

Hypothesis Testing

DSC-ATL-062419

Motivation

- <https://amstat.tandfonline.com/doi/pdf/10.1080/00031305.2016.1154108?needAccess=true>

Hypothesis Testing

The Steps:

1. Define your hypotheses (null, alternative)
2. Specify your null distribution
3. Do an experiment
4. Calculate the p-value of what you observed
5. Reject or fail to reject (~accept) the null hypothesis

The Underlying Logic of hypothesis tests

Follows this logic:

Assume A.

If A, then B.

Not B.

Therefore, Not A.

But throw in a bit of uncertainty...If A, then probably B...

Type I Error



Type II Error



Errors

Type-I Error (also known as “ α ” and “False Positive”): Rejecting the null when the effect isn’t real.

- Incorrectly reject a true null hypothesis

Type-II Error (also known as “ β ” and “false negative”): Failing to reject the null when the effect is real.

- Failing to reject a false null hypothesis.

Type I and Type II

	<i>Decision</i>	
	Accept H_0	Reject H_0
H_0 (true)	Correct decision	Type I error (α error)
H_0 (false)	Type II error (β error)	Correct decision

Example: Type I and Type II

Your Statistical Decision	True state of null hypothesis	
	H_0 True (example: the drug doesn't work)	H_0 False (example: the drug works)
Reject H_0 (ex: you conclude that the drug works)	<i>Type I error (α)</i>	<i>Correct</i>
Do not reject H_0 (ex: you conclude that there is insufficient evidence that the drug works)	<i>Correct</i>	<i>Type II Error (β)</i>

P-Value

- Rejecting H_0 at a specified α does not full convey the information in the data.
- More useful to report the smallest α -level at which the observed result is significant.
- This smallest α -level is called the **P-Value** (observed level of significance).
- Smaller the P-Value the more significant the test result.

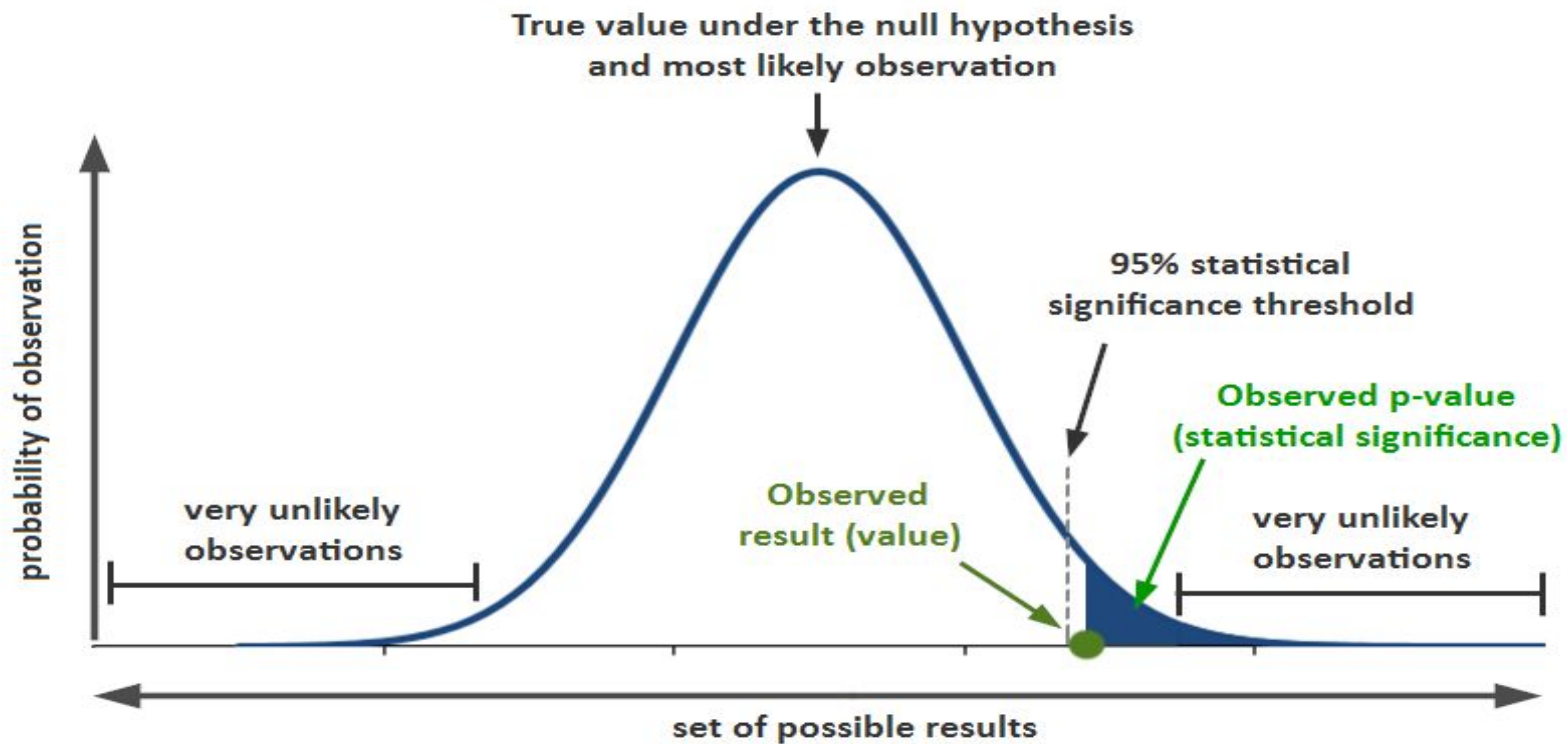
General Rule

$$P - Value < \alpha \quad \text{reject} \quad H_0$$

Alternative Definition P-Value

- It is the probability under H_0 of obtaining a test statistic at least as “extreme” as the observed value.
- The statement above can be interpreted as a small P-Value indicates that the observed result is rare under the assumptions of H_0

Probability & Statistical Significance Explained



Careful on Interpretations

- Results that are not statistically significant should not be interpreted as "evidence of no effect," but as "no evidence of effect"

T-Test Background

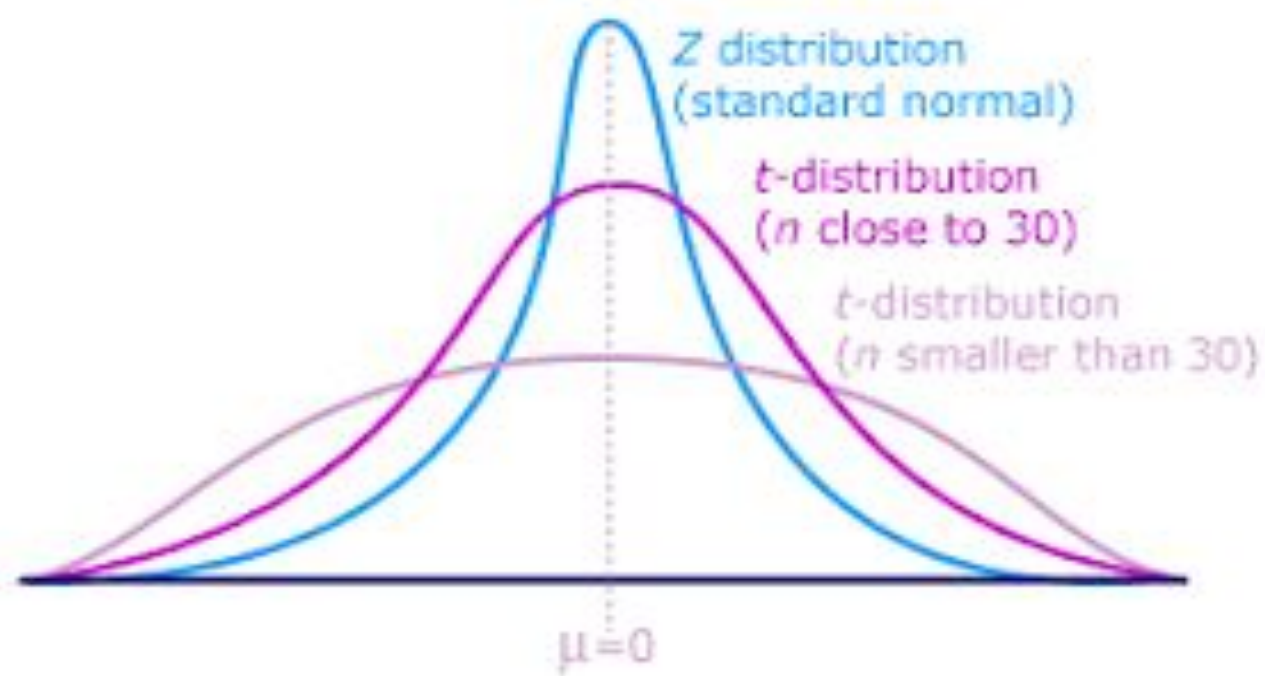
- The **t-test** is used to test hypotheses about means **when the population variance is unknown** and the sample size is small say less than 100.

Closely related to z , the unit normal.

- Single sample, independent samples, and dependent(paired) samples.

T-Dist Again

- The t distribution is the short, fat relative of the normal. The shape of t depends on its df . As N becomes infinitely large, t becomes normal.



What Type of T-test is it?

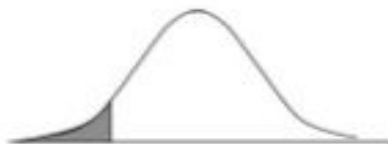
- Single sample t – we have only 1 group; want to test against a hypothetical mean.
- Independent samples t – we have 2 means, 2 groups; no relation between groups, e.g., people randomly assigned to a single group.
- Dependent t – we have two means. Either same people in both groups, or people are related, e.g., husband-wife, hospital patient and visitor.

Tails

One-Tail Test
(left tail)

$$H_0 : \mu = \mu_0$$

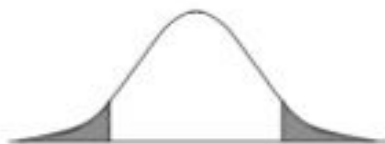
$$H_1 : \mu < \mu_0$$



Two-Tail Test

$$H_0 : \mu = \mu_0$$

$$H_1 : \mu \neq \mu_0$$



One-Tail Test
(right tail)

$$H_0 : \mu = \mu_0$$

$$H_1 : \mu > \mu_0$$



Tails and P-Values Two Sample

A **two-tailed P-Value** answers this question:

Assuming the **null hypothesis** is true, what is the chance that a randomly selected samples would have a mean as far or further than you observed in this experiment with either group having the larger mean?

To interpret a **one-tail P-Value**, you must predict which group will have the larger mean before collecting any data. The **one-tail P-Value** answers this question:

Assuming the **null hypothesis** is true, what is the chance that a randomly selected samples would have a mean as far apart as (or further) than observed in this experiment with the specified group having the larger mean?

Note

- The one-tail P-Value is half the two-tail P-Value.
- The two-tail P-Value is twice the one-tail P value.

Example