changes in DV)

  - The aim is to disprove the null hypothesis

Hypotheses Examples

- ***If*** *task success* *is* ***related*** *to website structure*, ***then*** *changing the website's structure will result in changes in task success.*

- ***If*** *user preference* *is* ***related*** *to speed of spoken output*, ***then*** *people who experience different speed of speech synthesiser will give different preference ratings.*

  - Blue is dependent variable, red is independent variable
  - Blue is what you measure, red is what you manipulate/ change

Attributions

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