Quantitative Analyses

User Research Methods 2017

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slides adapted from Petr Slovak

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13.4.3 Poisson Regression Analysis

Exactly paralleling logistic regression, we have three forms of the regression equation in Poisson regression. First, we predict the expected number of events ($\hat{\mu}$) from values on a set of predictors $X_1, X_2, \ldots, X_k$.

(13.4.3) $$\hat{\mu} = e^{(B_1X_1+B_2X_2+\cdots+B_kX_k+B_0)}.$$

Equation (13.4.3) is not in a form that is linear in the coefficients. If we take the logarithm of both sides, we have a second regression equation that is linear in the coefficients and in which the logarithm of the predicted expected number of events is the predicted score:

(13.4.4) $$\ln(\hat{\mu}) = B_1X_1 + B_2X_2 + \cdots + B_kX_k + B_0.$$

Third, we can write an equation in which we predict the probability of each specific number of events, given the expected average number of events $\hat{\mu}$. For the predicted probability of a count of c events ($\hat{p}_c$) we have

(13.4.5) $$\hat{p}_c = \frac{e^{(-\hat{\mu})}\hat{\mu}^c}{c!}.$$

Let us focus on Eq. (13.4.3). This is a simple exponential equation. The equation represents a curve like that in Fig. 13.1.1(C), which shows the predicted number of events as a func-

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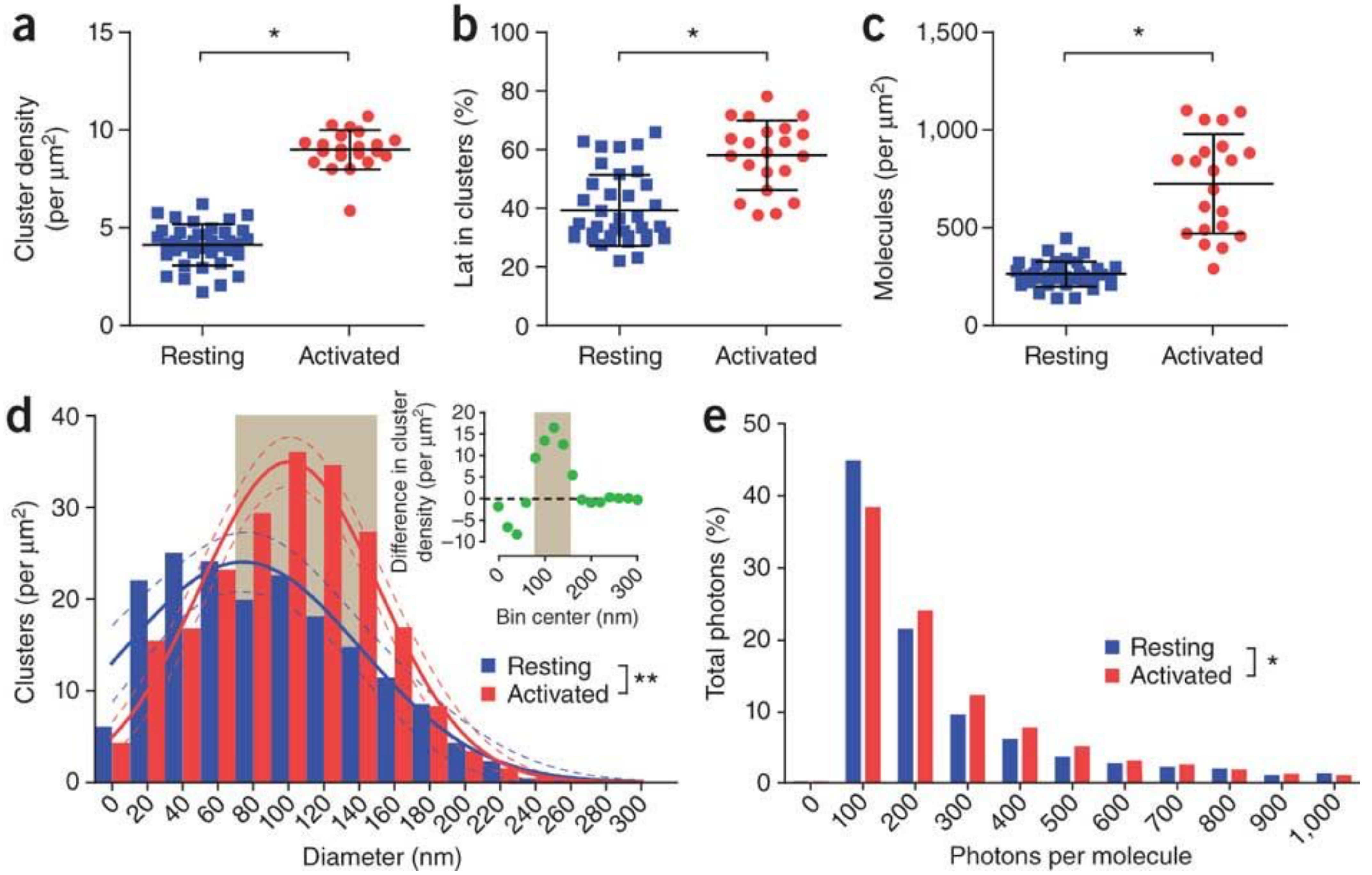

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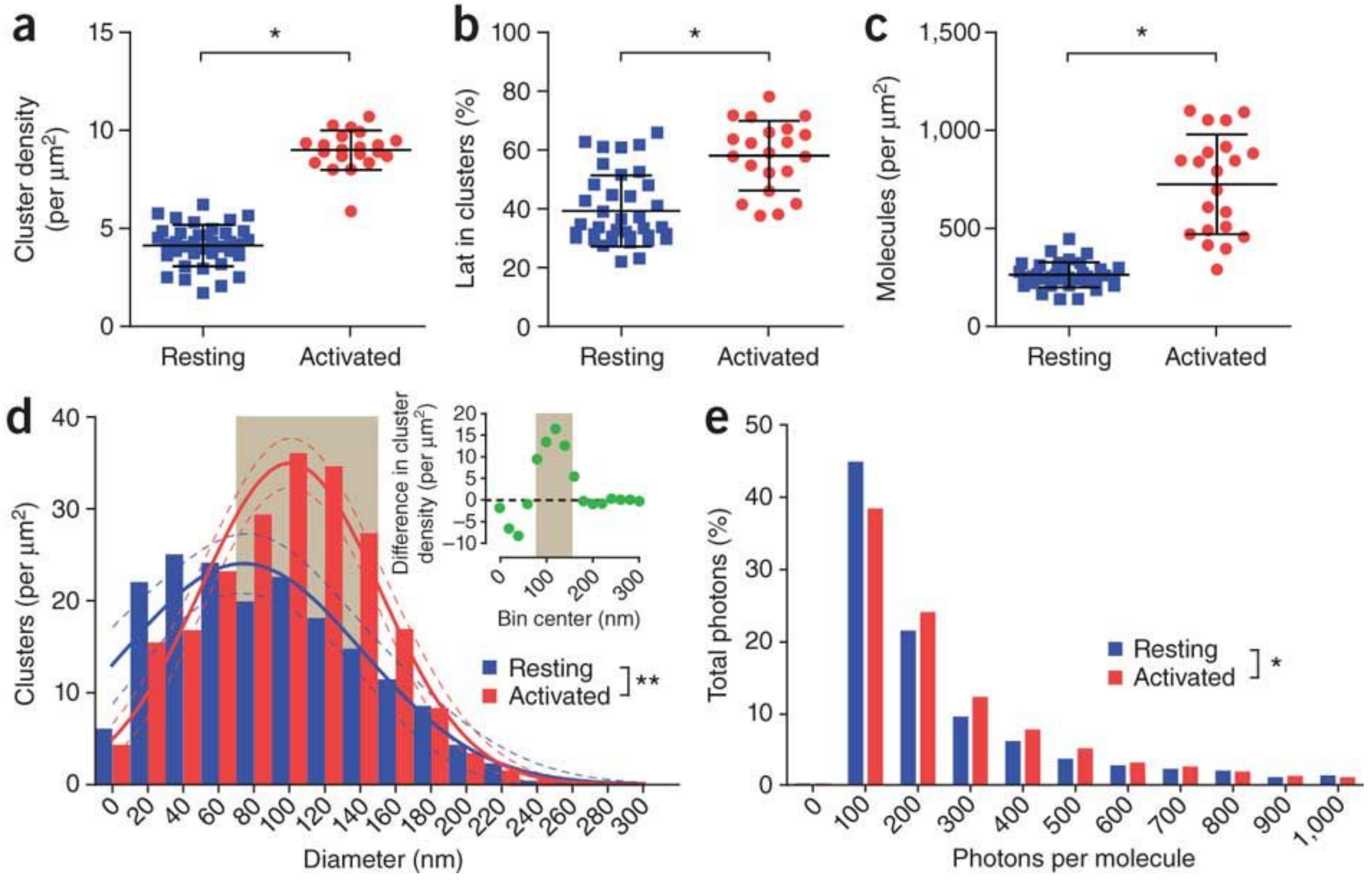
	Null Hypothesis (H_0)			
Population mean (μ)	$\mu = \mu_0$	$\dfrac{(\bar{x}-\mu_o)}{\sigma/\sqrt{n}}$	Z	Normal distribution or $n > 30$; σ known
Population mean (μ)	$\mu = \mu_0$	$\dfrac{(\bar{x}-\mu_o)}{s/\sqrt{n}}$	t_{n-1}	$n < 30$, and/or σ unknown
Population proportion (p)	$p = p_0$	$\dfrac{\hat{p}-p_o}{\sqrt{\dfrac{p_o(1-p_o)}{n}}}$	Z	$n\hat{p},\ n(1-\hat{p}) \geq 10$
Difference of two means ($\mu_1 - \mu_2$)	$\mu_1 - \mu_2 = 0$	$\dfrac{(\bar{x}_1-\bar{x}_2)-0}{\sqrt{\dfrac{\sigma_1^2}{n_1}+\dfrac{\sigma_2^2}{n_2}}}$	Z	Both normal distributions, or $n_1, n_2 \geq 30$; σ_1, σ_2 known
Difference of two means ($\mu_1 - \mu_2$)	$\mu_1 - \mu_2 = 0$	$\dfrac{(\bar{x}_1-\bar{x}_2)-0}{\sqrt{\dfrac{s_1^2}{n_1}+\dfrac{s_2^2}{n_2}}}$	t distribution with df = the smaller of n_1-1 and n_2-1	$n_1, n_2 < 30$; and/or σ_1, σ_2 unknown
Mean difference μ_d (paired data)	$\mu_d = 0$	$\dfrac{(\bar{d}-\mu_d)}{s_d/\sqrt{n}}$	t_{n-1}	$n < 30$ pairs of data and/or σ_d unknown
Difference of two proportions ($p_1 - p_2$)	$p_1 - p_2 = 0$	$\dfrac{(\hat{p}_1-\hat{p}_2)-0}{\sqrt{\hat{p}(1-\hat{p})\left(\dfrac{1}{n_1}+\dfrac{1}{n_2}\right)}}$	Z	$n\hat{p}, n(1-\hat{p}) \geq 10$ for each group



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What to take home

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Reading!

Questions to ask yourself during reading

- The text talks about statistical methods in social sciences… **how is that relevant & what are the links** to user research in HCI?
- What do you think are the **key concepts/ideas** the author highlights?
- Which **words, phrases, and concepts** did you find difficult to understand?

Additionally: Come up with an example **question** relevant to the URM Course that could be addressed with quantitative methods

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Types of research/ questions we can ask

	Focus	General Claims	Typical Methods
Descriptive	Summarises data to describe a situation or events	X is happening	Observations, field study, focus group, interview

Adapted from: Lazar et al, Research Methods in Human Computer Interaction, Ch2 (p22).

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Causal	Identify causes of situation or events	X is responsible for Y	Controlled experiments, quasi-experiment

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What are descriptive statistics?

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What are descriptive statistics?

Trying to provide summarising information about a large number of observations:

- **average value** – mean, median, percentage …
- **measure of spread** – variance, range …
- **dependence** – correlation, covariation …

It is important to understand what the numbers **mean** and what they do not.

Relational Questions

	Focus	General Claims	Typical Methods
Descriptive	Summarises data to describe a situation or events	X is happening	Observations, field study, focus group, interview
Relational	**Identify relation between multiple variables**	X is related to Y	Observations, field studies, surveys
Causal	Identify causes of situation or events	X is responsible for Y	Controlled experiments, quasi-experiment

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Causal Questions

	Focus	General Claims	Typical Methods
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Relational	Identify relation between multiple variables	X is related to Y	Observations, field studies, surveys
Causal	**Identify causes of situation or events**	X is responsible for Y	Controlled experiments, quasi-experiment

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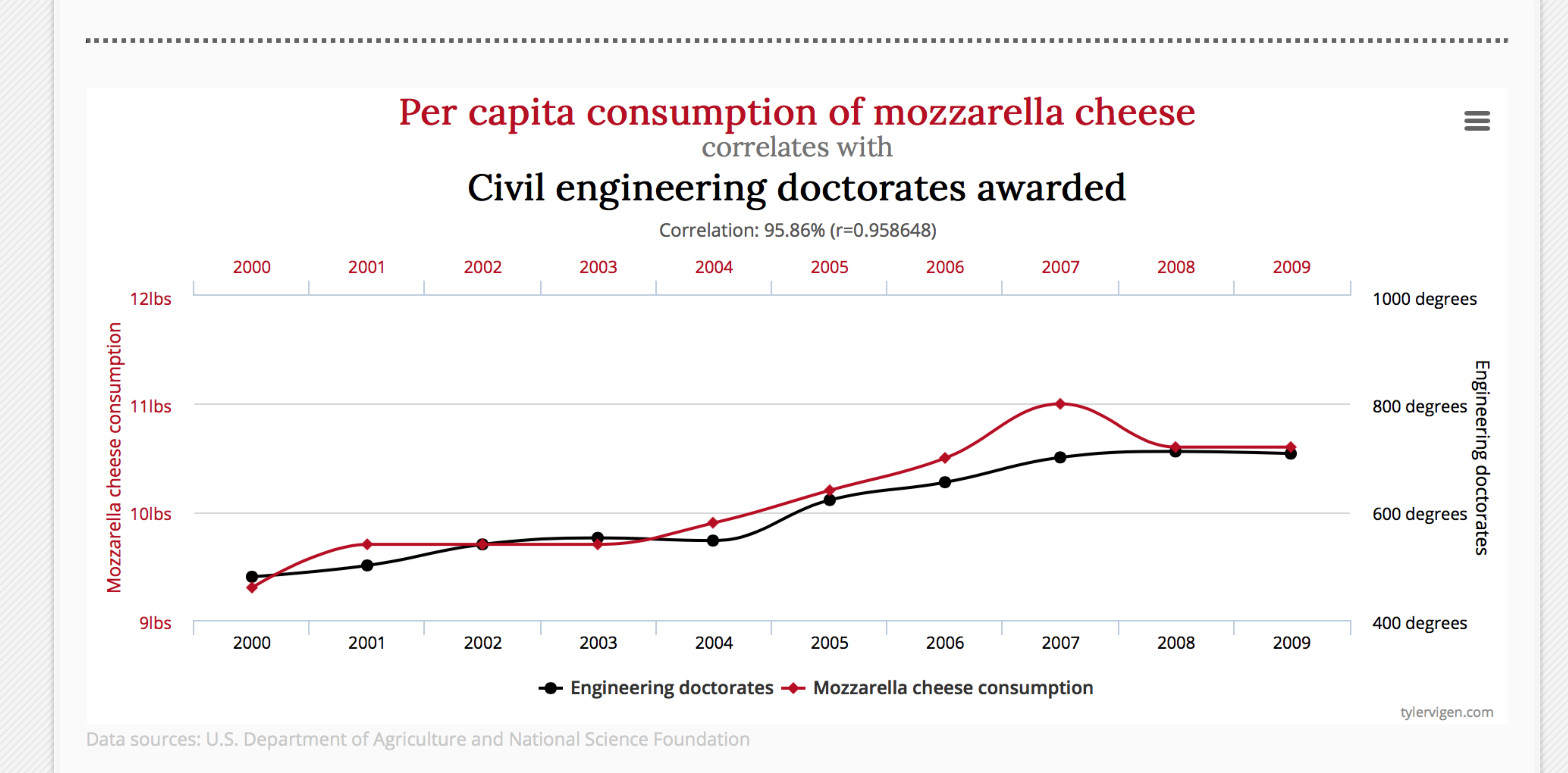
Problems with Causality



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How do you prove causality?

Discuss:

Smoking causes lung cancer?

is this ‘true’?
in what sense?

Excellent health statistics - smokers are less likely to die of age related illnesses.'

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Smoking causes lung cancer?

"… the individuals with whom we met believed that smoking causes lung cancer, if by 'causation' we mean any chain of events which leads finally to lung cancer and which involves smoking as an indispensable link"

[Cummins, Brown, O'Conner, Cancer Epide Biom Prev, 2007]

How do you prove causality?

Discuss:

Humans cause climate change?

is this ‘true’?
in what sense?

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Dependent and independent variables

Experiment: a way to look for causal effects

Independent variables: Factors to be studied that the researcher can control, possible 'cause' of the change in dependent variable

These are deemed to be **independent** of a participant's behaviour.

Typical independent variables: technology (different designs/tech/device), user (age, gender, experience), context (noise, lighting, activity level, social factors)

Dependent and independent variables

Dependent variables: Variable **dependent** on a participant's behaviour or changes in independent variables.
These are the outcomes that the researcher needs to **measure**.
Typical: time, speed, accuracy, satisfaction, retention rate...

Study: find out whether & how **changes** in independent variables **induce changes** in dependent variables
This is an attempt to uncover **causal relations**.

Experiment
Hypotheses

Experiment: a way to look for causal effects

Research Hypothesis: Precise problem statement that can be directly tested
So, it needs to **clearly operationalise** dependent & independent variables

Null Hypothesis: states no difference between experimental treatments
Alternative Hypothesis: statement that is mutually exclusive with the null hypothesis

Experiment Goals

Experiment: a way to look for causal effects

Goals:

- To find '**evidence**' to refute or nullify the null hypothesis in order to support the alternative hypothesis
- Rule out **alternative explanations**
- Potentially give arguments to **generalise** the results beyond current sample

Uncertainty remains!

Participants

Participants are often **randomly** assigned to groups according to independent variables.

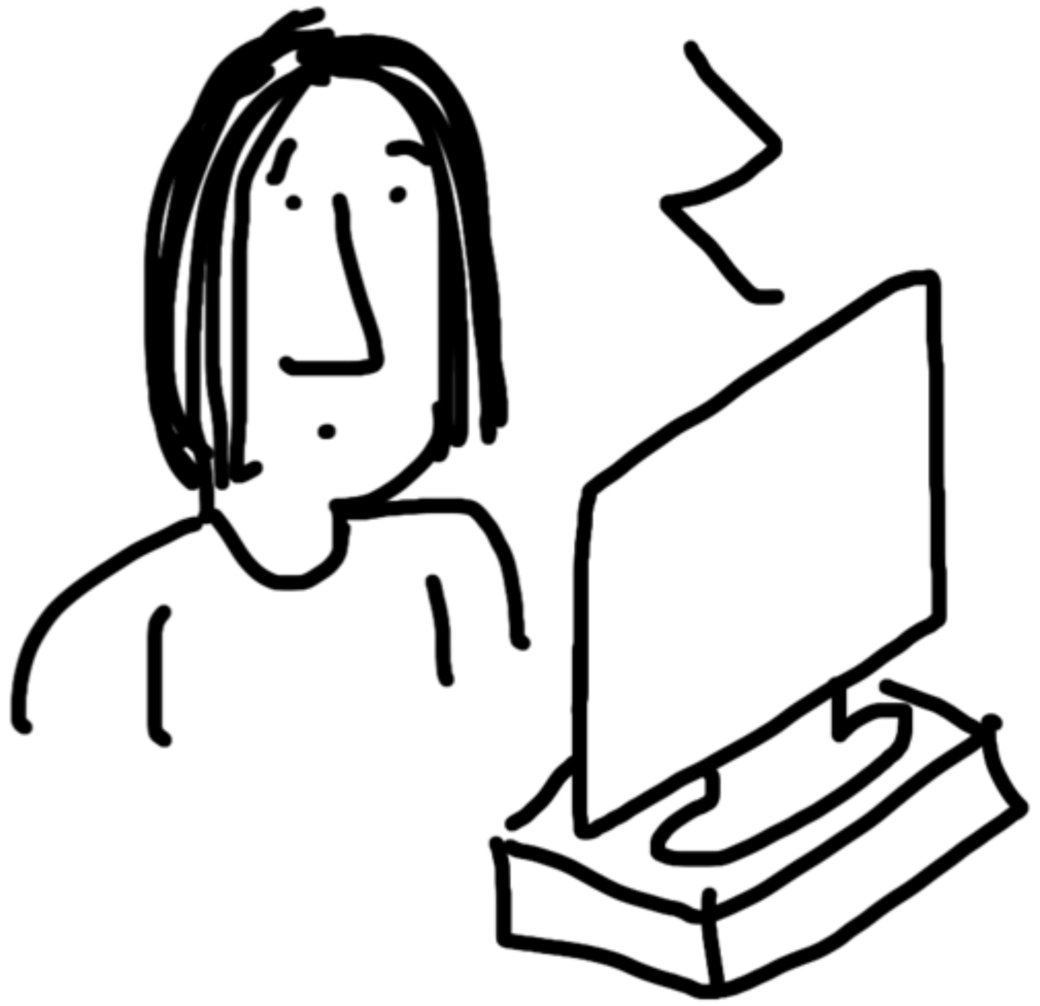
The groups are supposed to be as **similar as possible**.

Why would/could/should this work?
Is it always possible?
Any alternatives?

Participants

Participants are often **randomly** assigned to groups according to independent variables.

Dear Parents,
To show our commitment to evidence-based practice, this year's fourth grade class will be randomly assigned to one of two groups.
The treatment group will receive a good education while the control group will receive a placebo. This study will provide value for generations to come.



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Within- and Between Subject Design

Between (group) subject design

Each participant only experiences one task condition

Pro's:

- **cleaner**, since only exposed to one condition
- avoids learning effects
- fewer confounding factors, eg. fatigue

Con's:

- **individual differences** might impact results
- accordingly, need for **larger sample sizes**
- harder to get significant results

Within- and Between Subject Design

Within (group) subject design

Each participants experiences multiple task conditions

Pro's:

- **smaller sample size**
- impact of individual differences isolated
- more **powerful** tests

Con's:

- hard to control **learning effect**
- large impact of **fatigue**

randomise order of condition; provide sufficient time for training

Experiment Design

How do trackers influence activity?

Devices: Device or no device
Measures: GPS, heartrate, steps, calories, time of use
Activity: Running

Consider:

- causality vs. correlation
- types of variables (dependent, independent, intervening)
- concepts vs. measurable aspects
  ➔ operationalisation
- hypothesis (null/alternative …)
- list intervening variables you can think of

Which aspects will the study be **unable** to answer?

Assume you are able to compare the conditions perfectly for now.

Interpreting Results

In order to **generalise** to larger populations than the participants of a study, researchers use **inferential statistics**.

These are statistical assessments of whether observations reflects a **pattern** or are occurring by **chance**.

If something is deemed **significant**, it is inferred that the results have a causal link to the **independent variables**.

Significance

Common **Tests**: t-test, u-test, ANOVA, Kruskal-Wallis...

Often reported in terms of **p-values**.

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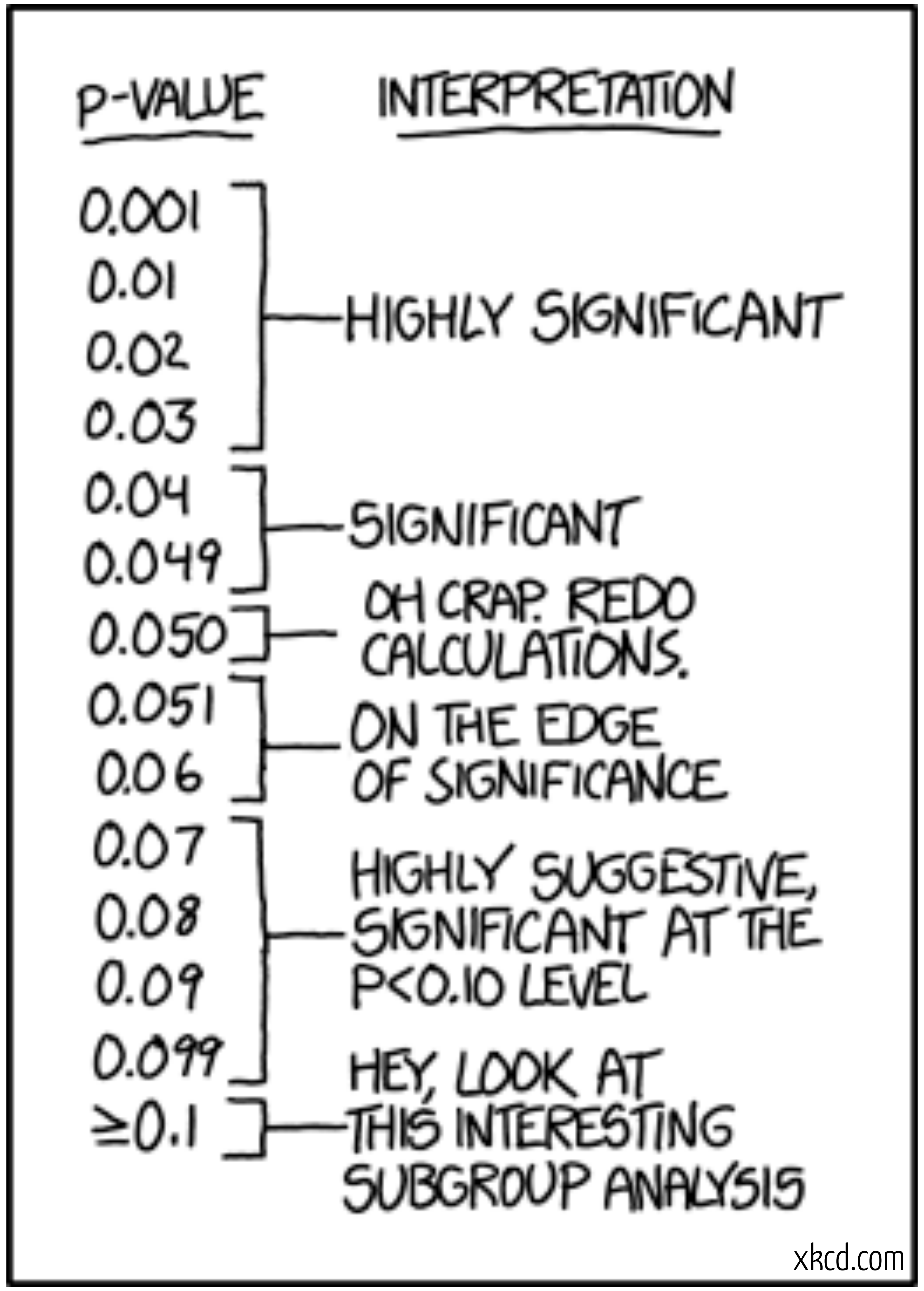

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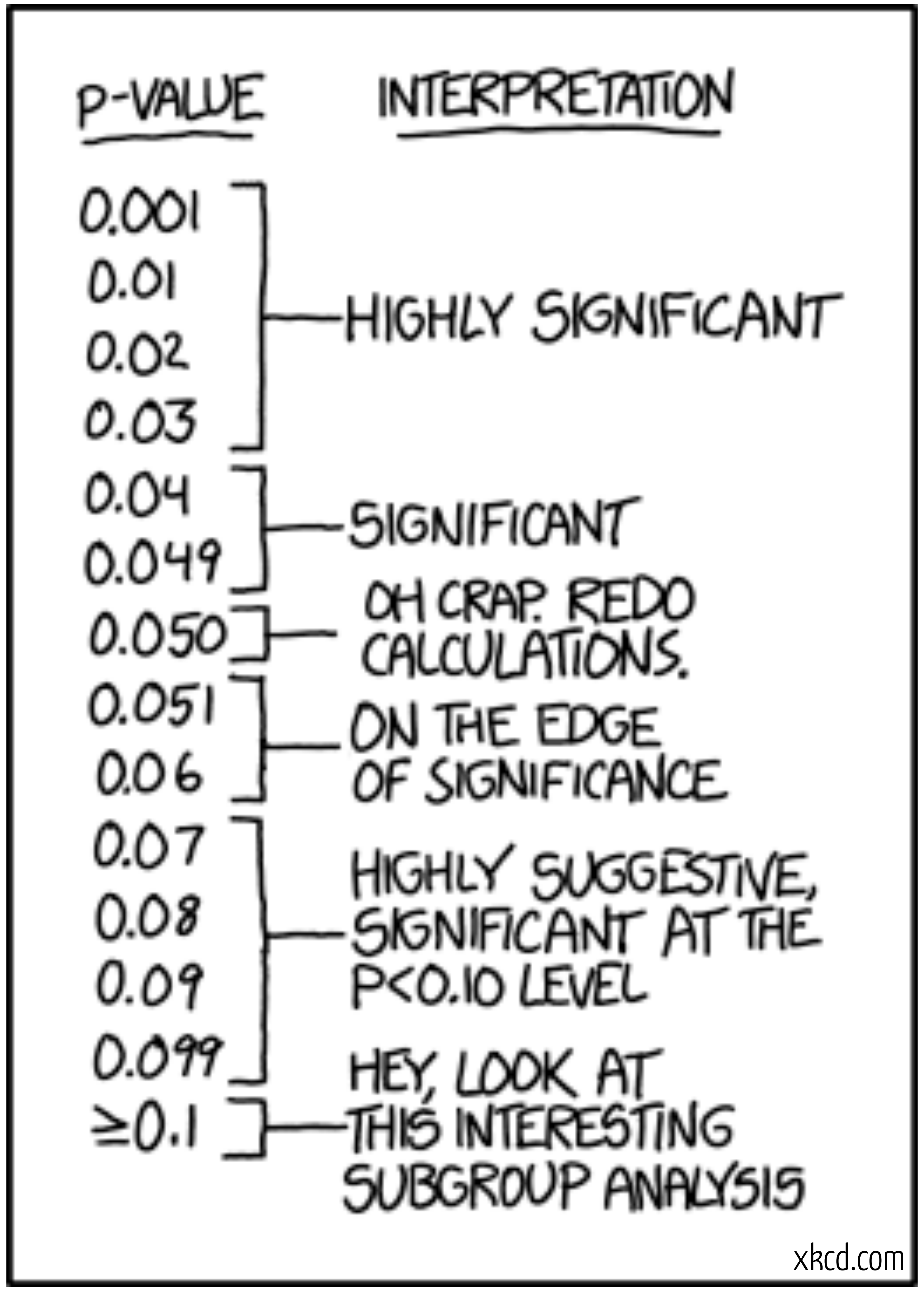
Often reported in terms of **p-values**.

T-test result significant at $p<0.05$ means we are confident that 95% of the time, the test result applies to a larger population with the same characteristics as the test participants.



Significance
... and effect sizes

Effect sizes inform about the **strength** of the relationship of the independent variables on the outcome.

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… and effect sizes

Effect sizes inform about the **strength** of the relationship of the independent variables on the outcome.

Careful interpretation and meaning making of the reported stats makes for the most useful quantitative research reports.

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Back to the Reading!

Points to Consider

- quantitative studies aim at **abstraction**
- **constructed** knowledge in a pure form
- mostly **descriptive**
- often motivated by (difficult) questions

- critical **reflection** of one's method is always relevant
- don't hide behind quantitative methods, they are hard to get right.

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Core Concepts

types of questions/research

descriptive, relational, causal

experiment as a method to reach causal explanations

(in some aspects a myth, especially for HCI/social sciences!)

key concepts of experiments

- causality vs. correlation
- types of variables (dependent, independent, intervening)
- concepts vs. measurable aspects ➔ operationalisation
- hypothesis (null/alternative …)
- randomisation and its rationale
- between vs. within designs
- generalisability of results – inferential statistics (significance, effect sizes …)