**3.1Basic Concept**

Test statistic is a standardized value that is calculated from sample data for a hypothesis test which measures the agreement in between the sample data. The calculated value of the test statistic is used to compare the data obtained from the experimental conditions with the data expected to be obtained if the null hypothesis is valid. The test statistic is used to determine whether or not the null hypothesis should be rejected. The methods of calculation for both test statistics and critical values are different between a small sample and a large sample.

Generally, test statistics for small sample will be based on the number of runs, while approximation technique will be applied for large sample. Besides, critical values for small sample will be obtained from a runs test for randomness table while a formula will be used to generate critical values for large sample. The sample sizes are considered as small when both n1 and n2 are 20 or less. It is recommended that, for sample size more than 20 to apply approximation method.

**3.2 Terminology used in Run test**

**3.2.1 Total sample size, and number of runs**

First we need to determine the total sample size, and then the number of observation of each type. First we need to identify number runs in the data available for the analysis consists of a sequence of observations, recorded in order of occurrence, which we can categorize into two mutually exclusive types.

n = total sample size

n1 = the number of observation of one type

n2 = the number of observations of the other type

**3.2.2 Hypothesis**

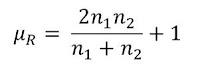
Then State the null and alternate hypothesis

H0: the pattern of occurrence is random

H1: the pattern of occurrence is not random

**2.3.3 Calculate the Mean runs**

The mean is given by the formula



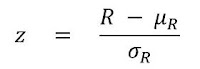
**3.2.4 Calculate the Standard Deviation**

You can find the standard deviation for a runs test using the formula

[https://1.bp.blogspot.com/-8ys1VgHvxws/WrrLVVHY9UI/AAAAAAAABpo/D7Ev_3bonlQczGFoFBDVKVWYHyshuXVrgCLcBGAs/s320/Run%2BTest%2BSD%2BFormula.jpg](https://1.bp.blogspot.com/-8ys1VgHvxws/WrrLVVHY9UI/AAAAAAAABpo/D7Ev_3bonlQczGFoFBDVKVWYHyshuXVrgCLcBGAs/s1600/Run+Test+SD+Formula.jpg)

**3.2.5 Calculate the z-Statistic**

The z-Statistic can be calculated using the formula

[](https://2.bp.blogspot.com/-5njFy_zXhZM/WrrRL35XjrI/AAAAAAAABqA/XQOuR0WC4_U6a_-7vwVYvaFlLv7-t4YOQCLcBGAs/s1600/Run+Test+z-Statistic+formula.jpg)

Then we can substitute the value of

### 3.2.6 Determine the Critical Value

### 3.2.7 Look up the value of the critical value from statistical table of normal distribution State the Decision

Since the calculated value of z = 1.0909 is within the accept region(less than the critical value of 1.96), we therefore accept (fail to reject) the null hypothesis and conclude that there is not real evidence that the arrangement is not random

**3.4 Steps Used in Run test**

Then we go ahead to find the z-statistic. We would use the following 7 steps to disolve this problem.

[Step 1: State the null and alternate hypothesis](https://kindsonthegenius.com/blog/hypothesis-testing-question-21-walf-wolfowitz-run-test-for-large-sample-step-by-step-procedure#s1)  
[Step 2: Determine the number of runs](https://kindsonthegenius.com/blog/hypothesis-testing-question-21-walf-wolfowitz-run-test-for-large-sample-step-by-step-procedure#s2)  
[Step 3: Calculate the mean runs](https://kindsonthegenius.com/blog/hypothesis-testing-question-21-walf-wolfowitz-run-test-for-large-sample-step-by-step-procedure#s3)  
[Step 4: Calculate the Standard deviation](https://kindsonthegenius.com/blog/hypothesis-testing-question-21-walf-wolfowitz-run-test-for-large-sample-step-by-step-procedure#s4)  
[Step 5: Calculate the z-Statistic](https://kindsonthegenius.com/blog/hypothesis-testing-question-21-walf-wolfowitz-run-test-for-large-sample-step-by-step-procedure#s5)  
[Step 6: Determine the Critical value](https://kindsonthegenius.com/blog/hypothesis-testing-question-21-walf-wolfowitz-run-test-for-large-sample-step-by-step-procedure#s6)  
[Step 7: Draw a conclusion](https://kindsonthegenius.com/blog/hypothesis-testing-question-21-walf-wolfowitz-run-test-for-large-sample-step-by-step-procedure#s7)

**3.2 Example of Approximation Technique for Large Samples**

The following arrangement of men, M, and women, W, lined up to purchase tickets for a rock concert:

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **M** | **W** | **M** | **W** | **M** | **M** | **M** | **W** | **M** | **W** | **M** | **M** |
| **M** | **W** | **W** | **M** | **M** | **M** | **M** | **W** |  | **M** | **W** | **M** |
| **M** | **M** | **W** | **M** | **M** | **M** | **W** | **W** | **W** | **M** | **W** | **M** |
| **M** | **M** | **W** | **M** | **W** | **M** | **M** | **M** | **M** | **W** | **W** | **M** |

Test for randomness at the α = 0.05 significance level

Solution Steps

In this case, we see that the sample size is fairly large, so we are going to use a slightly different method in this case. We are going to calculate the mean runs and the standard deviation.

**Step 2: Determine the Number of Runs**

This means that you need to mark each of the categories so you can easily count them  
Here I mark each run alternatively with red for M and black for W. The outcome is given below.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **M** | **W** | **M** | **W** | **M** | **M** | **M** | **W** | **M** | **W** | **M** | **M** |
| **M** | **W** | **W** | **M** | **M** | **M** | **M** | **W** | **W** | **M** | **W** | **M** |
| **M** | **M** | **W** | **M** | **M** | **M** | **W** | **W** | **W** | **M** | **W** | **M** |
| **M** | **M** | **W** | **M** | **W** | **M** | **M** | **M** | **M** | **W** | **W** | **M** |

The number of runs is given by R = 27  
the number of Men, n1 = 30  
The number of Women, n2 = 18

### Step 3: Calculate the Mean runs

The mean is given by the formula

We can go ahead to substitute the value of n1 = 30 and n2 = 18

**Step 4:** Calculate the Standard Deviation

You can find the standard deviation for a runs test using the formula

We can go ahead to substitute the value of n1 = 30 and n2 = 18

**Step 5:** Calculate the z-Statistic

The z-Statistic can be calculated using the formula

Then we can substitute the value of  
R = 27  
= 23.5  
= 3.2083

### Step 6: Determine the Critical Value

Look up the value of the critical value from statistical table of normal distribution  
We get a critical value for of 1.96

**Step 7: State the Decision**

Since the calculated value of z = 1.0909 is within the accept region(less than the critical value of 1.96), we therefore accept (fail to reject) the null hypothesis and conclude that there is not real evidence that the arrangement is not random

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Standard normal distribution with upper tail at 1.645 and alpha=0.05  Rejection Region for Upper-Tailed Z Test (H1: μ > μ0 ) with α=0.05  The decision rule is: Reject H0 if Z > 1.645. | |  |  | | --- | --- | | **Upper-Tailed Test** | | | α | Z | | 0.10 | 1.282 | | 0.05 | 1.645 | | 0.025 | 1.960 | | 0.010 | 2.326 | | 0.005 | 2.576 | | 0.001 | 3.090 | | 0.0001 | 3.719 | |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Standard normal distribution with lower tail at -1.645 and alpha=0.05  Rejection Region for Lower-Tailed Z Test (H1: μ < μ0 ) with α =0.05  The decision rule is: Reject H0 if Z < 1.645. | |  |  | | --- | --- | | **Lower-Tailed Test** | | | a | Z | | 0.10 | -1.282 | | 0.05 | -1.645 | | 0.025 | -1.960 | | 0.010 | -2.326 | | 0.005 | -2.576 | | 0.001 | -3.090 | | 0.0001 | -3.719 | |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Standard normal distribution with two tails  Rejection Region for Two-Tailed Z Test (H1: μ ≠ μ 0 ) with α =0.05  The decision rule is: Reject H0 if Z < -1.960 or if Z > 1.960. | |  |  | | --- | --- | | **Two-Tailed Test** | | | **α** | **Z** | | 0.20 | 1.282 | | 0.10 | 1.645 | | 0.05 | 1.960 | | 0.010 | 2.576 | | 0.001 | 3.291 | | 0.0001 | 3.819 | |

**3.5 Outline of the proposed work**

Calculate mean for all groups

State the null and alternate hypothesis and the value of Alpha

Calculate Sum of Squares Total, Sum of Squares between and within groups

Calculate the Degrees of Freedom (df)

Calculate the Mean Squares between (MSB) Mean Squares within

Create a Summary Table and Calculate the F Statistic

### Look up F from table

Calculate F value is greater than the critical value

Reject the null hypothesis

Aspect the null hypothesis

Figure 3.1 Outline of proposed approach