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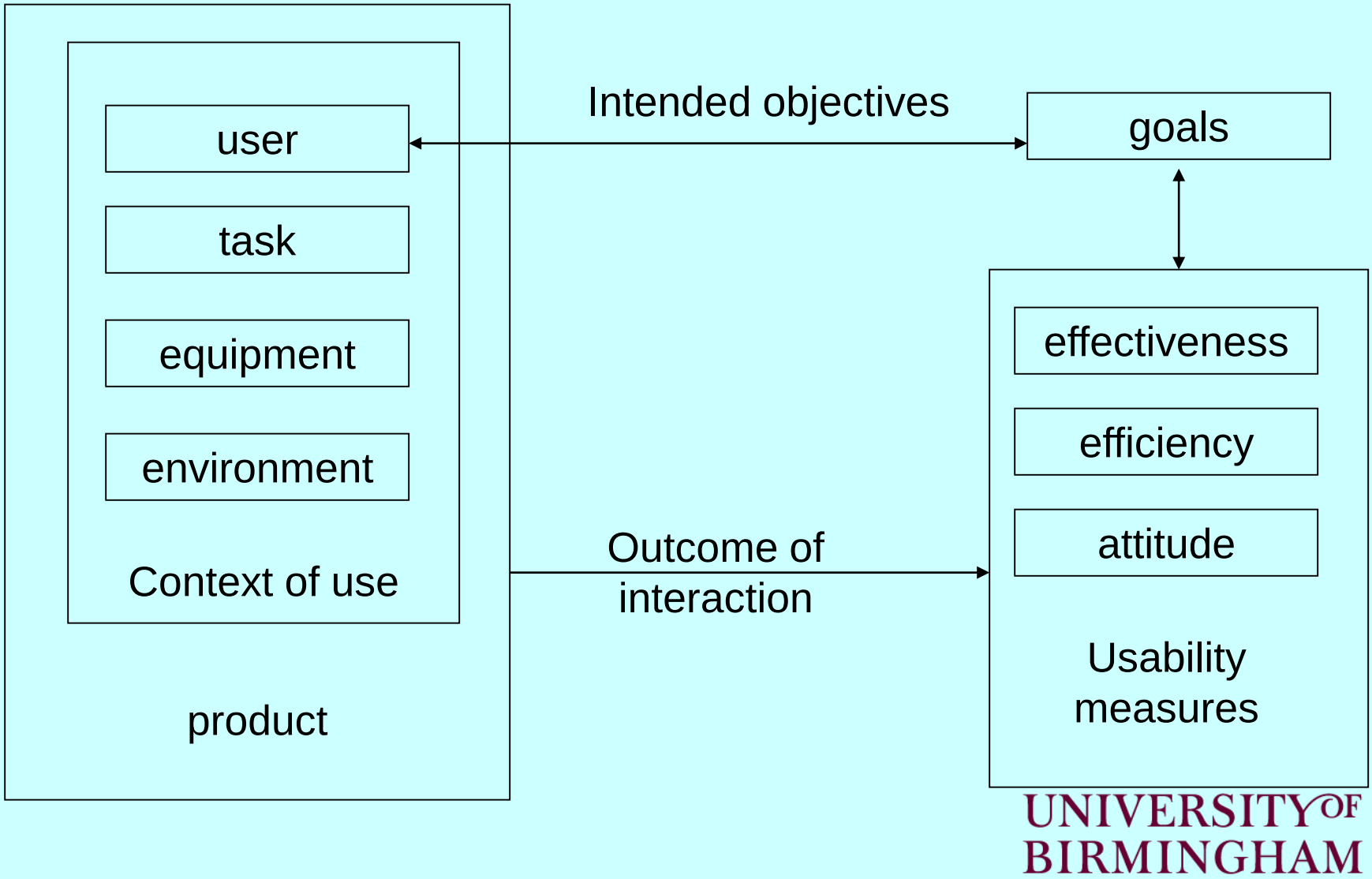
School of Computer Science

EVALUATION METHODS AND STATISTICS

Prof. Chris Baber

Chair of Pervasive and Ubiquitous Computing

ISO 9241 Context of Use



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EXERCISE#2

- measurements on each scale for Usability…

Usability Measure	What is measured?	Nominal	Ordinal	Interval / Ratio
Effectiveness	How well has a task be performed?			
Efficiency	How well has performance used the resources available?			
Attitude	How good do users think the performance has been?			

Possible answers to Exercise#2

	Nominal	Ordinal	Interval	Ratio
Efficiency	Helpful / Not	Likert scale of 'helpfulness'	Proportion of task completed	Time completion time
Effectiveness	Easy / Hard	Subjective Workload		Number of errors; physiological measures of effort/ attention
Attitude	Like / Dislike	Software Usability Scale; Software Usability Inventory Metric		

EXERCISE#3

name the colour of the ink in which these words are printed as quickly as possible

Yellow

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Blue

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Red

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Green

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Blue

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Green

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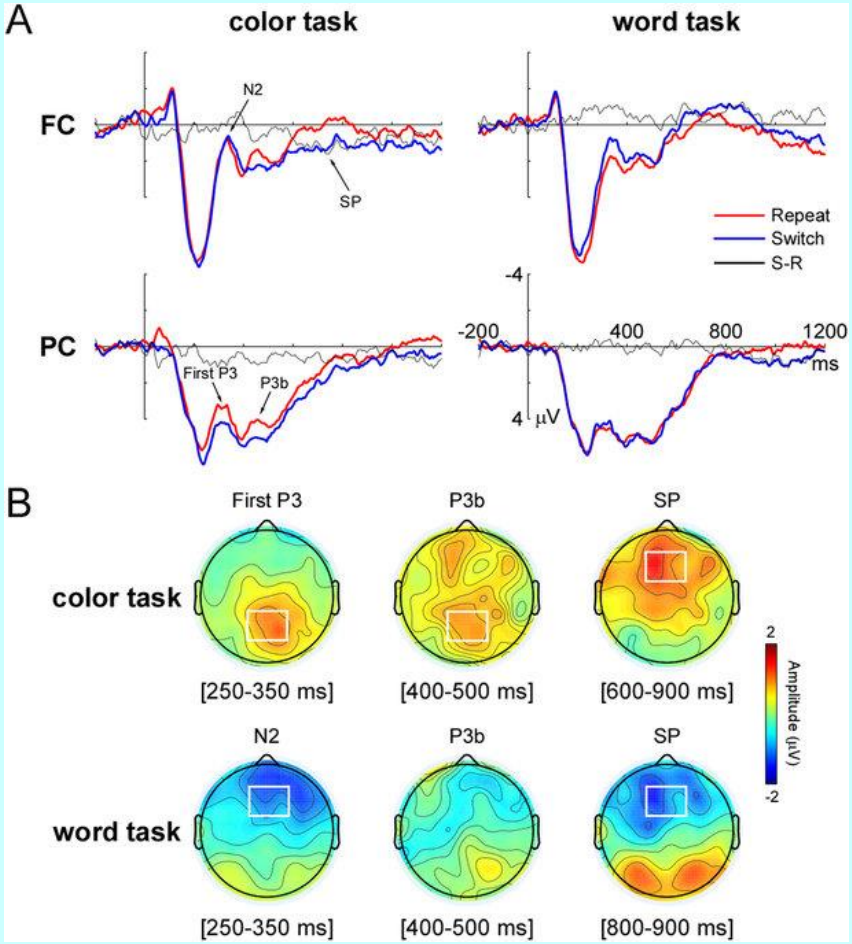
Stroop Task

Stroop (1935):

- Congruent: word name equals ink colour
- Incongruent: word name does not equal ink colour

Stroop, J.R. (1935). Studies of interference in serial verbal reactions. J. Exp. Psychol., 18:643-662.



Wu et al., 2015, ***Nature*, http://www.nature.com/articles/srep10240**

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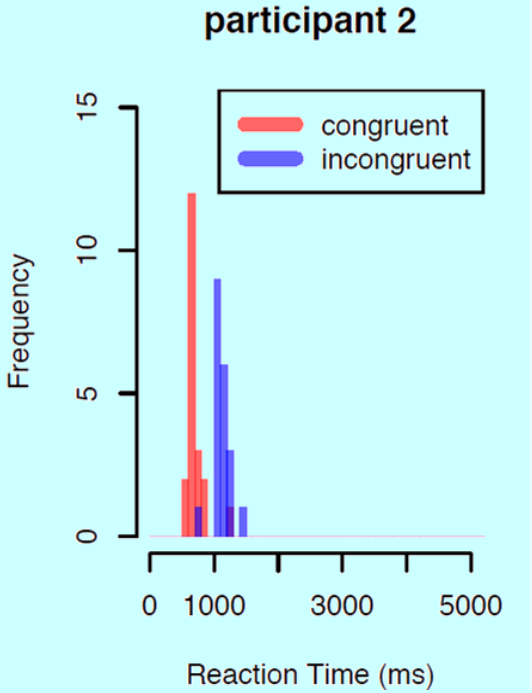
Warrant (Theory / Assumptions)

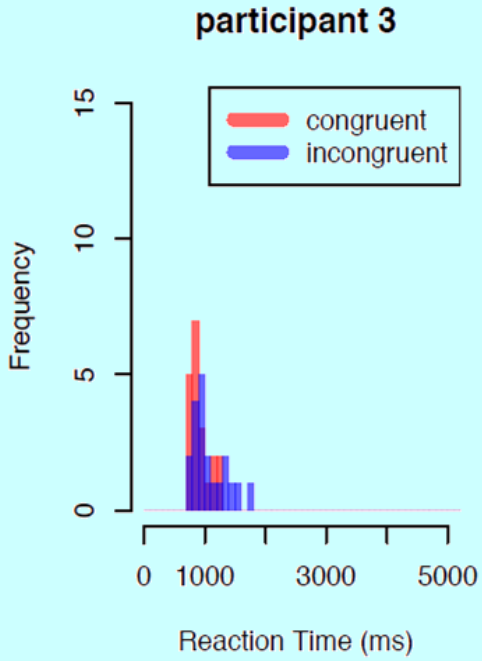
- Top-down control of human information processing is limited
- (Adult) Humans do not seem to capable of ‘switching off’ word reading
- Words can be read more quickly than colours can be named

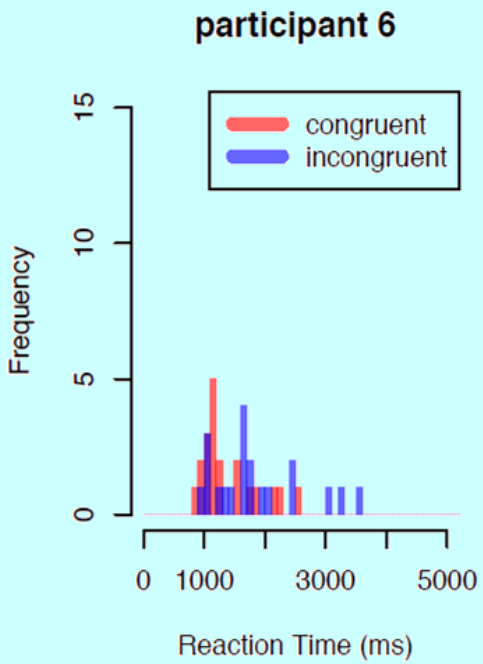
Example of Data from the Stroop Task

UserID	T	Cond	Word	Color	Response	Time
74229	15	IncW	YELLOW	G	G	896
74229	16	IncW	GREEN	B	B	1472
74229	17	IncW	YELLOW	R	R	1008
74229	18	IncW	BLUE	Y	B	1023
74229	19	IncW	GREEN	R	R	1056
74229	20	IncW	BLUE	Y	Y	1040
74229	21	ConW	YELLOW	Y	Y	1548
74229	22	ConW	RED	R	R	840
74229	23	ConW	YELLOW	Y	Y	640
74229	24	ConW	RED	R	R	752
74229	25	ConW	GREEN	G	G	815
74229	26	ConW	YELLOW	Y	Y	800
74229	27	ConW	RED	R	R	736

Looking at the data…







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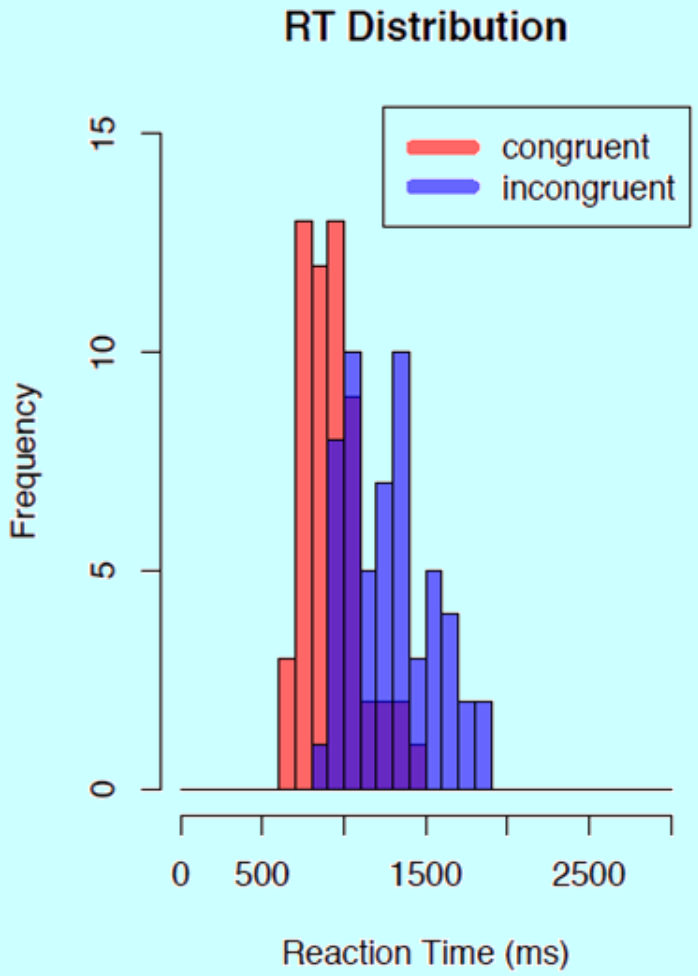
Features of the Frequency Plots

- There are more values in the middle than at the extremes.
- The data are is **noisy**. While there is a pattern the curves are not perfectly smooth.
- The plots are **skewed**. The frequency distributions have a long-tail to the right (i.e., there is a limit on how fast you can be (to the left) but no limit on how slow.)
- Plots for 4 and 6 have **outliers.**
- There are general properties of human reaction time curves though for tasks that take a longer duration the curves become progressively less skewed.

Distribution of means from Stroop Experiment

- n = 57 participants
- Skew is (somewhat) reduced for Congruent and Incongruent conditions



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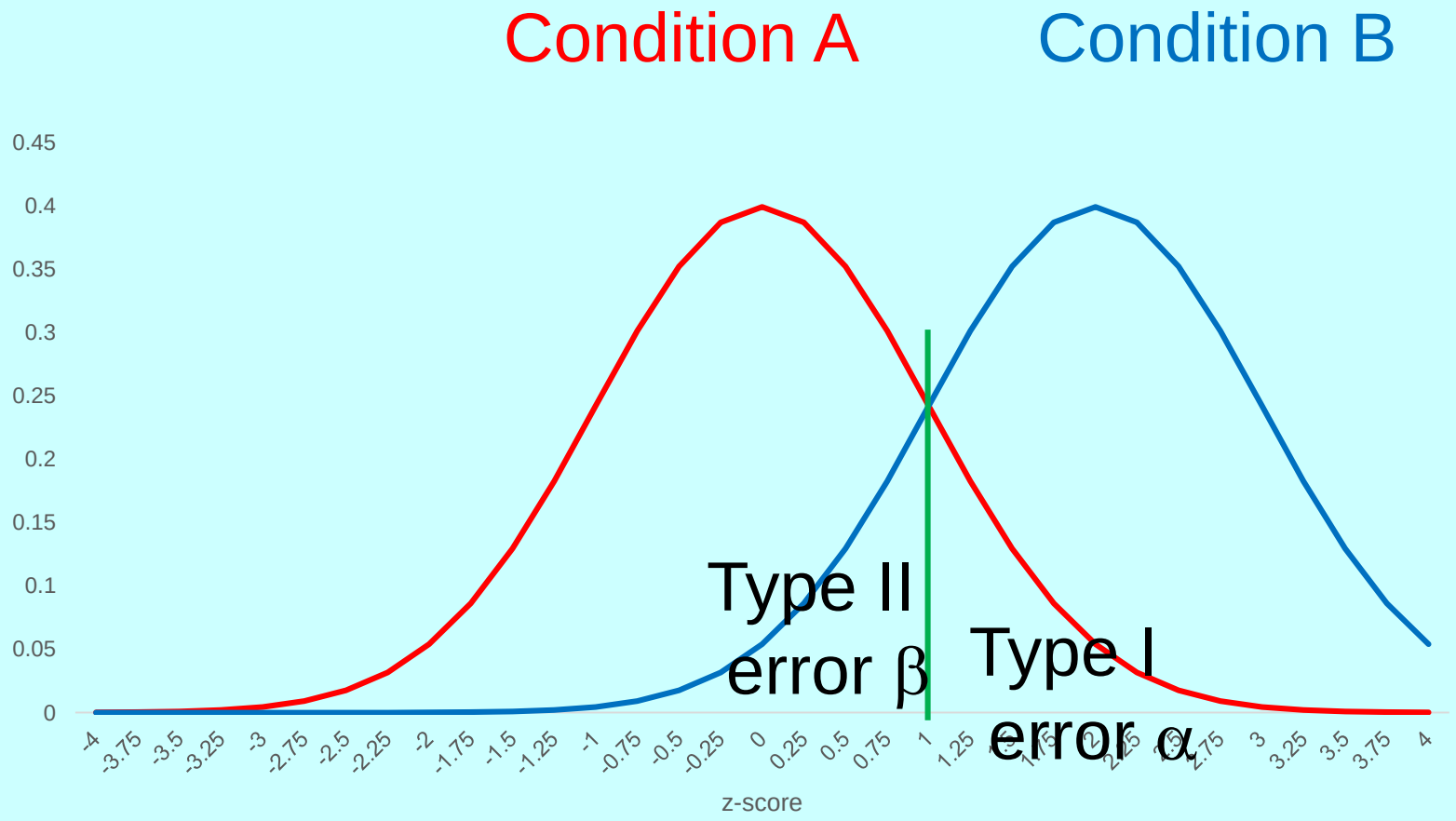
Type I and Type II Errors



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False Claims and Errors

- **Type I error**
  - We could accept the Alternative hypothesis when it is false (false positive).
  - Many statistics tests are designed to minimise this error.
  - Type I errors define the significance level (α) that the experimenter will accept (conventionally 5%)

False Claims and Errors

- **Type II error**
  - We could accept the Null hypothesis (fail to reject it) when it is false (false negative).
  - The probability of a Type II error is defined as β
  - The probability of correctly rejecting a false null hypothesis is defined as 1- β, which called Power.

Hypothesis Definition and Testing

- A good hypothesis is one that can be rejected.
- That is, a good hypothesis is **falsifiable**.
- We define Null and Alternative Hypotheses when planning an experiment. These can be regarded as claims (in an argument).
- If we present claims, we should also present warrant (to explain why we make the claim) and data

Which hypothesis can be falsified?

H0 (null): There are no birds of prey on the University of Birmingham campus.

H1 (alternative): There are birds of prey on the University of Birmingham campus.

Absence of evidence is not evidence of absence.

But, we can **reject** H0 as soon as we see (or hear) a bird of prey.

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Statistical testing can help us reject the null hypothesis

The results indicated significant correlation between Facebook use and social capital, $r(267) = .29$, $p<0.001$.

There was a significant effect on incongruence on reaction times [$t(56) = 15.58$, $p<0.001$].

These state that the likelihood of accepting the null hypothesis is less that 1 in 1000, so we can reject it (and accept the alternative hypothesis)

Designing Experiments

- **Independent** Variables define the conditions of the experiment
  - In the Stroop task, there are two Levels of the independent variable ‘ink colour and name of word’: congruent and incongruent
- **Dependent** Variables defines what is measured
  - In the Stroop task, the dependent variable is Reaction Time
- **Confounding** Variables define what *might* expect the results of the experiment if they are not taken into account
  - These could include the Order in which each condition is performed or the Order in which stimuli are presented
  - These could include characteristics of people taking part in the experiment

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Experimental Design for Stroop Task

- The **Independent Variable** for the Stroop experiment has two conditions: One with congruent stimuli and the other with incongruent stimuli.
- The **Dependent Variable** is Reaction Time
- The claim concerns the relative effect of congruent and incongruent colour words on **Reaction Time** (**RT**) and applies to a **population**, i.e., all adult humans.
  - To test this claim, we define an Hypothesis
    - Two-tailed: There will be a difference in reaction time to congruent and incongruent words.
    - One-tailed: Reaction time to congruent words will be faster than reaction time to incongruent words.

Variation in Dependent Variables

- Systematic: due to change in Independent Variable
- Unsystematic: due to confounding variables

Experimental Design

Hypothesis: Reaction time to congruent words will be faster than reaction time to incongruent words	
Independent Variable: Congruent Words (colour of ink = name of word), Incongruent Words (colour of ink ≠ name of word)	
Control Condition: Congruent Words	**Experimental Condition:** Incongruent Words
Dependent Variable(s): Reaction Time	
Task: participants will be asked to read, as quickly as possible, single words on a display. The words will be the names of colours and will be presented either in the same colour as the word's name or in a different colour	
Confounding Variables: performance could be affected by ability to perceive colour ('colour-blindedness') and knowledge of the names of colour ('language skills')	

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Types of Study Design

- Post-test
  - Control versus experimental group complete task: outcome is measured and compared
- Pretest-Post-test
  - Control versus experimental group complete task and outcome is measured and compared; experimental group treatment and both groups tested again
- Solomon Four Group
  - 2 control groups and 2 experimental groups; pretest-post-test and post-test only.
- Factorial Design
  - 2 or more independent variables manipulated.
- Crossover (repeated measures) Design
  - Participants randomly allocated to perform both control and experimental conditions complete task and outcome is measured and compared

Experimental Design for Stroop Task

- From the population (say, all adult humans in the world), we take a **sample** of **N participants**.
- Stroop experiments typically use a **within-participant design**, where all participants take part in all **conditions**.

Participants (Subjects)

	Source of Unsystematic DV variation	Control
Between Subjects	Individual differences	Match participants on key characteristics
		Random allocation to condition
Within Subjects	Practice / Order effects	Modify order of stimuli
	Boredom / fatigue effects	Design in breaks
	Asymmetric transfer effects	Counterbalance conditions

Assigning Participants to Conditions

- We want to reduce the Confound of Order Effects
  - That is, if every participant does the same tasks in the same order, how do we know that they are not simply getting better with practice (or worse through fatigue)?
  - So, we randomise the Order in which people complete the tasks
  - For two conditions, this is easy to manage…

Participant	Trial 1	Trial 2
1	A	B
2	B	A

  - …and we assign participants to either group 1 or group 2 (either by Appearance (when they turn up to do the study) or by Random number generation)

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Latin Squares

- We *could* simply put in more conditions, offsetting to cycle around…
- …making sure that each condition appears once in each row and column

Participant	Trial 1	Trial 2	Trial 3	Trial 4
1	A	B	C	D
2	D	A	B	C

- …BUT this introduces a confound of unbalanced Order Effects because, sometimes B follows A, C follows B…

Balanced Latin Squares

- …so we ensure that each condition appears once in each row and column
- AND that each condition follows each other condition.

Group	Trial 1	Trial 2	Trial3	Trial4
1	A	B	D	C
2	B	C	A	D
3	C	D	B	A
4	D	A	C	B

- There is a simple algorithm here…
  - Column 1 has the conditions in alphabetic order
  - Column 2 is the same as column 1 with wraparound…
- Notice also, that for four conditions, we need multiples of 4 groups (assuming that we'd need at least 8 participants per group, we can estimate the size of the sample we require for such an experiment)

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