Statistical inference (continued), simulation

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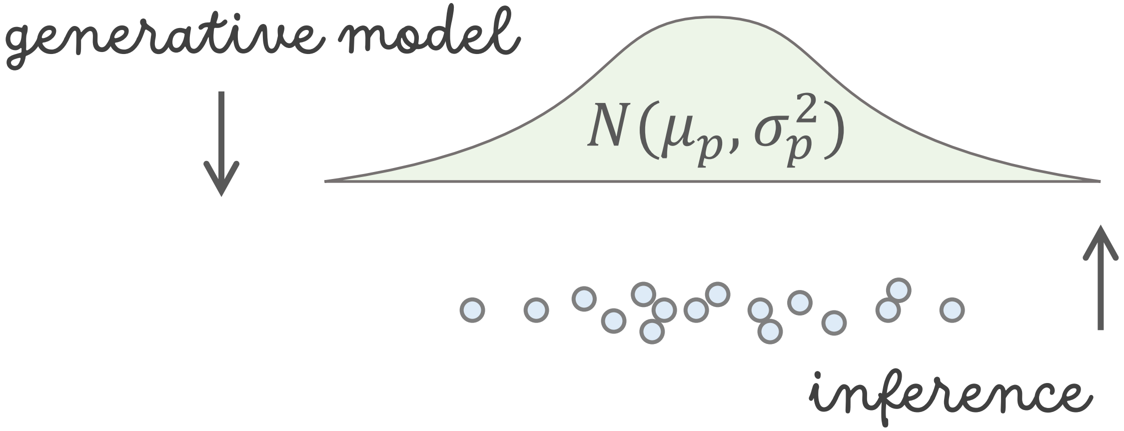
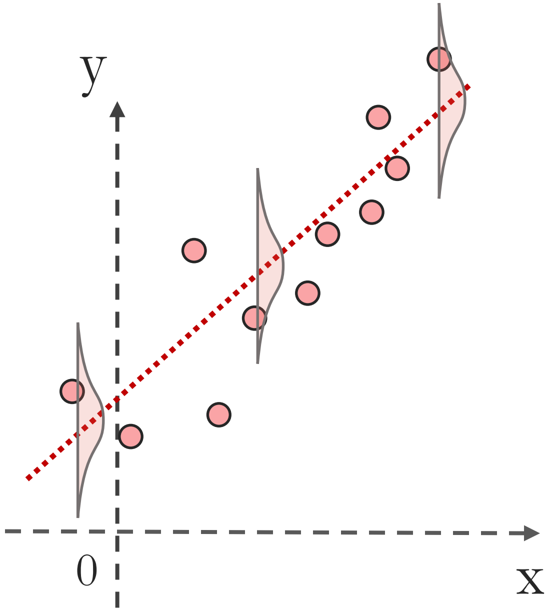
Simulations – Measurement error

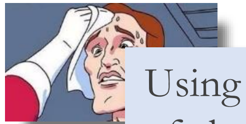


- Using a normal distribution with the parameters of your choice, sample 200 times 5 observations and plot the distribution of their mean using a histogram.
- Do the same, but this time using 50 observations each time.
- Which estimate is the most reliable?

Simulations – Sampling distribution



$$\mu_x = 5.0$$
$$\sigma_x = 3.0$$
$$\alpha = 1.5$$
$$\beta = 2.0$$
$$x \sim N(\mu_x, \sigma_x^2)$$
$$y_i = \alpha + \beta x_i$$

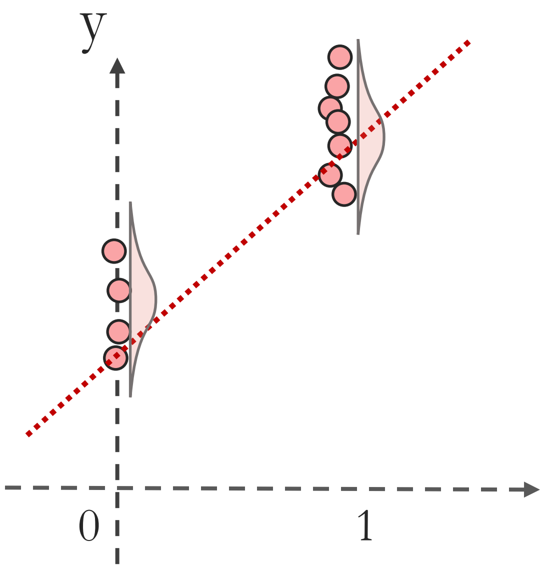


Using R, create a scatterplot of the variables x and y as defined by the model above.

…

$$\sigma_\epsilon = 0.5$$
$$\epsilon_i \sim N(0, \sigma_\epsilon^2)$$
$$y_i = \alpha + \beta x_i + \epsilon_i$$

Using R, create a scatterplot of the variables x and y as defined by the model above that adds noise to the previous definition.



This is the same, except that x is either 0 or 1. We can do this by "hard-coding" the values, or by sampling from a binomial distribution (try it).

Summarizing a set of simulations

Median Absolute Deviation

$$M = med(z_1, \ldots, z_n)$$

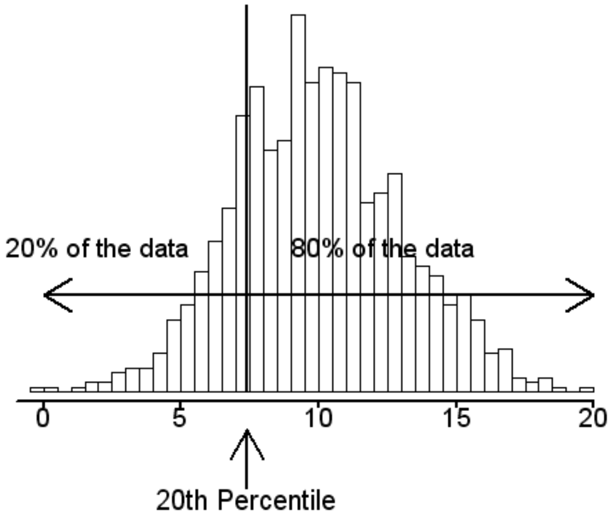
$$mad_X = med_{i=1}^{n}(|z_i - M|)$$

$$sd_X = mad_X * 1.483$$

Robust standard deviation

Uncertainty intervals

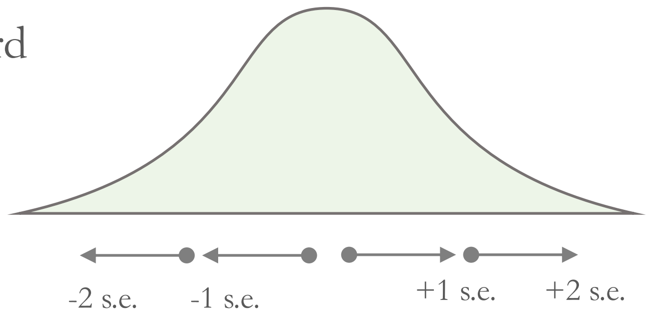
Using R, **quantile(z, 0.25, 0.75)** returns a central 50% interval and **quantile(z, 0.025, 0.975)** returns a central 95% interval.



Generate 200 observations from a Gaussian distribution with mean=8.0 and standard deviation = 2.5. Compute the robust standard deviation and 95% uncertainty interval.

Standard errors

The standard error is the estimated standard deviation of an estimate of interest.

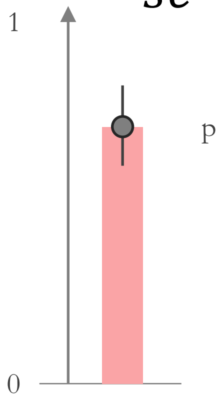


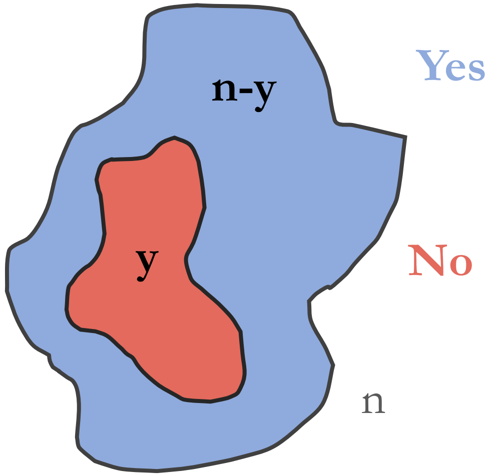
The x% confidence interval will include the true value of the parameter x% of the time.

Standard errors for proportions

$$p = \frac{y}{n}$$

$$se = \sqrt{\frac{p(1-p)}{n}}$$

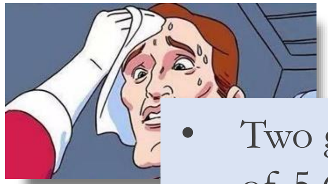




- We asked 50 people whether they would accept to participate in our study. 28 have declined. Compute *p*, the proportion of people that would accept to participate in the population, and the standard error around this estimate.
- We now asked 1000 and 569 have declined. How does this change your estimate?

Standard errors for differences

$$se = \sqrt{se_1^2 + se_2^2}$$



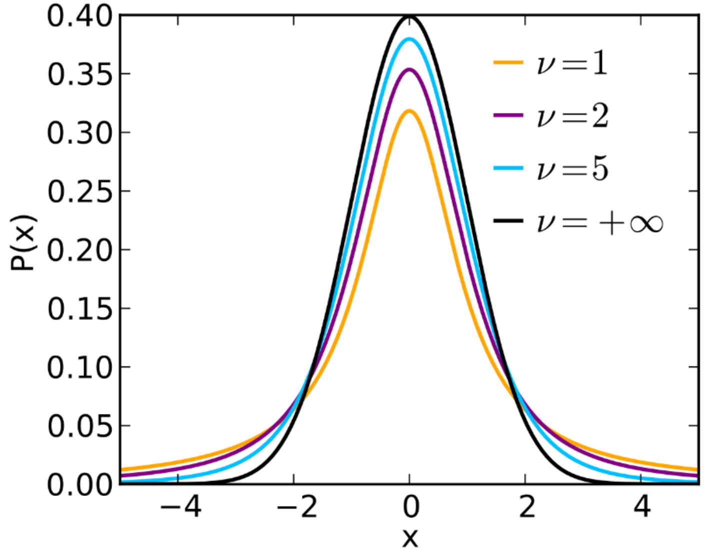
- Two groups were tested and have scores of 5.6 ±1.1 s.e. and 6.3 ±0.8 s.e. Compute their difference and the standard error around this difference.

Degrees of Freedom

Generally, the more degrees of freedom you have, the more closely your sampling distribution resembles a normal distribution, which has narrower tails and less variability. This means that your confidence interval will be narrower and more precise.

On the other hand, the fewer degrees of freedom you have, the more skewed and fat-tailed your sampling distribution will be, which means that your confidence interval will be wider and less precise.

t distribution



This might help

This as well

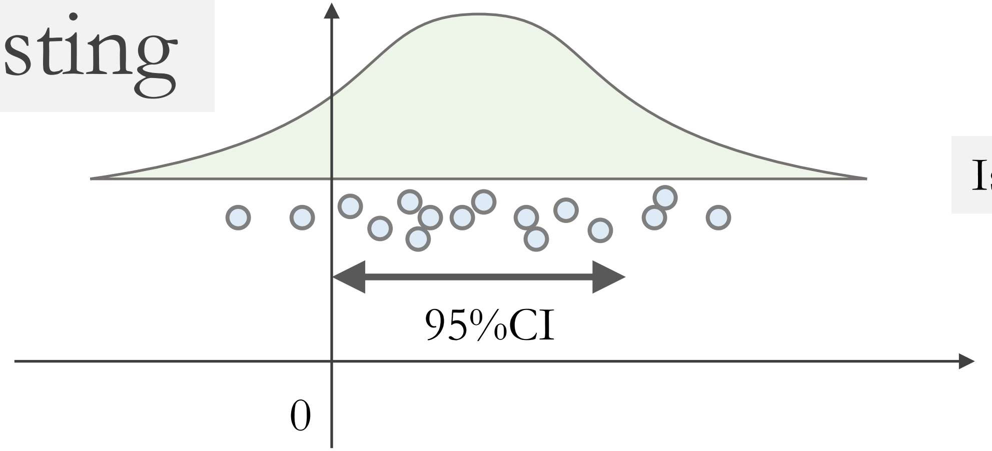
[link]

We have observed the following scores from Study 4:

$$x = \{6.5, 5.5, 6.0, 5.7, 8.1, 7.7, 6.9, 9.2, 5.6\}$$

Compute the 95% CI using base R (no *lm()*).

Hypothesis testing



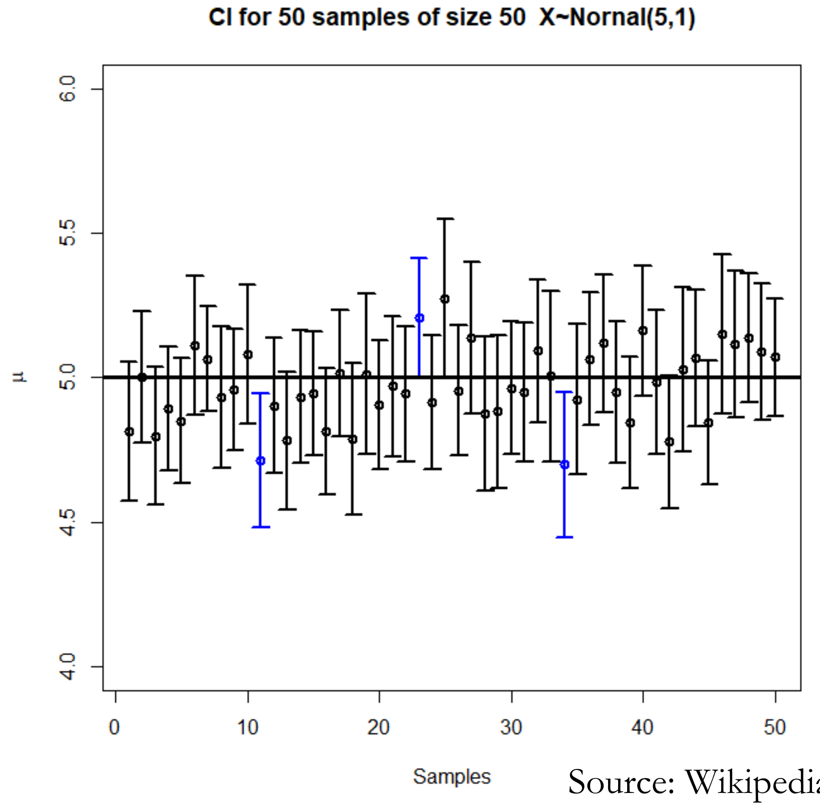
Is it different from 0?

Yes

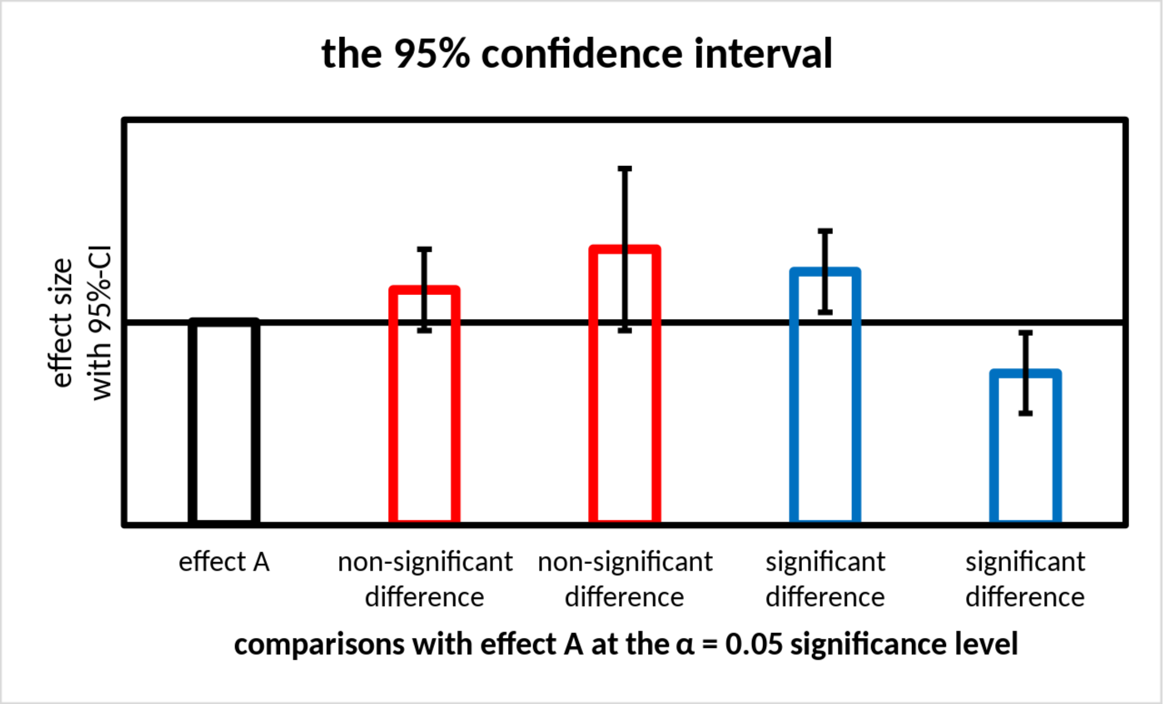
No

Let's see how it works

[link]



Source: Wikipedia

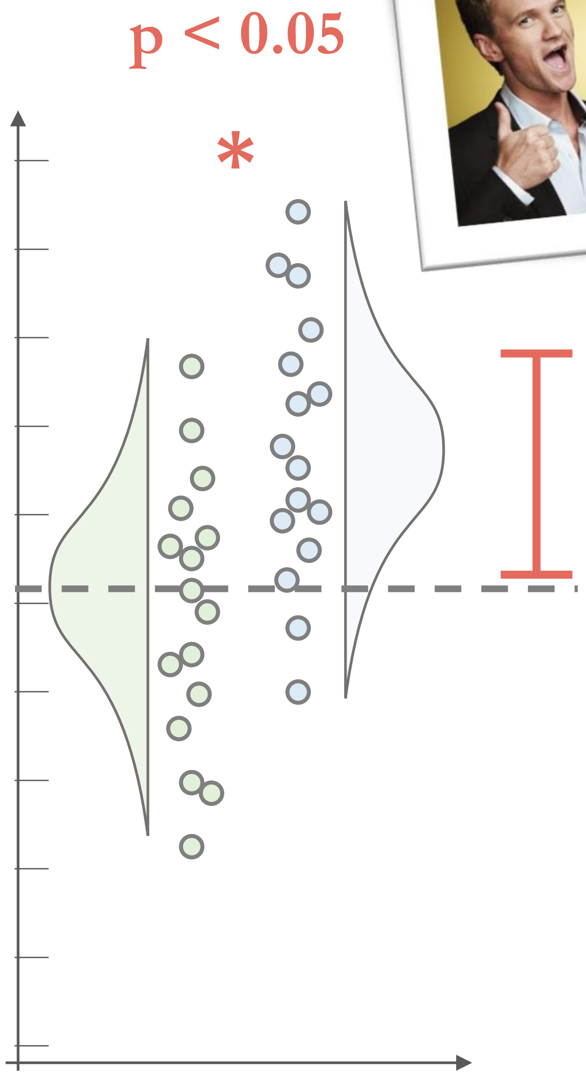


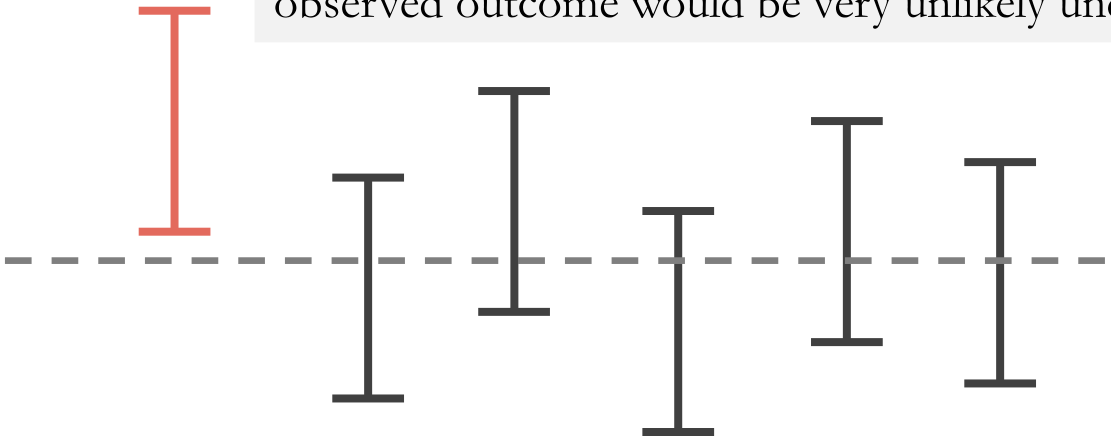
Source: Wikipedia

Epilogue

The *p*-value is the probability of obtaining test results at least as extreme as the result actually observed, under the assumption that the null hypothesis is correct. A very small p-value means that such an extreme observed outcome would be very unlikely under the null hypothesis.

Source: Wikipedia





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Facing uncertainty

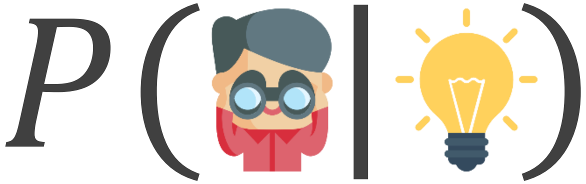
What p-values are not

- The *p*-value is *not* the probability that the null hypothesis is true, or the probability that the alternative hypothesis is false.
- The *p*-value is *not* the probability that the observed effects were produced by random chance alone.
- The 0.05 significance level is merely a convention.
- The *p*-value does not indicate the size or importance of the observed effect.

What confidence intervals are not

- A 95% confidence level does not mean that for a given realized interval there is a 95% probability that the population parameter lies within the interval.
- A 95% confidence level does not mean that 95% of the sample data lie within the confidence interval.
- A 95% confidence level does not mean that there is a 95% probability of the parameter estimate from a repeat of the experiment falling within the confidence interval computed from a given experiment.

We Won't Get Fooled Again

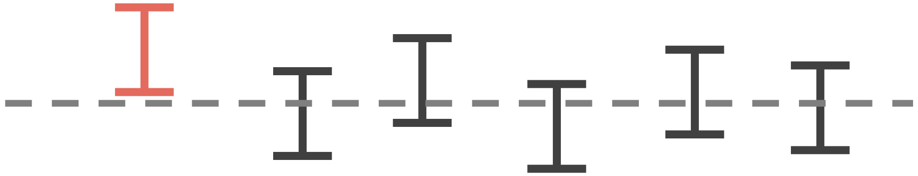


Thomas Bayes

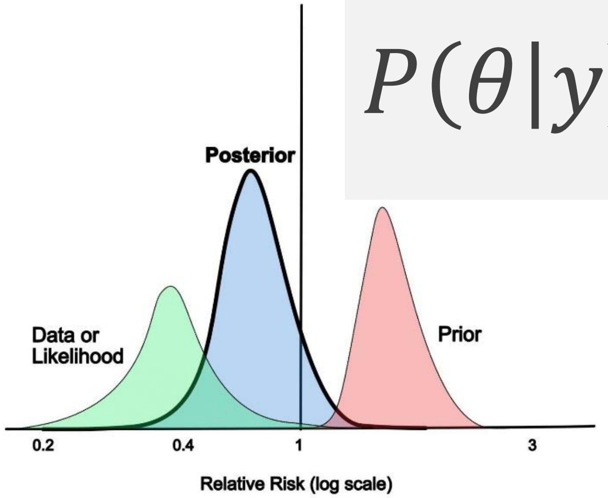
Probability is the most important concept in modern science, especially as nobody has the slightest notion what it means.
— Bertrand Russell, 1929 Lecture

Bayes' theorem

$$P(\theta|y) = \frac{P(y|\theta)P(\theta)}{P(y)}$$



Confidence intervals



Highest Density Intervals

Frequentism

Bayesianism