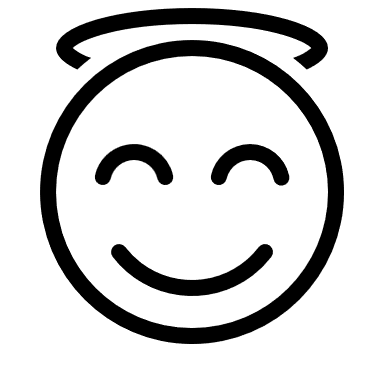
# Matching: Key Term, Notation, & Definition

**Directions:** Match each key term to its standard notation and definition. Fill the matching letters and Roman numerals into the table below. Note that there are more symbolic notations and definitions than there are key terms.

|  |  |  |
| --- | --- | --- |
| **Key Term** | **Notation** | **Definition** |
| Parameter | **E** | **IV** |
| Statistic | **F** | **V** |
| Null Hypothesis | **C** | **VI** |
| Hypothesized Value | **N** | **VIII** |
| Significance Level | **J** | **X** |

## Notation Choices

1. H1: µ ≠ k
2. H1: ≠ k
3. H0: µ = k
4. H0: ≠ k
5. µ
6. X
7. n
8. α
9. p
10. 
11. ≠
12. k
13. 0.05
14. 95%

## Definition Choices

1. Unknown probability distribution of values for the random variable of interest
2. Collected distribution of the observed values for the random variable of interest
3. Probability distribution associated with the statistic
4. Unknown summary of the population distribution
5. Calculated summary of the sample distribution
6. Statement about a parameter with respect to a value of interest that is assumed as true when conducting a hypothesis test
7. Statement about a parameter with respect to a value of interest that the hypothesis test is used to indicate supportive evidence for
8. Constant value that is of interest in a hypothesis test
9. A statement that contains both hypotheses
10. Probability of rejecting the null hypothesis when the null hypothesis is true
11. Probability of making a mistake in a hypothesis test
12. Probability of observing a test statistic at least as extreme when the null hypothesis is true.

# Multiple Choice: Concepts

**Directions:** For each of the questions below, select one answer.

1. Which of the following definitions best describes a **null distribution**?
2. Probability distribution of the parameter
3. Probability distribution of the statistic
4. Probability distribution of the parameter when the null hypothesis is true
5. **Probability distribution of the statistic when the null hypothesis is true**
6. Normal distribution
7. Normal distribution when the null hypothesis is true
8. Probability distribution of the random variable of interest
9. Probability distribution of the random variable of interest when the null hypothesis is true
10. Suppose that you are interested in testing the following hypotheses for a population mean, µ:  
     H0: µ ≥ 10

H1: µ < 10

Which of the following notations is associated with the **standardized test statistic**?

1. N(0, 1)
2. Suppose that you are interested in testing the following hypotheses for a population mean, µ:  
    H0: µ ≥ 10

H1: µ < 10  
Where do you expect the distribution of the standardized test statistic to be centered when the null hypothesis is true?

1. 10
2. The calculated value of
3. **0**
4. 1
5. Cannot be determined
6. Which of the following statements best describes a **p-value**?
7. Probability of rejecting the null hypothesis when the null hypothesis is true
8. **Probability of observing a test statistic at least as extreme as was calculated from your sample data when the null hypothesis is true**
9. Probability that the null hypothesis is incorrectly rejected
10. Probability that the null hypothesis is true
11. Probability of observing the same test statistic that you calculated from your sample data
12. Suppose that hypothesis test calculations have resulted in a p-value = 0.083 when the significance level for the test was 0.05. Which of the following decisions is correct?
13. With a p-value = 0.083 > 0.05, accept the null hypothesis.
14. With a p-value = 0.083 > 0.05, accept the alternate hypothesis.
15. **With a p-value = 0.083 > 0.05, do not reject the null hypothesis.**
16. With a p-value = 0.083 > 0.05, do not reject the alternate hypothesis.
17. Suppose that hypothesis test calculations have resulted in a p-value = 0.013 when the significance level for the test was 0.05. Which of the following decisions is correct?
18. With a p-value = 0.013 < 0.05, accept the null hypothesis.
19. With a p-value = 0.013 < 0.05, accept the alternate hypothesis.
20. **With a p-value = 0.013 < 0.05, reject the null hypothesis.**
21. With a p-value = 0.013 < 0.05, reject the alternate hypothesis.
22. Suppose that you are interested in testing the following hypotheses for a population mean, µ:  
     H0: µ ≥ 10

H1: µ < 10  
The hypothesis test calculations have resulted in a p-value = 0.083 when the significance level for the test was 0.05. Which of the following conclusions is justified?

1. There **is** statistical evidence to support a claim that the sample mean is *at least as large* as 10.
2. There **is** statistical evidence to support a claim that the sample mean is *smaller than* 10.
3. There **is not** statistical evidence to support a claim that the sample mean is *at least as large* as 10.
4. There **is not** statistical evidence to support a claim that the sample mean is *smaller than* 10.
5. There **is** statistical evidence to support a claim that the population mean is *at least as large* as 10.
6. There **is** statistical evidence to support a claim that the population mean is *smaller than* 10.
7. There **is not** statistical evidence to support a claim that the population mean is *at least as large* as 10.
8. **There is not statistical evidence to support a claim that the population mean is *smaller than* 10.**
9. Suppose that you are interested in testing the following hypotheses for a population mean, µ:  
    H0: µ ≥ 10

H1: µ < 10  
The hypothesis test calculations have resulted in a p-value = 0.013 when the significance level for the test was 0.05. Which of the following conclusions is justified?

1. There **is** statistical evidence to support a claim that the sample mean is *at least as large* as 10.
2. There **is** statistical evidence to support a claim that the sample mean is *smaller than* 10.
3. There **is not** statistical evidence to support a claim that the sample mean is *at least as large* as 10.
4. There **is not** statistical evidence to support a claim that the sample mean is *smaller than* 10.
5. There **is** statistical evidence to support a claim that the population mean is *at least as large* as 10.
6. **There is statistical evidence to support a claim that the population mean is *smaller than* 10.**
7. There **is not** statistical evidence to support a claim that the population mean is *at least as large* as 10.
8. There **is not** statistical evidence to support a claim that the population mean is *smaller than* 10.

# Applet: Exploring the Long-Run Error Rate

**Remember, the significance level (α) could be interpreted as a long run error rate.** For example,

Suppose we had the ability to gather 100 independent samples, each sample of size n, from the population of interest. When the null hypothesis is true, we expect approximately (100α) of the hypothesis tests to result in a decision where the null hypothesis is incorrectly rejected.

1. Suppose that α=0.02 and you had the ability to gather 1,000 independent samples, each sample of size 12, from the population of interest. If the null hypothesis were true, approximately how many of your hypothesis test results should result in an incorrect decision?
2. 12
3. 2
4. **20**
5. Cannot be determined
6. Suppose that α=0.05 and you are looking at simulation results where 1,000 independent samples, each of size 7, were obtained from a population distribution where the null hypothesis is true. Which of the following numbers might be associated with the number of times the null hypothesis was rejected, if the statistical methodology used to implement the test works as expected?
7. 8
8. **52**
9. 35
10. 5
11. Cannot be determined

Since we cannot obtain hundreds or thousands of independent samples from the population of interest (really, we usually have access to just one sample of a given size, n), we will use an applet to simulate the long-run error rate behavior for α.

A qr code with a black and red background

AI-generated content may be incorrect.

<https://meganheyman.shinyapps.io/PowerCompApp/>

The applet provides the ability to explore the long-run behavior of α for several population distribution shapes and sample sizes. It also allows for understanding of another type of long-run error behavior related to “Power” of the test. This review does not address the concept of statistical power.

Thus, for our purposes, we will be looking at one point along the plotted power curve(s) in the “Compare Methods” tab.

1. Suppose that you plan to test the following set of hypotheses about the population mean, µ  
    H0: µ = 1.3  
    H1: µ ≠ 1.3

Re-write the set of hypotheses as a difference between the parameter and hypothesized value.

**H0: µ - 1.3 = 0  
 H1: µ - 1.3 ≠ 0**

1. Suppose that you plan to test the following set of hypotheses about the population mean, µ  
    H0: µ = 1.3  
    H1: µ ≠ 1.3  
   If the null hypothesis is true, what is the true difference between the parameter and the hypothesized value? (This value, along the horizontal axis of the applet power curve, is where we will focus our attention.)

**0**

1. Suppose that you plan to test the following set of hypotheses about the population mean, µ  
    H0: µ = 1.3  
    H1: µ ≠ 1.3  
   You gather a sample of size 8 where you feel comfortable asserting that the observations are independent and identically distributed from a normal population. Which statistical method is preferred for analysis?
2. **t-test**
3. residual bootstrap
4. wild bootstrap
5. permutation test
6. Suppose that you plan to test the following set of hypotheses about the population mean, µ  
    H0: µ = 1.3  
    H1: µ ≠ 1.3  
   **You could gather a sample of size 8 where you feel comfortable asserting that the observations are independent and identically distributed from a normal population**.
   1. Using your answers to questions 12 and 13 and the online applet, what % of times was the null hypothesis incorrectly rejected? What significance level did you use for your test?

**If students have correctly set up the applet with Normal population, n=8, then they should have one of:**

**α=0.01, 1.3%**

**α=0.05, 5.5%**

**α=0.1, 11.5%**

* 1. Does the simulated % match what you might expect to see for the statistical method you selected, which should exhibit correct behavior?

**Yes, although the percent is not exactly = to 100α, the observed percentage is very close to that value. We don’t expect it to be exactly = due to sampling variability.**

* 1. How does the % change if you had selected a different (not preferred, but in this case, not necessarily incorrect) statistical method?

|  |  |  |  |
| --- | --- | --- | --- |
| **α** | **Wild Bootstrap** | **Residual Bootstrap** | **Randomization Test** |
| **.01** | **3.0%** | **0.5%** | **2.1%** |
| **.05** | **7.7%** | **3.8%** | **6.2%** |
| **.1** | **13%** | **9.4%** | **11.5%** |

**If the student selected wild bootstrap or a randomization test, the % is higher than the simulated and target/expected percentage. Residual bootstrap is more conservative.**

1. Suppose that you plan to test the following set of hypotheses about the population mean, µ  
    H0: µ = 1.3  
    H1: µ ≠ 1.3  
   You gather a sample of size 8 where you feel comfortable asserting that the observations are independent and identically distributed from a LaPlace population. Which statistical method should be appropriate for analysis?
2. t-test
3. residual bootstrap
4. wild bootstrap
5. **permutation test**
6. Suppose that you plan to test the following set of hypotheses about the population mean, µ  
    H0: µ = 1.3  
    H1: µ ≠ 1.3  
   **You could gather a sample of size 8 where you feel comfortable asserting that the observations are independent and identically distributed from a LaPlace population.**
   1. Using your answers to questions 12 and 15 and the online applet, what % of times was the null hypothesis incorrectly rejected? What significance level did you use for your test?

**If students have correctly set up the applet with LaPlace population, n=8, then they should have one of:**

**Randomization, α=0.01, 1.5%**

**Randomization, α=0.05, 4.3%**

**Randomization, α=0.1, 8.9%**

**Residual Bootstrap, α=0.01, 0.6%**

**Residual Bootstrap, α=0.05, 3.1%**

**Residual Bootstrap, α=0.1, 6%**

* 1. Does the simulated % match what you might expect to see for the statistical method you selected, which should exhibit correct behavior?

**Yes, the simulated % is close to the expected percent. Unless the student chose a randomization test with 0.01 sig. level, the simulated % is lower than what we expect.**

* 1. If you had incorrectly asserted that the population distribution was Normal, you would have utilized a different statistical method for analysis. If you had used the incorrect statistical method, what % of times is the null hypothesis incorrectly rejected?

**t-test, α=0.01, 0.9%**

**t-test, α=0.05, 3.9%**

**t-test, α=0.1, 9.1%**

# Reflection

1. The applet simulates many samples of a specific size from a known population distribution. In reality, you will have one sample of a specific size from an unknown population. If the null hypothesis were true, what is the probability that you will reject the null hypothesis for your single sample? Briefly justify your answer.

**The probability is either 0 or 1 – you will either make a correct or incorrect decision with the collected sample information.**

1. Is there any behavior that you observed in the applet that was unexpected? If so, please briefly describe.
2. What concept(s) from this activity might still need more review or study effort for you to feel comfortable in your understanding?