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Demystifying Hypothesis Testing: Choosing Between Z-Test And T-Test With Clarity

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ABSTRACT

In the realm of hypothesis testing, students often encounter a perplexing dilemma: when to employ a z-test versus a t-test. Traditional guidelines suggest that a z-test is appropriate for sample sizes exceeding 30, while a t-test is suitable for smaller samples. However, this distinction becomes murkier when considering statistical software like SPSS, which exclusively utilizes t-tests for hypothesis testing, leaving the z-test seemingly absent. In this paper, we aim to provide clarity on the appropriate circumstances for employing both z-tests and t-tests, thereby dispelling the confusion surrounding their usage. Through a comprehensive exploration, we endeavor to equip readers with the knowledge necessary to confidently navigate hypothesis testing scenarios, elucidating the nuanced differences between these two methodologies.

Key words:

Hypothesis, z-test, t-test

Introduction

Hypothesis testing is a cornerstone of statistical analysis, guiding researchers in drawing conclusions from sample data. Key to this process is the z-test and t-test, yet determining when to use each can be perplexing. While conventional wisdom suggests using a z-test for large samples and a t-test for small ones, the reality is more nuanced, especially with modern statistical software like SPSS favoring the t-test.

In this article, we aim to clarify the selection between z-test and t-test. We'll define hypothesis testing as the process of evaluating null and alternative hypotheses. Then, we'll briefly outline the z-test's reliance on the standard normal distribution for large samples with known standard deviation, contrasting it with the t-test's utility for smaller samples or when standard deviation is unknown. Finally, we'll highlight the practical implications of test selection, offering clarity for researchers navigating hypothesis testing scenarios.

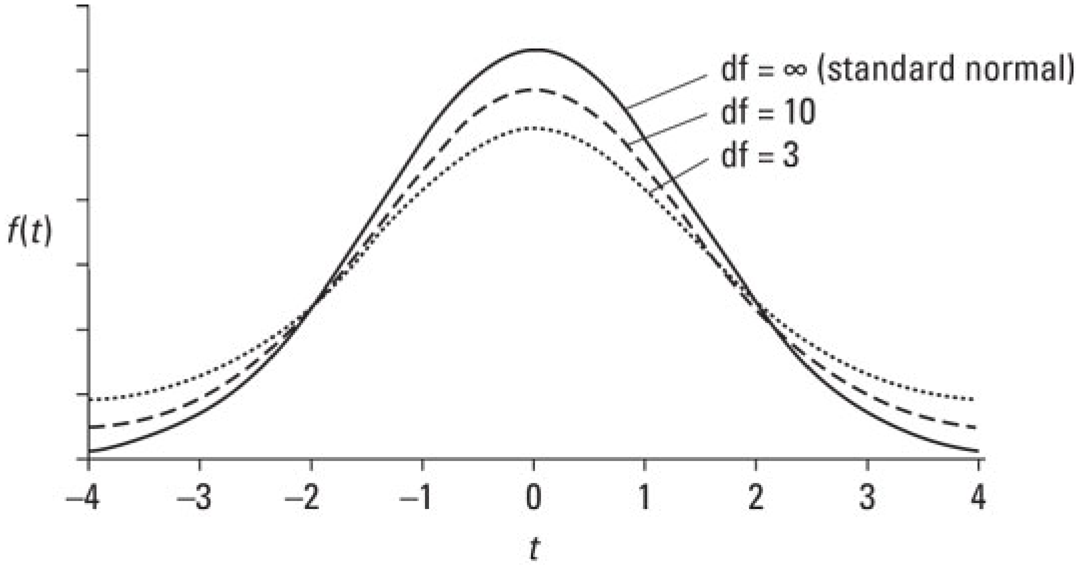
Z-test and t-test comparison:

1. Z-test:

- The name "z-test" is derived from the z-score of the normal distribution.
- The z-score measures how many standard deviations a sample statistic is away from the population mean.
- In the z-test, z-scores provide standard scores, indicating the deviation of sample means from the population mean.
- Known values in the normal distribution, such as the 1.96 z-score for a 0.05 level of significance, help establish critical ratios.
- Critical ratios, like 1.96 for a 0.05 level and 2.58 for a 0.01 level of significance, aid in hypothesis testing.

2. T-test:

- The t-test is primarily used for small sample sizes.
- Unlike the z-test, the critical ratio in t-tests varies based on sample size and degrees of freedom.
- As sample size increases, degrees of freedom increase, and the t-distribution approaches the normal distribution.
- The variability of the critical ratio in t-tests reflects the adjustment for smaller sample sizes and the resulting uncertainty in estimating population parameters.



In summary, while the z-test relies on fixed critical ratios derived from the normal distribution, the t-test adapts its critical ratio based on sample size and degrees of freedom, making it suitable for small sample cases. Understanding these differences is essential for effectively applying hypothesis testing methods in statistical analysis.

Let us use a comparative table to understand how the conventional wisdom interprets z-test and t-test by fixing 30 (thirty) as the demarcation for large and small samples

Sample Size (N1+N2)	Critical Ratio	
	0.05 level of significance	0.01 level of significance
30	1.96	2.58
31	1.96	2.58
200	1.96	2.58
500	1.96	2.58
1000	1.96	2.58
∞ Infinity	1.96	2.58

critical value for z-test having sample size greater than 30

Degree of freedom (N1+N2-2)	Critical Ratio (t distribution)	
	0.05 level of significance	0.01 level of significance
1	12.71	63.66
2	4.30	9.92
3	3.18	5.84
4	2.78	4.60
5	2.57	4.03
40	2.02	2.71
100	1.98	2.63
200	1.97	2.60
300	1.97	2.59
400	1.97	2.59
500	**1.96**	2.59
1000	1.96	**2.58**
∞ Infinity	1.96	2.58

critical value for t-test having sample size less than 30

How is degree of freedom calculated?

Suppose we wish to test the statistical significance of difference between the means of two samples having sample size 30 (N1) and and 50 (N2) for 1st and 2nd sample respectively then the total degree of freedom is

df = (N1-1) + (N2-1)

df = (N1+N2-2)

So, we can say that for df=78, combined sample size i.e (N1+N2)=80

The t-test is employed for sample sizes less than 30, where the distribution becomes platykurtic rather than normally distributed. In such cases, critical values are calculated using degrees of freedom and the desired level of significance, resulting in a set of critical values corresponding to various degrees of freedom, such as 1, 2, 3,... up to 29.

For instance, at a 0.05 level of significance, there are 29 critical values in the t-distribution, reflecting the variability introduced by smaller sample sizes. Understanding these distinctions is crucial for accurate hypothesis testing, ensuring informed decisions in statistical analysis.

TABLE-(C)

Table C Critical Values of *t*

Degrees of freedom	*Probability P* 0.10	0.05	0.02	0.01
1	$t = 6.34$	$t = 12.71$	$t = 31.82$	$t = 63.66$
2	2.92	4.30	6.96	9.92
3	2.35	3.18	4.54	5.84
4	2.13	2.78	3.75	4.60
5	2.02	2.57	3.36	4.03
6	1.94	2.45	3.14	3.71
7	1.90	2.36	3.00	3.50
8	1.86	2.31	2.90	3.36
9	1.83	2.26	2.82	3.25
10	1.81	2.23	2.76	3.17
11	1.80	2.20	2.72	3.11
12	1.78	2.18	2.68	3.06
13	1.77	2.16	2.65	3.01
14	1.76	2.14	2.62	2.98
15	1.75	2.13	2.60	2.95
16	1.75	2.12	2.58	2.92
17	1.74	2.11	2.57	2.90
18	1.73	2.10	2.55	2.88
19	1.73	2.09	2.54	2.86
20	1.72	2.09	2.53	2.84
21	1.72	2.08	2.52	2.83
22	1.72	2.07	2.51	2.82
23	1.71	2.07	2.50	2.81
24	1.71	2.06	2.49	2.80
25	1.71	2.06	2.48	2.79
26	1.71	2.06	2.48	2.78
27	1.70	2.05	2.47	2.77
28	1.70	2.05	2.47	2.76
29	1.70	2.04	2.46	2.76
30	1.70	2.04	2.46	2.75
35	1.69	2.03	2.44	2.72
40	1.68	2.02	2.42	2.71
45	1.68	2.02	2.41	2.69
50	1.68	2.01	2.40	2.68
60	1.67	2.00	2.39	2.66
70	1.67	2.00	2.38	2.65
80	1.66	1.99	2.38	2.64
90	1.66	1.99	2.37	2.63
100	1.66	1.98	2.36	2.63
125	1.66	1.98	2.36	2.62
150	1.66	1.98	2.35	2.61
200	1.65	1.97	2.35	2.60
300	1.65	1.97	2.34	2.59
400	1.65	1.97	2.34	2.59
500	1.65	1.96	2.33	2.59
1000	1.65	1.96	2.33	2.58
∞	1.65	1.96	2.33	2.58

Major Observation:

In **Table-(C),** follow the values from top to bottom at 0.05 and 0.01 level of confidence. As the sample size(degree of freedom) increases from 1 through 500, the critical t value approaches 1.96 which is the same critical value used for z-test at 0.05 level. Similarly the critical t-value approaches 2.58 when the sample size reaches 1000 at the 0.01 level of confidence **(Indicated by arrow marks)**.

To summarize, the conventional wisdom of utilizing the z-test for sample sizes equal to or greater than 30 warrants reevaluation. Our analysis reveals that adherence to this guideline may lead to misleading interpretations. Instead, considering critical t-values provides a more nuanced approach to determining the appropriate test for hypothesis testing. For instance, our findings suggest that the z-test should be employed at a 0.05 significance level only when the degree of freedom reaches 500, indicating a combined sample size of 502. Similarly, at a 0.01 significance level, the z-test is justified when the degree of freedom reaches 1000, corresponding to a combined sample size of 1002.

Alternatively, if a single threshold is preferred for both significance levels, a degree of freedom of 500 serves as a suitable demarcation point for distinguishing between smaller and larger samples. This approach offers a practical approximation of critical ratios at both levels of significance, enhancing the accuracy and reliability of hypothesis testing procedures. By challenging conventional norms and advocating for a more nuanced understanding of statistical methods, we aim to empower researchers to make informed decisions and advance the rigor of empirical inquiry.

Conclusion:

In conclusion, the customary reliance on the z-test for sample sizes of 30 or more may lead to misinterpretations. Our analysis suggests a reassessment, emphasizing the significance of considering critical t-values for hypothesis testing. Specifically, the z-test should be reserved for a 0.05 significance level when the degree of freedom reaches 500 (indicating a combined sample size of 502), or for a 0.01 significance level when the degree of freedom reaches 1000 (implying a combined sample size of 1002). Alternatively, adopting a singular threshold of 500 as a dividing line to decide large and small sample for both significance levels offers a practical approximation of critical ratios. Therefore, it is always safe to use t-test, which mirrors the z-test's outcomes once the sample size reaches 500, and it ensures robust and dependable hypothesis testing results.

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