Scales of Measurement

Scale	Description	Examples
Nominal	Catergorical; order doesn't matter	*Gender*: 1 (male), 2 (female)
Ordinal	Ordered values. Order matters, but not difference between values	*Agreement*: 1 (SD), 2 (D), 3 (Neutral), 4 (A), 5 (SA). *Pain Scale* (1-10)
Interval	Numeric. Difference between values is meaningful	*Relative Temperature*: °C, °F, pH
Ratio	Numeric. Zero and ratios are meaningful	*Height, Weight, Absolute Temperature (K)*

Measurement is the process of observing and recording the observations collected as a part of a research effort.

Step 1: Define Research Questions

eg. How does your technique...

• Compare with alternative techniques?	**Techniques**
• For which target population?	**Target users**
• For what tasks?	**Tasks**
• In terms of what measures?	**Performance measures**
• In what context?	**Other factors**

Target users: need to be specific - students who have been using the desired medium *consistently*, for example
Performance measures: like *speed, accuracy*
Other factors: other than different techniques, what factors can *influence the measures?*

Step 2: Define Variables

IV	• Factors manipulated in the experiment • Have multiple levels
DV	• Factors being measured
Control variables	• Attributes fixed throughout the experiment • **Confounders** - attributes that vary and aren't accounted for
Random variables	• Attributes that are randomly sampled • Increases generalisability

Confounders rather than IVs could have caused changes in DV.
They make it difficult/impossible to draw conclusions.
Order of presentation and *prior experience* are two important confounders that we need to control. (by counter-balancing and proper sampling)

Step 3: Arranging Conditions (Within-Subjects)

List the **IV** and their **levels**	eg. Technique (2 levels: Gesture, Marking) Menu depth (2 levels: 1, 2)
Determine **counter-balancing strategies** for each IV	• Full counter-balancing (**n!** conditions) • Latin Square (**n** conditions) • No counter-balancing (sequential) (**1** condition)

Step 3: Arranging Conditions (Within-Subjects) (cont)

Determine **minimum no.** of participants	Multiply all conditions together
Determine **factorial arrangement** of conditions	Put the permutations together

Determine arrangement for **each participant**

Condition reduction strategies:
• Pick the most important/interesting factors to test
• Run a few IVs at a time - if strong effect, include IV in future studies, otherwise, pick *fixed control value* for it

One-way ANOVA

Basic Idea: ANOVA tries to find the sources of this variance:	• due to difference *between* groups • Variability *within* each group
Total Variability = BetweenGroup + WithinGroup	$SS^T = SS^M + SS^R$
Ratio of Variability	$F = (SS^M/DF^B) / (SS^R/DF^W)$

If the experiment is **successful**, then $SS^M > SS^R$.
Between-group variability will explain more variance than within-group.

The bigger the **F value**, the smaller the **p value**, and the less like the null hypothesis (no difference) is true.

Steps:

1. Calculate SS^T	$SS^T = s\_grand^2 (N-1)$ $DF^T = (N-1)$

One-way ANOVA (cont)

2. Calculate SS^M	SS^M=∑_i ✖ n_i ($\bar{x}_i$–x–$_{grand}$)^2 • sum of *n* ✖ difference of means from the grand mean DF^M = (No. of groups - 1)
3. Calculate SS^R	SS^R=∑_i ✖ s_i^2 (n_i–1) • sum of variance ✖ no. of results in each group DF^R = total no. of results - no. of groups
Double check: SS^T=SS^M+SS^R & DF^T = DF^M - DF^R	
4. Calculate Mean Squared Error	MS^M = SS^M/DF^M MS^R = SS^R/DF^R
5. Calculate F-ratio	F = MS^M / MS^R

if F is lower than value in F-table, then p < 0.05 ➔ results are statistically significant

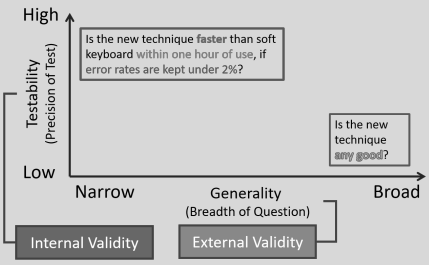
Behaviour Theories

Health Belief Model	Perceived Benefits v Perceived Barriers, Perceived Theat, Self-Efficacy, Cues to Action all contribute to Likelihood of Engaging in Health-Promoting Behaviour

Behaviour Theories (cont)

Theory of Reasoned Action	Self-belief + Influenced beliefs, Attitudes, Intention ➔ Behaviour
Self-Determination Theory	Intrinsic (self-benefit) v Extrinsic motivation (external benefits)
Goal Setting Theory	Basic idea: goal serves as a motivator, work harder as long as they believe goal is achievable. Importance in Clarity, Challenge and Feedback
Social Cognitive Theory	Cognitive, Environmental and Behavioural factors determine human behaviour
Fogg Behavioural Model	Behaviour = Motivators, Ability, Triggers • Motivators: Sensation, Anticipation, Social Cohesion • Ability: Train or Simplify • Triggers: Spark, Signal or Facilitator

Testable Research Questions



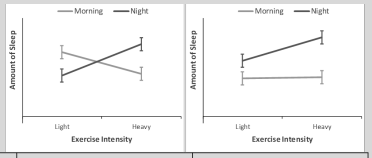
Weak questions are *untestable* and broad
Stronger questions are *more testable*, but *less generalizable*

Step 4: Define Trials

Estimate the **time for each trial**	around 5-10 seconds?
Estimate the **time for each condition**	Time for each trial ✖ no. of trials for each condition
Balance the trials (so experiment is within 45 min)	
Combine with the **condition arrangement**	Essentially, find the total time the experiment will take

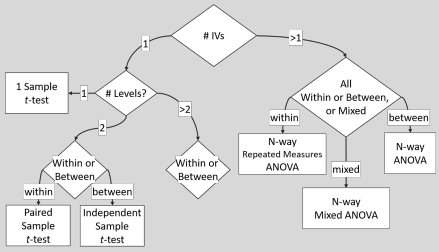
Trials: a single repetition of a single condition
Typically want to have at least **3 trials per condition** to increase reliability
Consider time: trials should last for **45 minutes** (excluding pre and post interviews)

Interaction Effect



Main effect? IV1: Exercise	✖	Maybe
Main effect? IV2: Time	✖	✓
Interaction Effect?	✓	✓

Which t-test or ANOVA?



Cognition Processes

Attention

Perception

Memory

Learning

Reading, speaking & listening

Problem-solving, planning, reasoning & decision-making

Attention

Selecting things to concentrate on at *a point in time* from the mass of stimuli around us

Focus on information that's **relevant** to what we are doing

Involves audio/visual senses

Design implications:	• Make information **salient** if it needs attending to • make things **stand out** •**avoid cluttering** interface

Perception

How information is **acquired** from the world, and transformed into experiences

Design representations that are readily perceivable

Implication:	• Group information • Text should bne legible and distinguishable from the background

Memory

Stages of memory:	• Encoding • Storage • Retrieval
Encoding:	• Determines which info is attended to in environment + how it's intepreted • Context affects extent to which info can be retrieved - different context → difficult to recall
Implications:	• Focus attention/no complicated procedures • Recognition over recall • Provide various ways of encoding and retrieving info (searching v history)
Storage:	
Sensory Memory:	• **shortest-term** memory, acts like a buffer for stimuli retrieved • Ability to remember and process info at same time • Information will **decay** within 10-15s • Extended by rehearsal, hindered by interference
Long-term Memory:	•Declarative Memory (factual info): • Semantic Memory (general) + Episodic Memory (personal knowledge) • Procedural Memory (skills/habits)

Memory (cont)

Retrieval:	• Internal/External stimuli for **retrieval cues** • Encoded at same time as memory

Cognitive System Principles

Uncertainty Principle	$T=I^CH$

where T = Decision time, H = log2(n+1) (where n is the no. of choices)

Variable Rate Principle	More effort → Faster processing (ie. cycle time ↓

Cycle time also diminishes with practice: $\_n=T\_1 \times n^{-\alpha}$

Fitts' Law	$T\_M=a+b$ log_2$(A/W+1)$

where A = distance to target, W = error tolerance

Trans-theoretical Models

5 Stages of Change	Pre-contemplation, Contemplation, Preparation, Action, Maintenance
Processes of Change	Consciousness raising, Social liberation, Goal setting, Helping relationships, Rewards

Processes of change can be applied to 5 stages of change.
Each person will value different processes differently.

By **eevyern**
cheatography.com/eevyern/

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Statistics

We use sample statistics to estimate/**make inferences** about population parameters

Due to *uncertainty* and *variability*, conclusions and estimates may not always be correct.

Need measures of **reliability**

• **Confidence interval**	• the confidence that the *true population value* of a parameter falls within a **confidence interval** • affected by: **variation & sample size**
• **Level of significance**	•"P value", α • the prob. of **rejecting the null hypothesis** when it is actually true (*Type I error*) • ie. concluding that there is a difference when there may be no actual difference • signifies the probability that the difference is due to chance
Level of Significance **Thresholds**	• Not significant (p>.1; p=n.s.) • Marginally significant (p<0.1) • (Fairly) significant (p<.05) • (Good) significant (p<.01) • (Excellently) significant (p<.001)

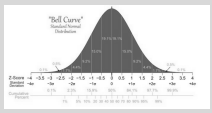
Some Formulae

$$SSE = \sum_{i=1}^{n} (x_i - \bar{x})^2 = 5.2$$

$$Variance = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n} = \frac{5.2}{5} = 1.04$$

$$SD = s = \sqrt{Variance} = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n}} = \sqrt{\frac{5.2}{5}} = 1.02$$

Cumulative Percentage



Central Limit Theorem

As the sample size gets larger...

The mean of sample means approaches the **population mean**

The standard error of the sameple means = the **standard deviation of the population mean**

$SE = s/\sqrt{n} = \sqrt{(Variance/n)}$

SED Between 2 Samples

$SE = \frac{s}{\sqrt{n}}$: $SE_{M_1} = \frac{s_1}{\sqrt{n_1}}$, $SE_{M_2} = \frac{s_2}{\sqrt{n_2}}$

Propagation of Errors: combine errors in **quadrature**

$$\Delta f(x,y) = \sqrt{\left(\frac{\partial f}{\partial x}\Delta x\right)^2 + \left(\frac{\partial f}{\partial y}\Delta y\right)^2} \qquad f(M_1, M_2) = M_1 - M_2$$

$$SE_{M_1 - M_2} = \sqrt{SE_{M_1}^2 + SE_{M_2}^2} = \sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}$$

2-Sample t-test

Small sample sizes → not normal distribution	Use **t-distribution**

2-Sample t-test (cont)

Steps:	1. Calculate mean difference 2. Calculate SD 3. Calculate no. of SDs away from 0 4. Calculate df = smaller *n* - 1 5. Calculate p-value, for significance (which p-value is it closest to)
If given desired **confidence interval**, steps:	1. Given desired CI 2. Get no. of SDs away from 0 from t-table 3. Calculate margin of error in units ((2) ✖ SD)
Difference between groups more likely to be significant if:	• **Large difference** between means • **Small SD** or **large n** in each group
Assumptions:	• Continuous variable • Independent samples

Also called the **independent-samples t-test**

Other tests:

• One-sample t-test (sample v constant)

• Paired-sampled t-test (within-subjects, repeated measures)

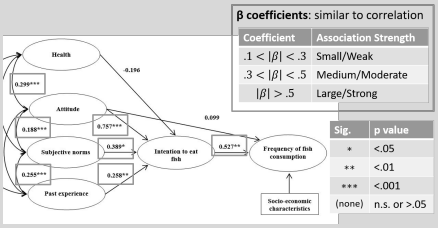
• One-way ANOVA

Cognitive Heuristics

Affects	where **emotions** influence **decisions**
Availability	where people **overestimate** the importance of information available to them
Confirmation Bias	where we only listen to information that confirms out **preconceptions**
Halo Effect	where an outcome in one area is due to factors *from another*
Framing Effect	where the words used push listeners in a **certain direction**

Implications: watch out for biasing your participants.

Structural Equation Modeling



Design Strategies for Lifestyle Behaviour Change

- Abstract & Reflective
- Unobtrusive
- Public
- Aesthetic
- Positive
- Controllable
- Trending/Historical
- Comprehensive

Nielsen Heuristics

- Visibility of system status
- Match system and real world
- User control and freedom
- Consistency and standards
- Error prevention
- Recognition over recall
- Flexibility and efficiency of use
- Aesthetic and minimalist design
- Help users recognise, diagnose, recover from errors
- Help and documentation

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