Σ+ SPSS TUTORIALS

BASICS   DATA ANALYSIS   T-TEST   ANOVA   CHI-SQUARE TEST

Null Hypothesis – Simple Introduction
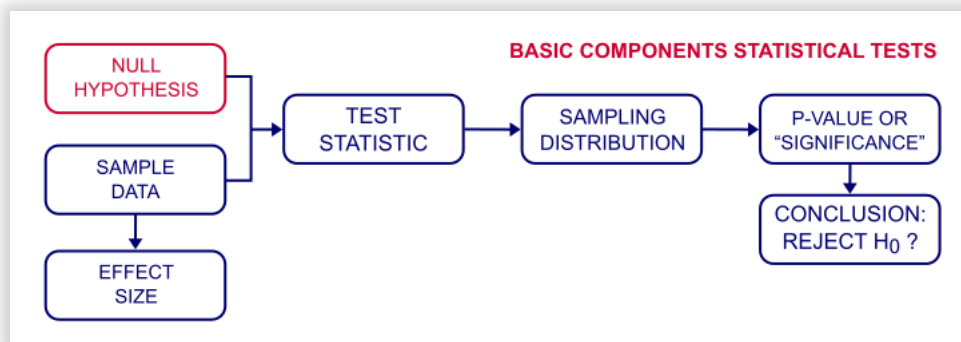
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Simple Introduction

A null hypothesis is a precise statement about a population that we try to reject with sample data.

We don't usually believe our null hypothesis (or H_0) to be true. However, we need *some* exact statement as a starting point for statistical significance testing.

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Null Hypothesis Examples

Often -but not always- the null hypothesis states there is no association or difference between variables or subpopulations. Like so, some typical null hypotheses are:

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- the **correlation** between frustration and aggression is **zero** (correlation-analysis);

- the **average** income for men is **similar to** that for women (independent samples t-test);

- Nationality is (perfectly) **unrelated to** music preference (chi-square independence test);

- the **average** population income was **equal** over 2012 through 2016 (repeated measures ANOVA).

"Null" Does Not Mean "Zero"

A common misunderstanding is that "null" implies "zero". This is often *but not always* the case. For example, a null hypothesis may also state that

the correlation between frustration and aggresion is 0.5.

No zero involved here and -although somewhat unusual- perfectly valid. The "null" in "null hypothesis" derives from **"nullify"**[5]: the null hypothesis is the statement that we're trying to refute, regardless whether it does (not) specify a zero effect.

Null Hypothesis Testing -How Does It Work?

I want to know if happiness is related to wealth among Dutch people. One approach to find this out is to formulate a null hypothesis. Since "related to" is not precise, we choose the opposite statement as our null hypothesis:

the correlation between wealth and happiness is zero among all Dutch people.

We'll now try to refute this hypothesis in order to demonstrate that happiness and wealth are related all right.
Now, we can't reasonably ask all 17,142,066 Dutch people how happy they generally feel.
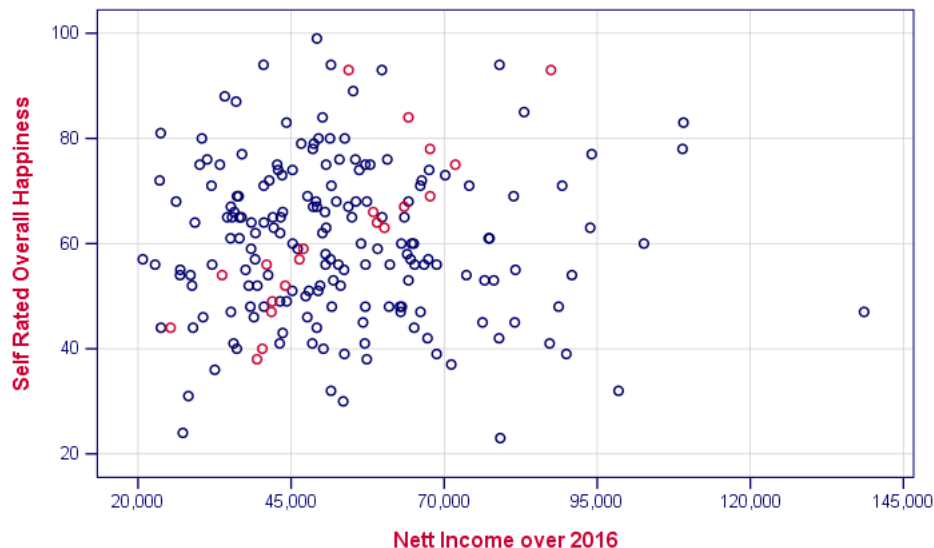
Population counter

01/12/2016 06:00

The counter below shows how many registered inhabitants there are in the Netherlands at this moment according to the most recent estimate of Statistics Netherlands.

| 1 | 7 | 1 | 4 | 2 | 0 | 6 | 6 |

So we'll ask a **sample** (say, 100 people) about their wealth and their happiness. The correlation between happiness and wealth turns out to be 0.25 in our sample. Now we've one problem: sample outcomes tend to differ somewhat from population outcomes. So if the correlation really is zero in our population, we may find a non zero correlation in our sample. To illustrate this important point, take a look at the scatterplot below. It visualizes a zero correlation between happiness and wealth for an entire population of N = 200.

Scatterplot Happiness by Income | Entire Population (N = 200), r = 0.

Now we draw a random sample of N = 20 from this population (the red dots in our previous scatterplot). Even though our population correlation is zero, we found a staggering **0.82 correlation in our sample**. The figure below illustrates this by omitting all non sampled units from our previous scatterplot.

Scatterplot Happiness by Income | Random Sample (N = 20), r = 0.82
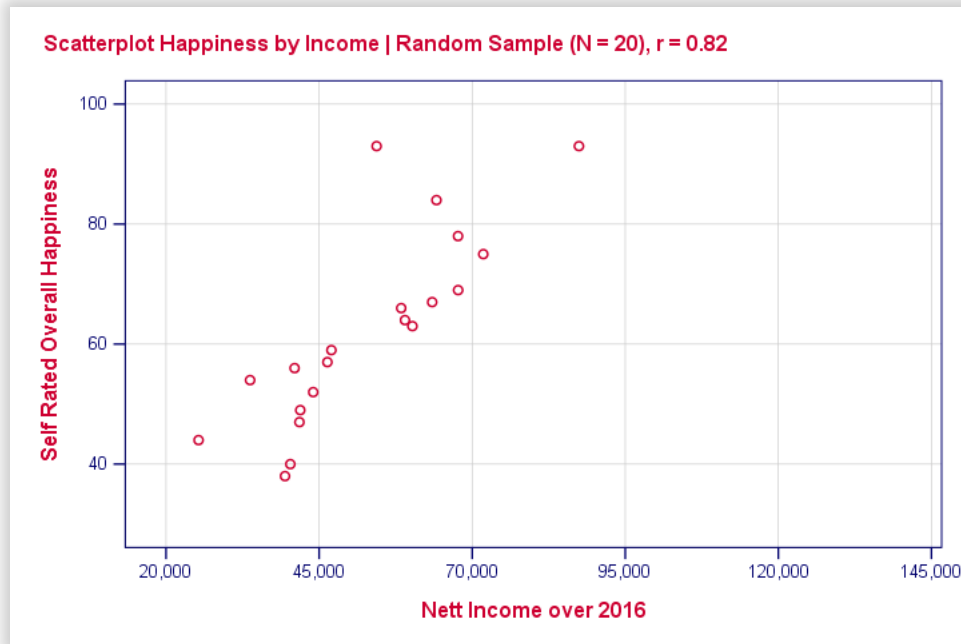
This raises the question **how we can *ever* say *anything*** about our population if we only have a tiny sample from it. The basic answer: we can rarely say anything with 100% certainty. However, we *can* say a lot with 99%, 95% or 90% certainty.

Probability

So how does that work? Well, basically, some sample outcomes are highly unlikely *given our null hypothesis*. Like so, the figure below shows the probabilities for different sample correlations (N = 100) if the population correlation really is zero.
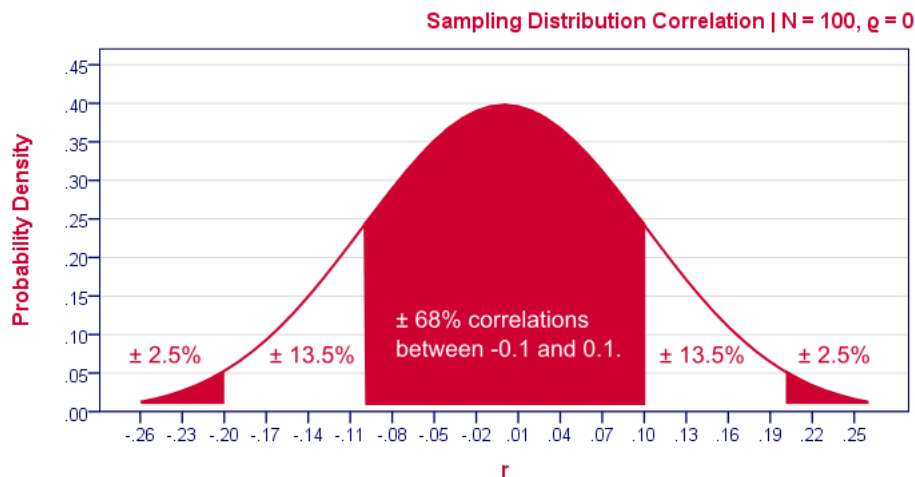
A computer will readily compute these probabilities. However, doing so requires a sample size (100 in our case) and a presumed population correlation ρ (0 in our case). So **that's why we need a null hypothesis**. If we look at this sampling distribution carefully, we see that sample correlations around 0 are most likely: there's a 0.68 probability of finding a correlation between -0.1 and 0.1. What does that mean? Well, remember that probabilities can be seen as relative frequencies. So imagine we'd draw 1,000 samples instead of the one we have. This would result in 1,000 correlation coefficients and some 680 of those -a relative frequency of 0.68- would be in the range -0.1 to 0.1. Likewise, there's a 0.95 (or 95%) probability of finding a sample correlation between -0.2 and 0.2.

P-Values

We found a sample correlation of 0.25. How likely is that if the population correlation is zero? The answer is known as the **p-value** (short for probability value):

> **A p-value is the probability of finding some sample outcome or a more extreme one if the null hypothesis is true.**

Given our 0.25 correlation, "more extreme" usually means larger than 0.25 or smaller than -0.25. We can't tell from our graph but the underlying table tells us that **p ≈ 0.012**. If the null hypothesis is true, there's a 1.2% probability of finding our sample correlation.

Conclusion?

If our population correlation really is zero, then we *can* find a sample correlation of 0.25 in a sample of N = 100. The probability of this happening is only 0.012 so it's **very unlikely**. A reasonable conclusion is that our population correlation wasn't zero after all.
Conclusion: **we reject the null hypothesis**. Given our sample outcome, we no longer believe that happiness and wealth are unrelated. However, we still can't state this with certainty.

Null Hypothesis - Limitations

Thus far, we only concluded that the population correlation is probably **not zero**. That's the only conclusion from our null hypothesis approach and it's not really that interesting.
What we really want to know is the population correlation. Our sample correlation of 0.25 seems a reasonable estimate. We call such a single number a **point estimate**.
Now, a new sample may come up with a different correlation. An interesting question is how much our sample correlations would fluctuate over samples if we'd draw many of them. The figure below shows precisely that, assuming our sample size of N = 100 and our (point) estimate of 0.25 for the population correlation.
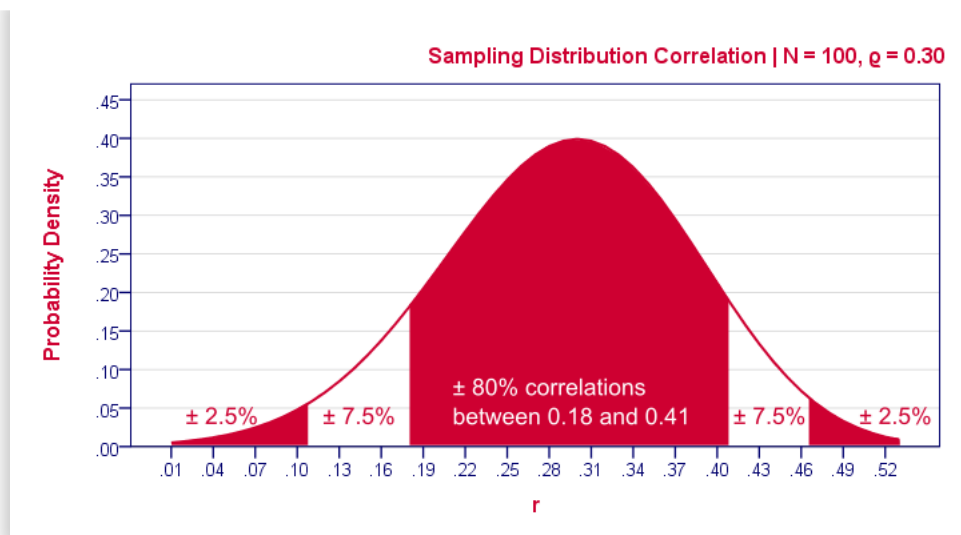
Confidence Intervals

Our sample outcome suggests that some 95% of *many* samples should come up with a correlation between 0.06 and 0.43. This range is known as a confidence interval. Although not precisely correct, it's most easily though of as the **bandwidth that's likely to enclose the population correlation**.
One thing to note is that the concidence interval is quite wide. It almost contains a zero correlation, exactly the null hypothesis we rejected earlier. Another thing to note is that our sampling distribution and confidence interval are slightly asymmetrical. They are symmetrical for most other statistics (such as means or beta coefficients) but not correlations.

References

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4. Howell, D.C. (2002). *Statistical Methods for Psychology* (5th ed.). Pacific Grove CA: Duxbury.

5. Van den Brink, W.P. & Koele, P. (2002). *Statistiek, deel 3* [Statistics, part 3]. Amsterdam: Boom.

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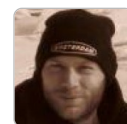**By Yuxuan Jiang on March 27th, 2019**

The tutorial is fantastic!

By Ruben Geert van den Berg on March 1st, 2019

Hi Edwin!

Sorry but that's too vague. What do you mean by "two sets of data"? And precisely which research question are you trying to answer?

By Edwin Quintinus Thunemann on March 1st, 2019

Define the Null Hypothesis as used in comparison of two means of two sets of data theoretically belonging to the same population.

By Ruben Geert van den Berg on January 25th, 2019

Hi Gabrielle!

Thanks for the compliments, I app
the time to create more written as

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