

Univariate Hypothesis Testing

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Objectives

- Understand the steps for statistical hypothesis testing
- Choose an appropriate statistical tests for various univariate statistical problems

Quiz

Part I. Below are the steps for statistical hypothesis testing. Place them in the correct order (1 through 7)

- ___ Define the test statistic
- ___ Calculate the test statistic
- ___ State the rejection region
- ___ State conclusion in context
- ___ Identify the parameter of interest
- ___ Decide if H_0 will be rejected
- ___ Determine the null and alternative hypothesis

Quiz

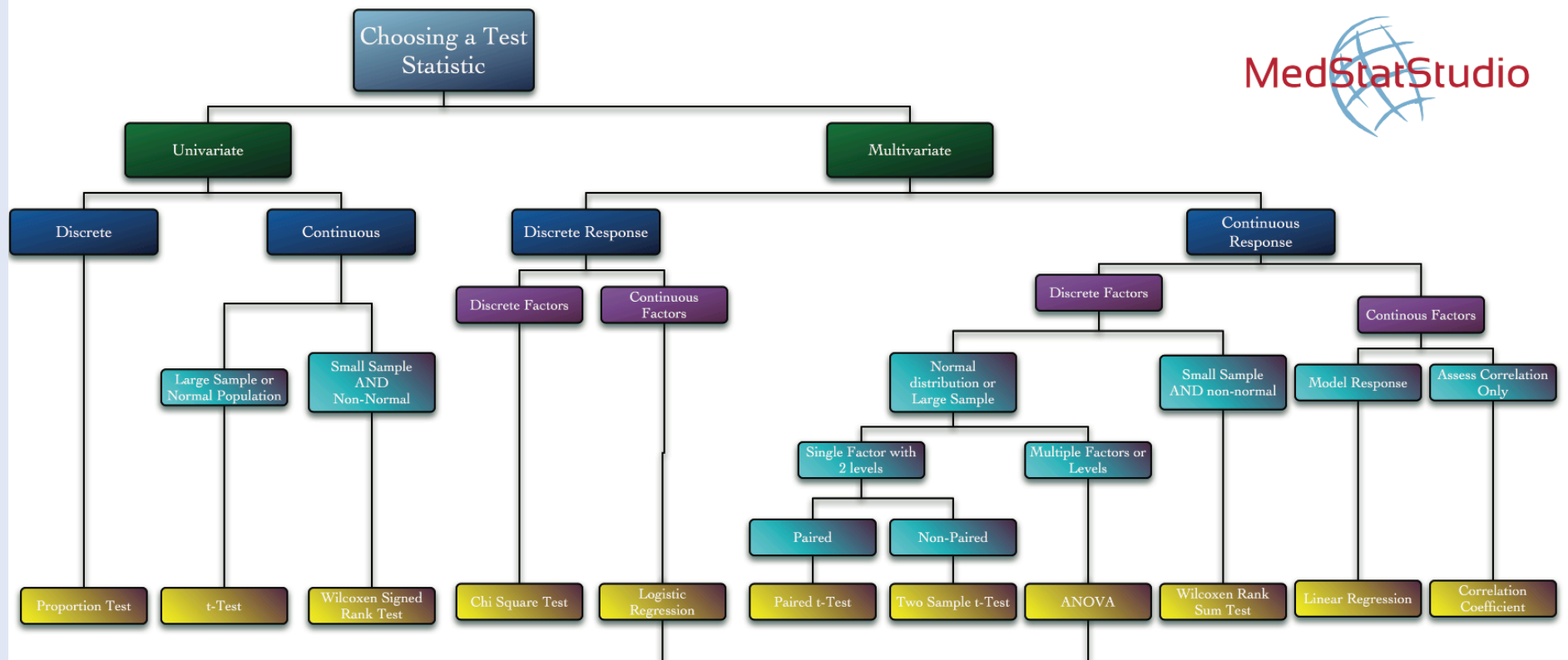
Part II. For the following scenarios, indicate which would be the best test statistic.

- A. Proportion Test
- B. T-test
- C. Wilcoxon Signed Rank Test

Hypothesis Testing

1. Identify parameter of interest
2. Determine null and alternative hypothesis
3. Define the test statistic***
4. State rejection region
5. Calculate test statistic
6. Decide if H_0 will be rejected
7. State conclusion in context

Choosing a Test Statistic



Procedure Success

A researcher has tabulated the success rate of a series of procedures in the emergency department and ICU. She wishes to show that the true success rate is greater than 90%.

She found 211 successful procedures, and 4 unsuccessful.

Procedure Success

1. Identify parameter of interest

P = proportion of successful procedures

Procedure Success

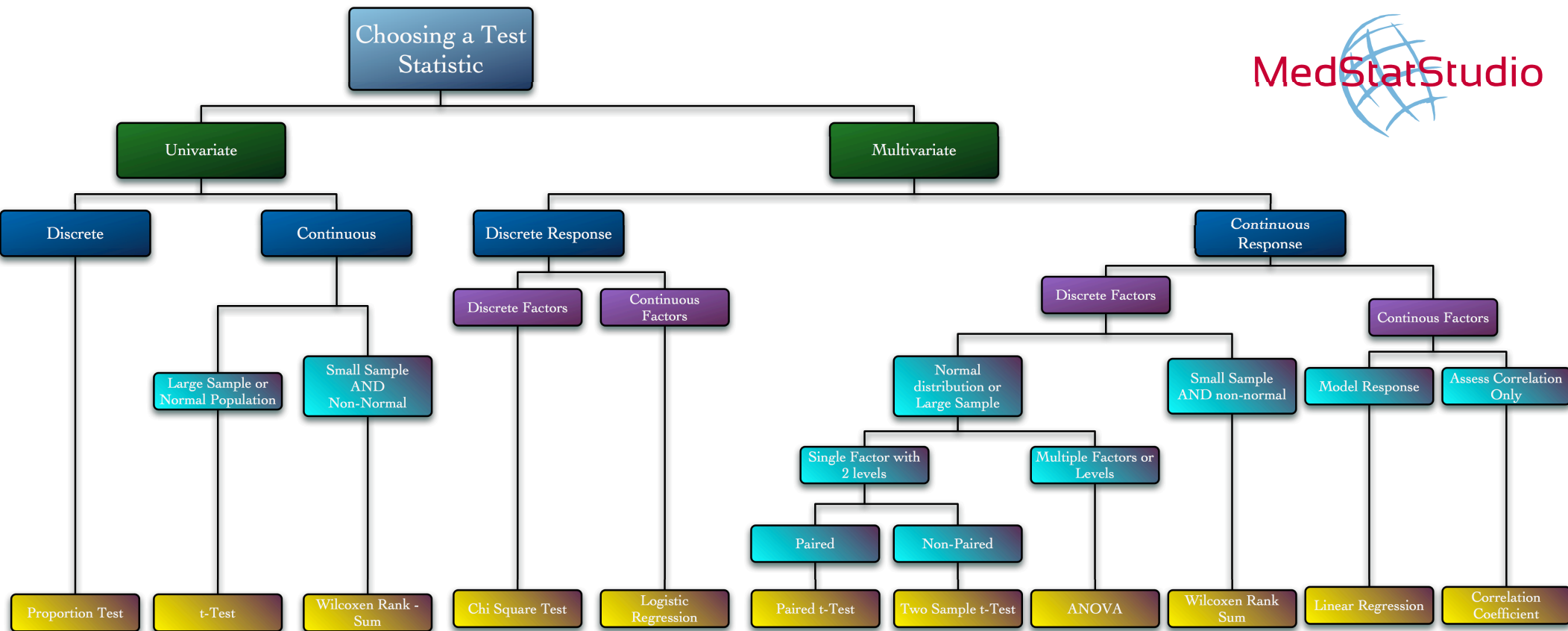
2. Hypotheses

$$H_0 : p = 0.1$$

$$H_A : p \neq 0.1$$

Procedure Success

3. Define the Test Statistic



Procedure Success

3. Define the Test Statistic

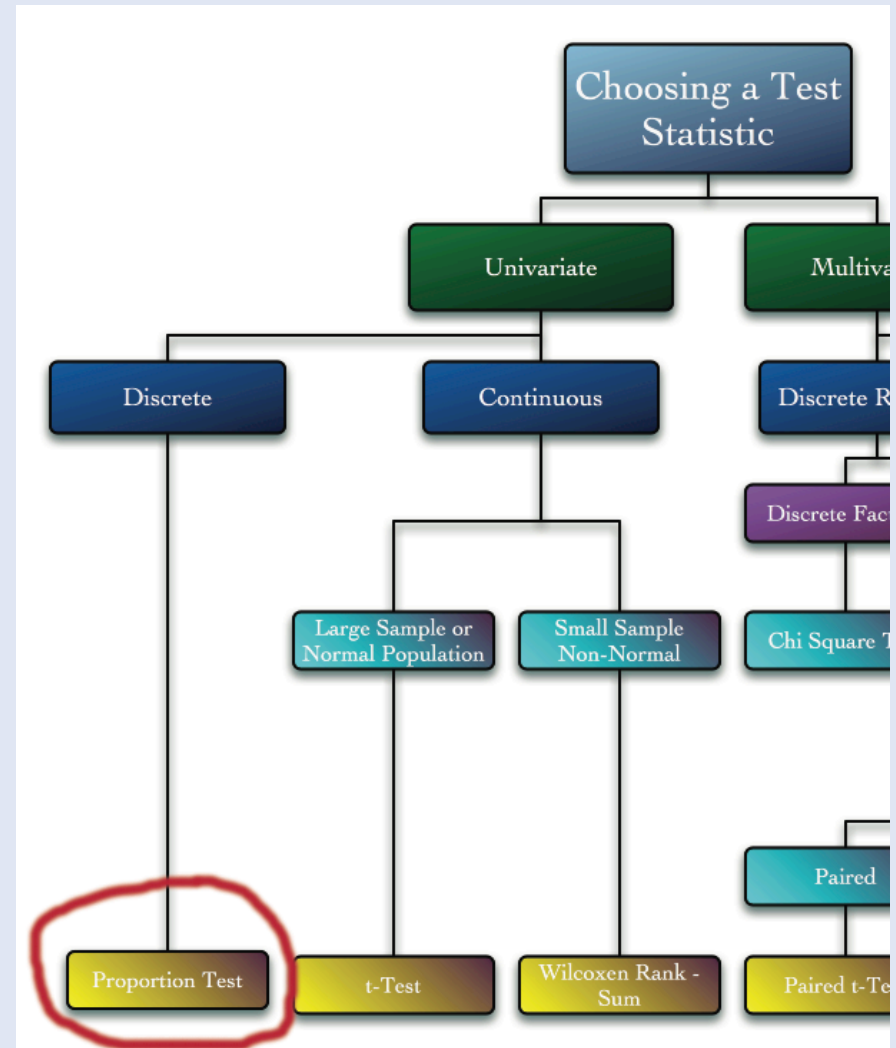
Univariate



Discrete



Proportion Test



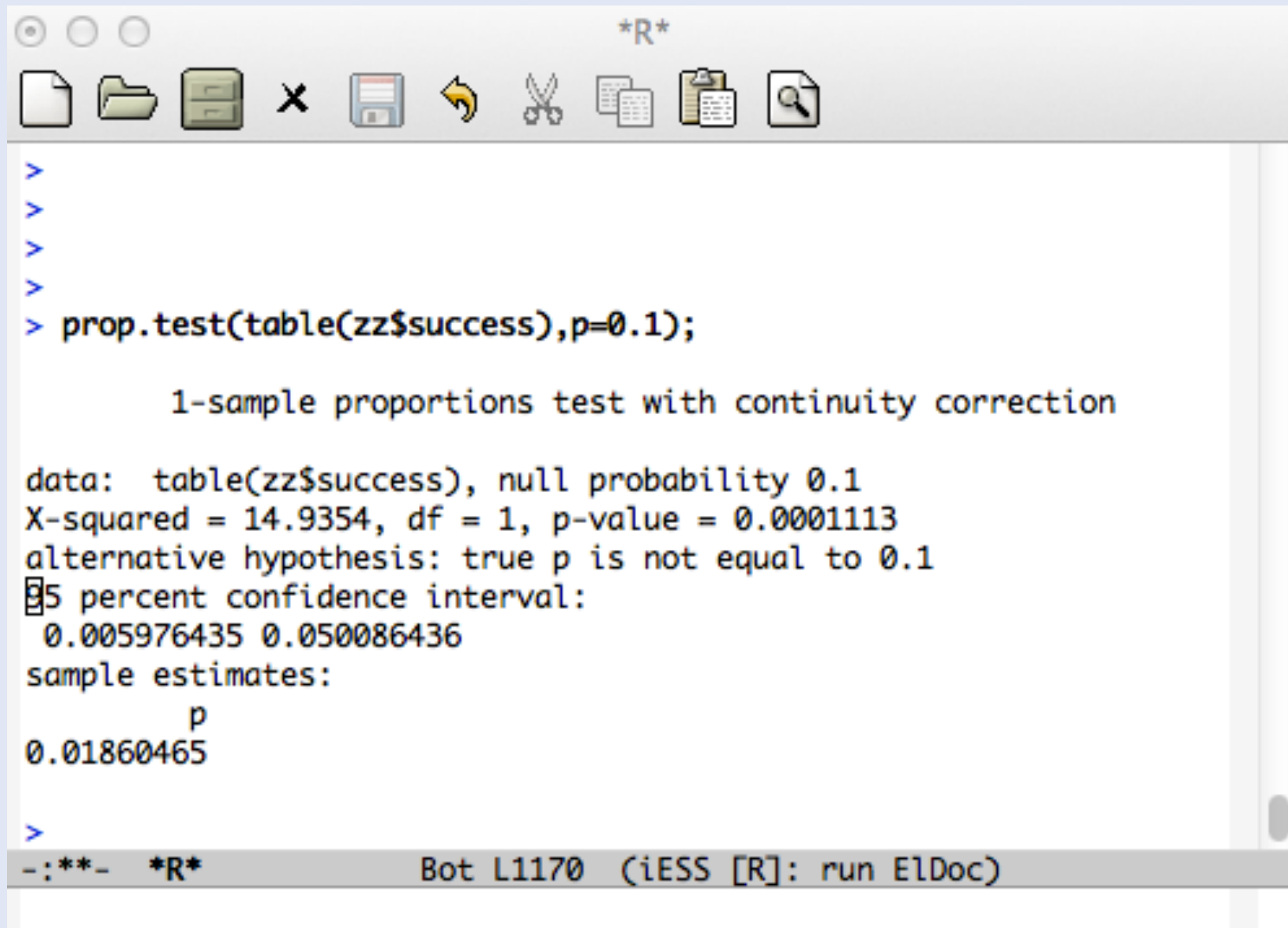
Procedure Success

4. Rejection Region

- Using $\alpha=0.05$
- Reject if $p < 0.05$

Procedure Success

5. Calculate Test Statistic



```
>
>
>
>
> prop.test(table(zz$success),p=0.1);

      1-sample proportions test with continuity correction

data:  table(zz$success), null probability 0.1
X-squared = 14.9354, df = 1, p-value = 0.0001113
alternative hypothesis: true p is not equal to 0.1
95 percent confidence interval:
 0.005976435 0.050086436
sample estimates:
              p
0.01860465

>
```

Bot L1170 (iESS [R]: run E1Doc)

Procedure Success

6. Decide if Null Hypothesis Rejected

Reject

Procedure Success

7. State conclusion in context

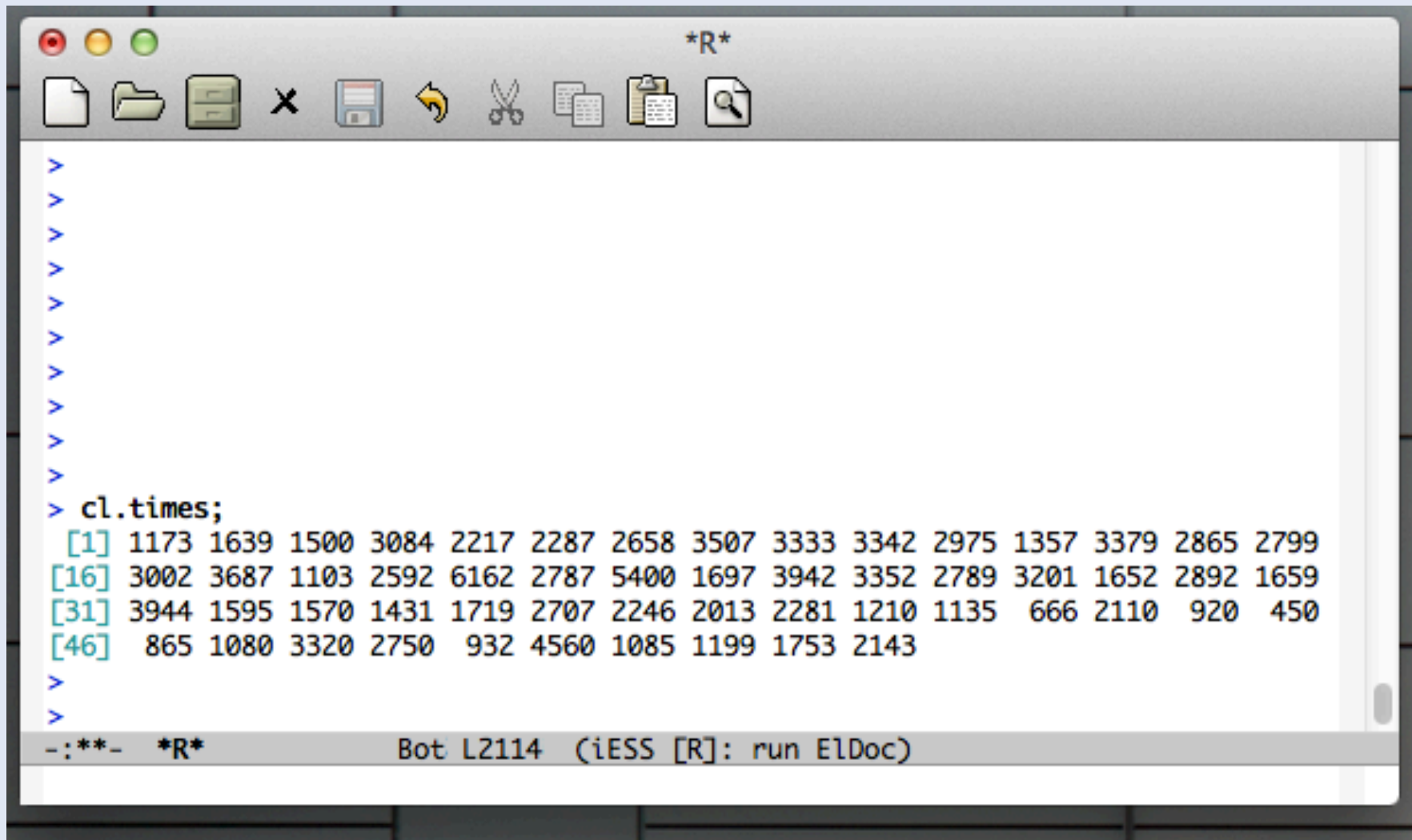
The observed procedure failure rate was 1.8% (95% confidence interval 0.6% to 5.0%). Thus, we are able to reject the null hypothesis of failure rate being 10% ($p < 0.0002$)

Central Line Times

At present, a simulation software uses an average time of 8 minutes for placement of a central line. A researcher feels that true central line placement is much longer.

The researcher measured time in seconds to place central line in 55 cases

Central Line Times



A screenshot of a terminal window titled '*R*' with a standard macOS-style title bar. The terminal shows the execution of the R command 'cl.times;', followed by four rows of numerical output. Each row is preceded by a blue index in square brackets: [1], [16], [31], and [46]. The output consists of 15 numbers per row. The window includes a toolbar with icons for file operations and a status bar at the bottom showing the prompt '-: **-' and the text '*R* Bot L2114 (iESS [R]: run ElDoc)'.

```
>
>
>
>
>
>
>
>
>
>
>
> cl.times;
[1] 1173 1639 1500 3084 2217 2287 2658 3507 3333 3342 2975 1357 3379 2865 2799
[16] 3002 3687 1103 2592 6162 2787 5400 1697 3942 3352 2789 3201 1652 2892 1659
[31] 3944 1595 1570 1431 1719 2707 2246 2013 2281 1210 1135 666 2110 920 450
[46] 865 1080 3320 2750 932 4560 1085 1199 1753 2143
>
>
```

-: **- *R* Bot L2114 (iESS [R]: run ElDoc)

Central Line Times

1. Parameter of interest

μ_1 (Mean time for line placement)

Central Line Times

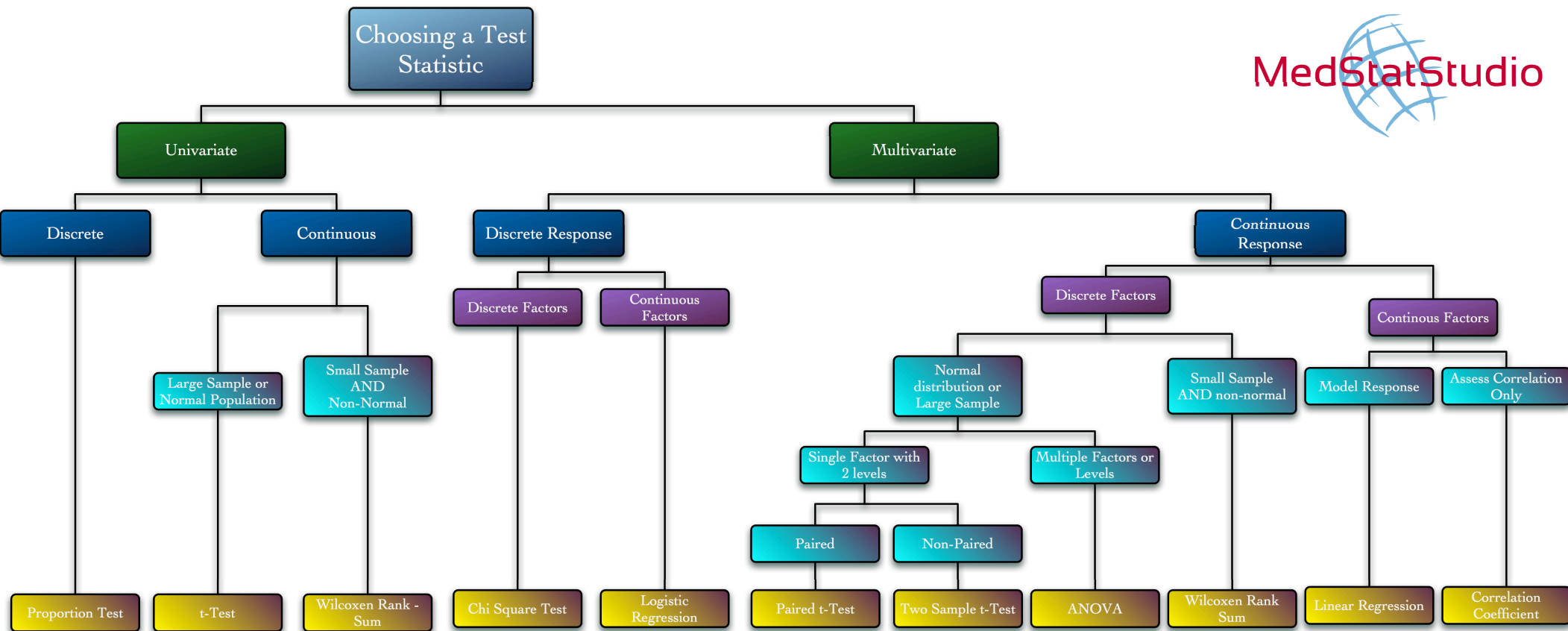
2. Determine null and alternative hypothesis

$H_0: \mu_1 = 480$ seconds

$H_A: \mu_1 \neq 480$ seconds

Central Line Times

3. Define the test statistic



Central Line Times

3. Define the test statistic

Univariate



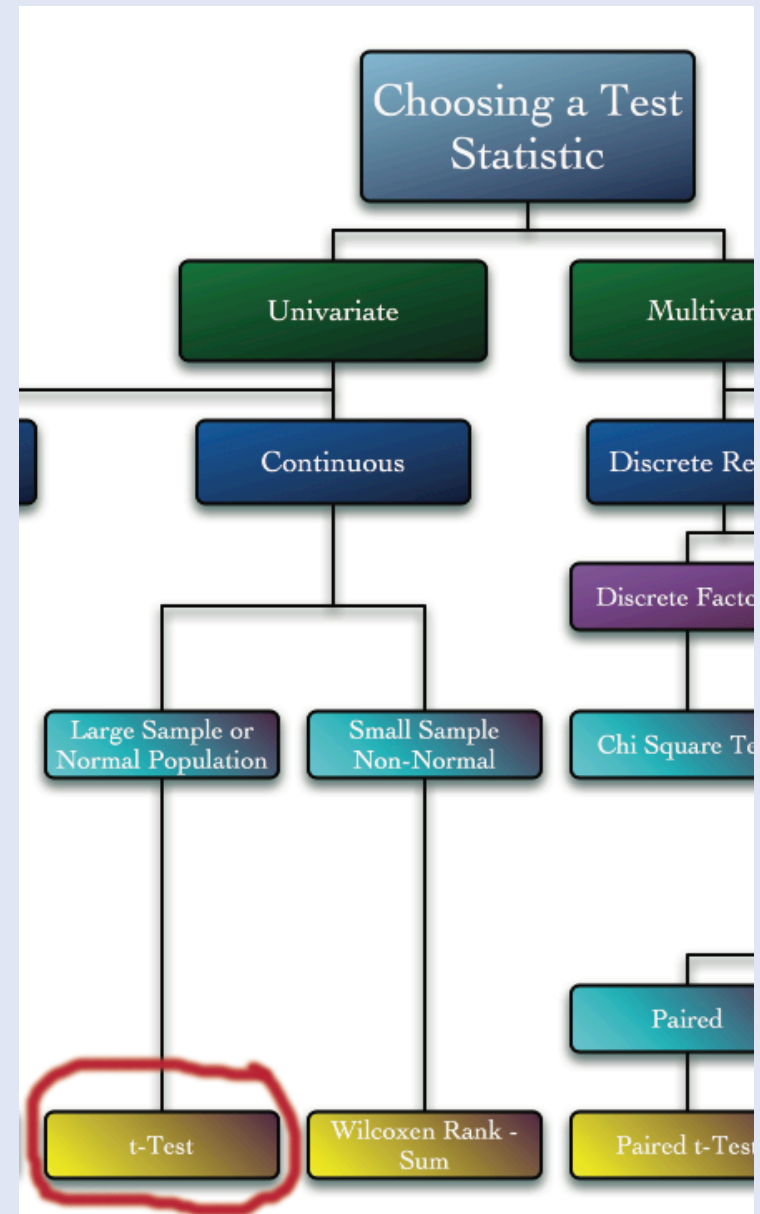
Continuous



Large Sample



t-Test



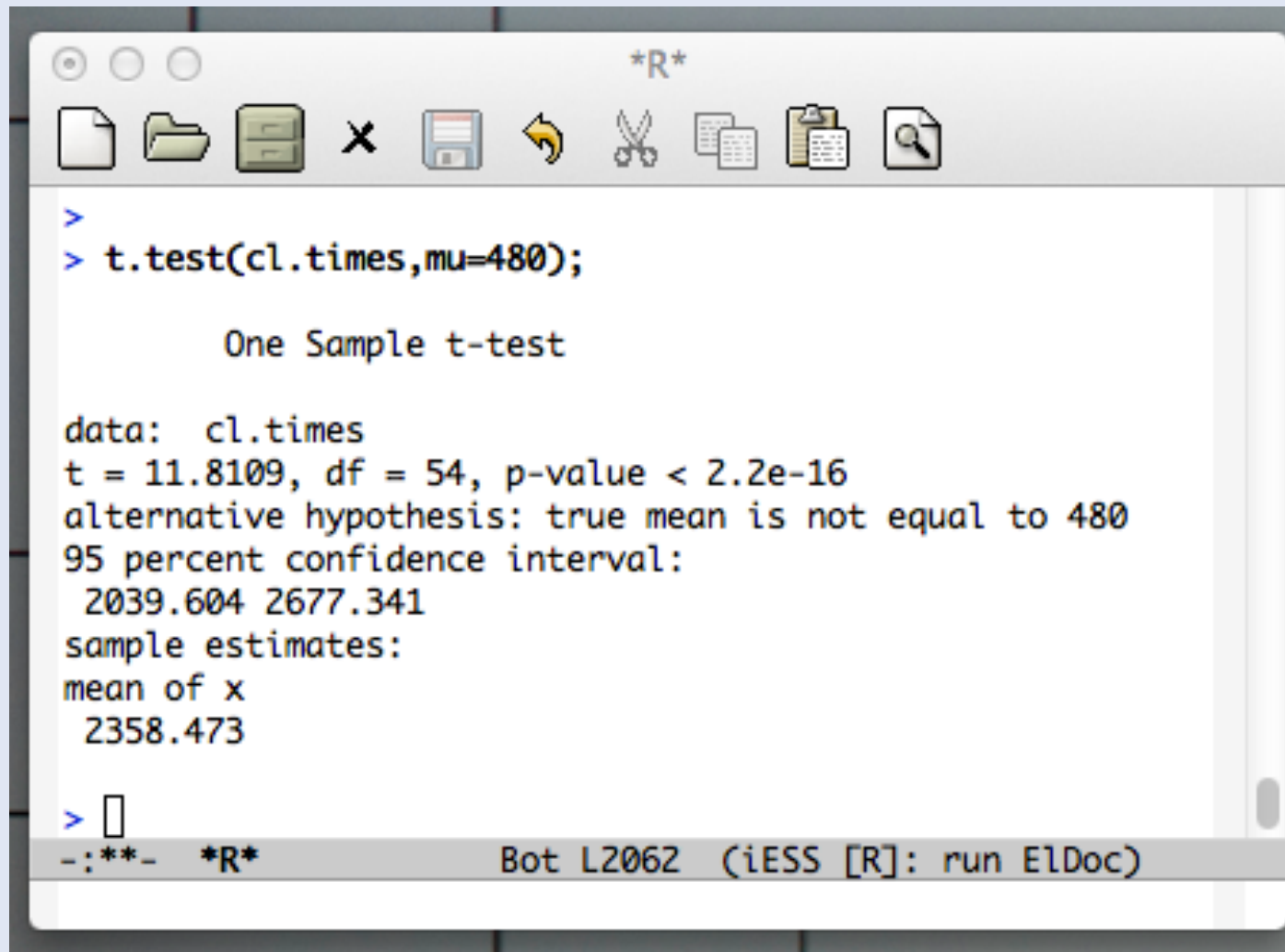
Central Line Times

4. State Rejection Region

- $\alpha=0.05$
- Reject if $p < 0.05$

Central Line Times

5. Calculate Test Statistic



```
>
> t.test(cl.times,mu=480);

      One Sample t-test

data:  cl.times
t = 11.8109, df = 54, p-value < 2.2e-16
alternative hypothesis: true mean is not equal to 480
95 percent confidence interval:
 2039.604 2677.341
sample estimates:
mean of x
 2358.473

> 
```

Bot L2062 (iESS [R]: run E1Doc)

Central Line Times

6. Decide if H_0 will be rejected

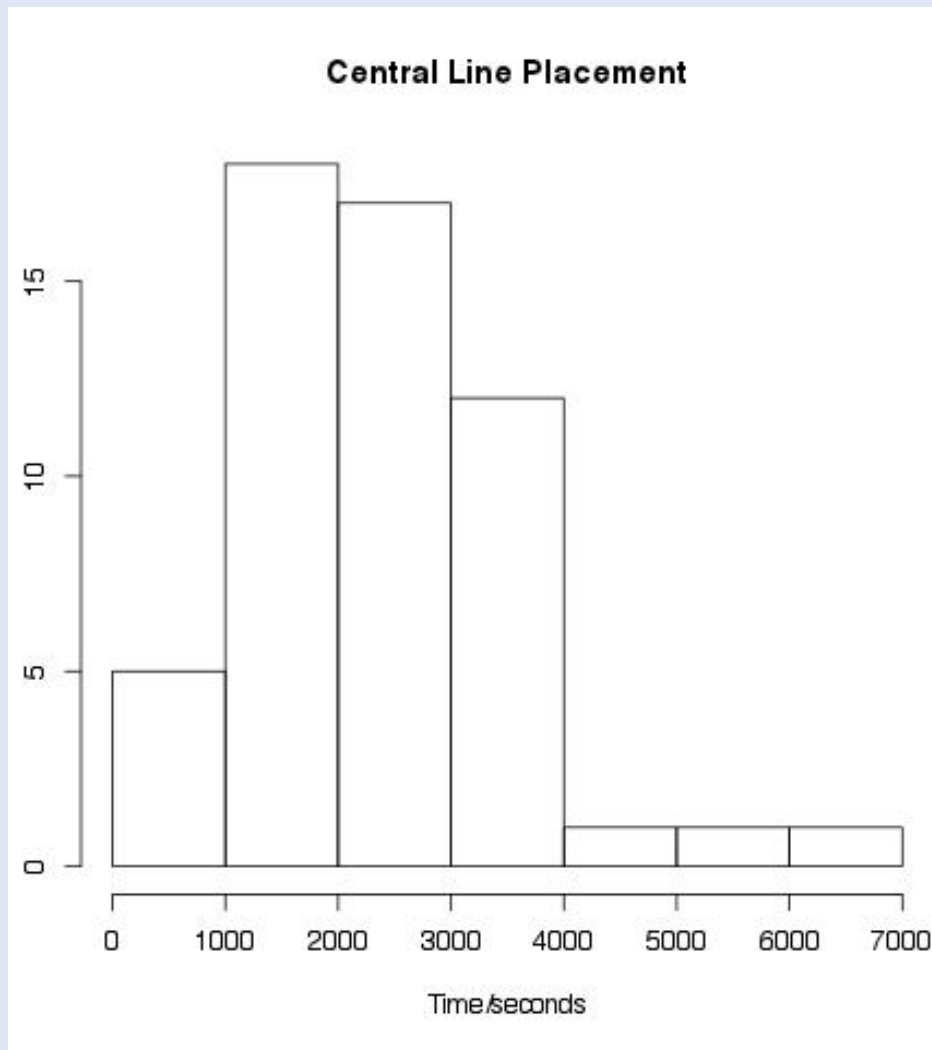
- Reject

Central Line Times

7. State conclusion in context

The mean time for central line placement was 2358 seconds (95% confidence interval 2039 to 2677 seconds). Thus, the null hypothesis of mean time being 480 seconds was rejected ($p < 0.0001$).

Central Line Times



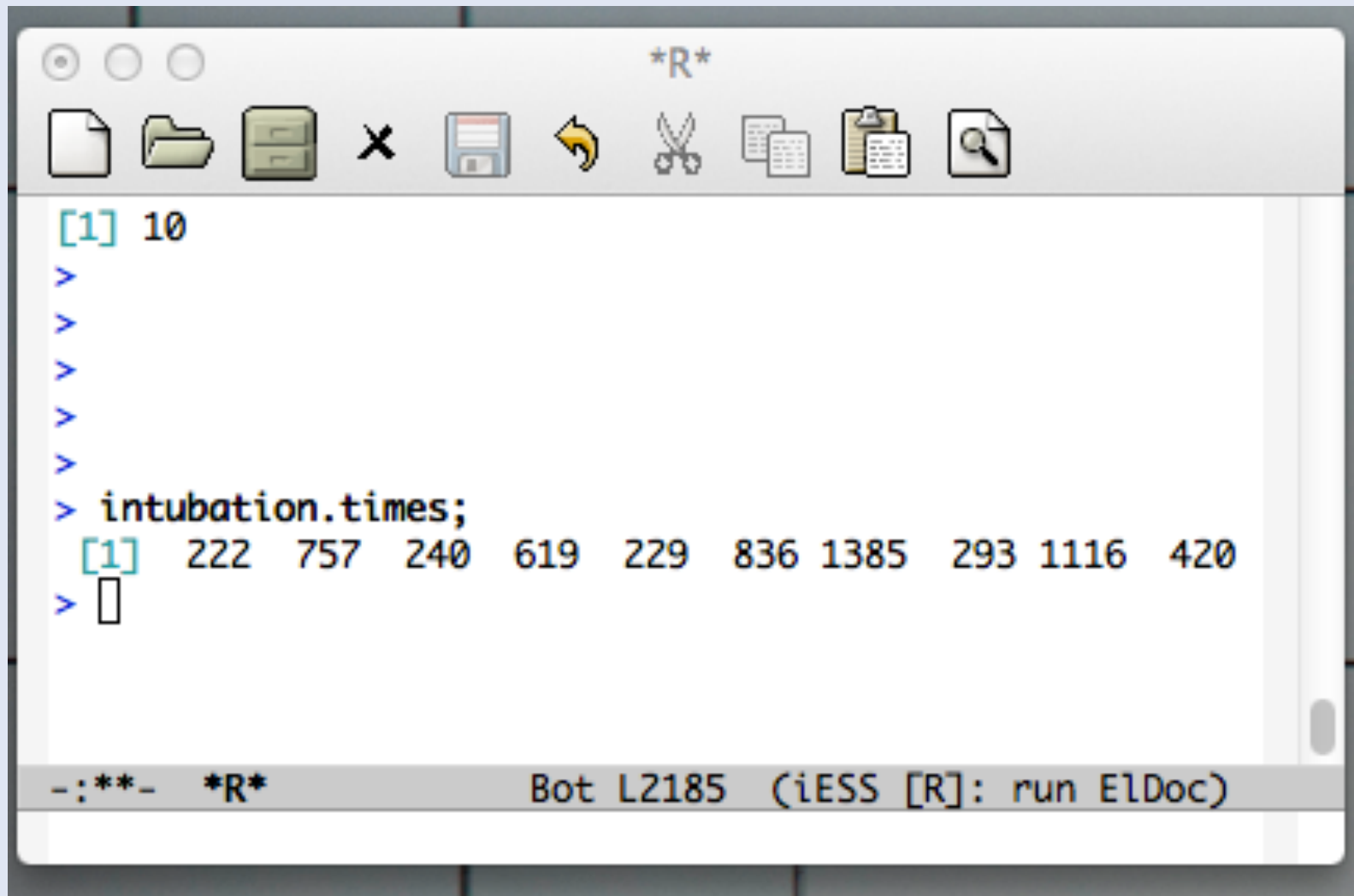
Sometimes Graphical methods are far superior!!

Intubation Times

The researcher is also investigating intubation time for the same study. The simulation software has been using 10 minutes as the estimated time for intubation. She believes that the true time is much shorter at her institution.

She has intubation times for 10 intubations

Intubation Times



```
[1] 10
>
>
>
>
>
>
> intubation.times;
[1] 222 757 240 619 229 836 1385 293 1116 420
> 
```

_:***- *R* Bot L2185 (iESS [R]: run EIDoc)

Intubation Times

1. Parameter of interest

- μ_1 (Mean Intubation Time)

2. Null and Alternative Hypothesis

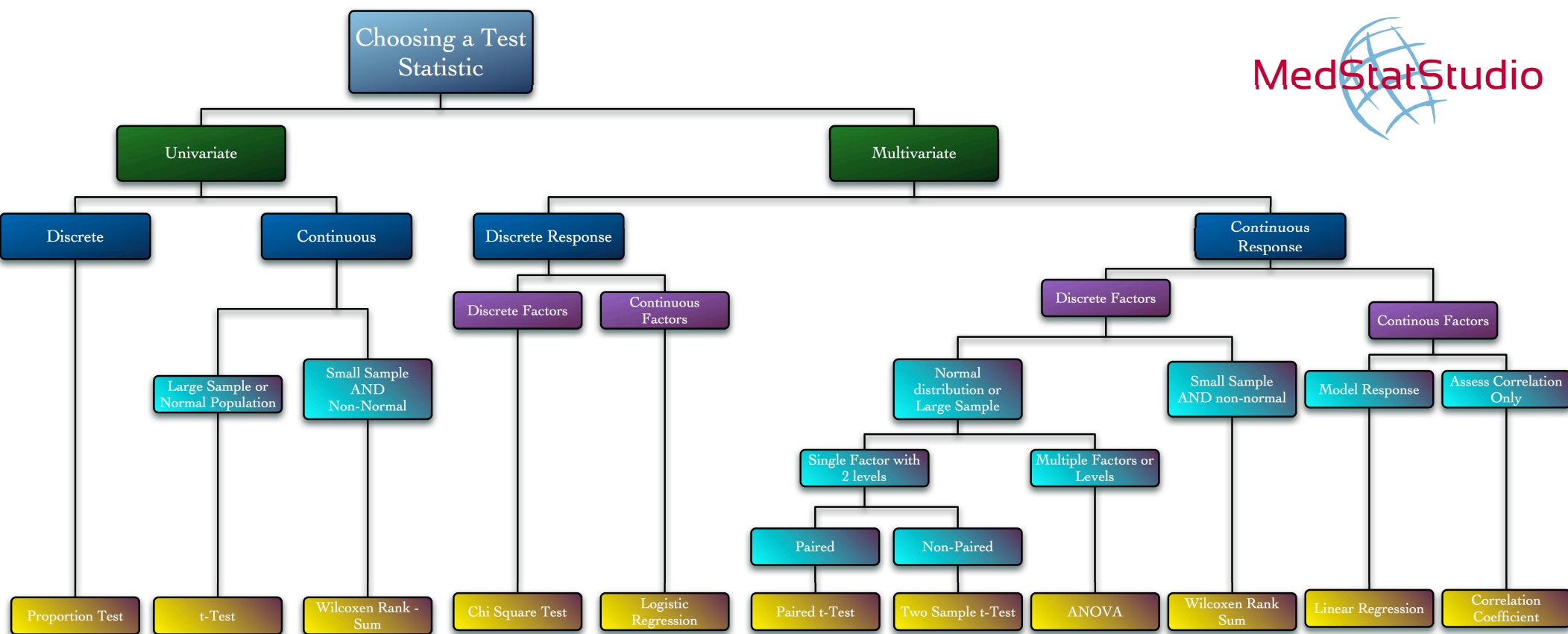
- $H_0: \mu_1 = 600$ seconds
- $H_A: \mu_1 \neq 600$ seconds

4. State Rejection Region

- $\alpha = 0.05$
- Reject if $p < 0.05$

Intubation Times

3. Define Test Statistic



Intubation Times

3. Define test statistic

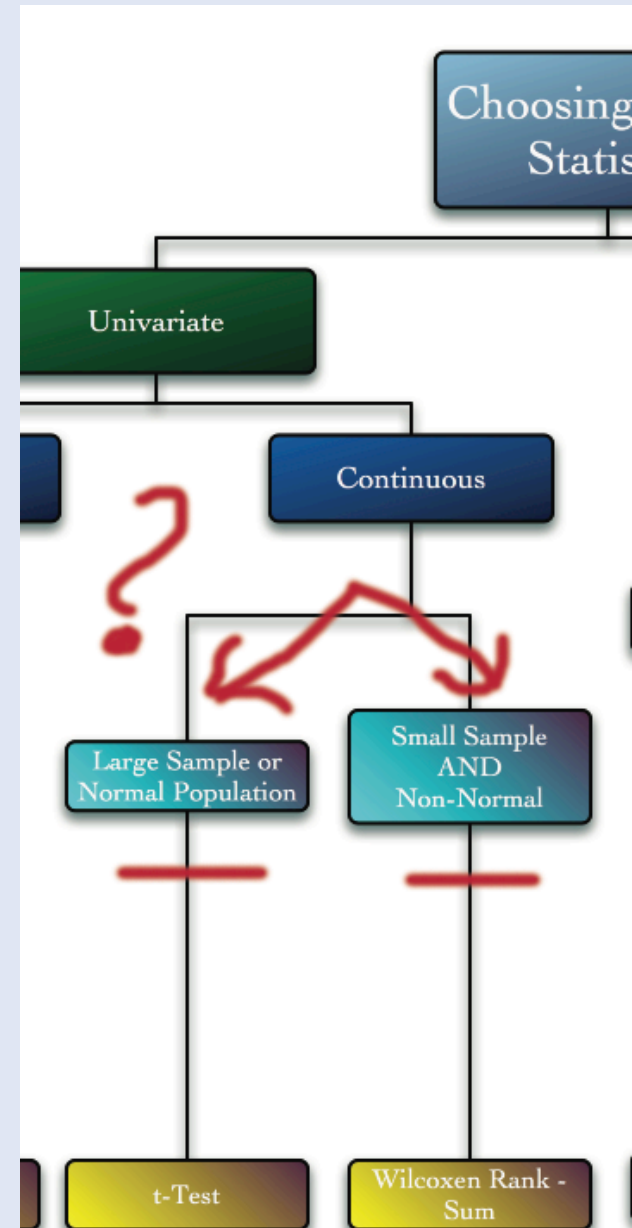
Univariate



Continuous



????

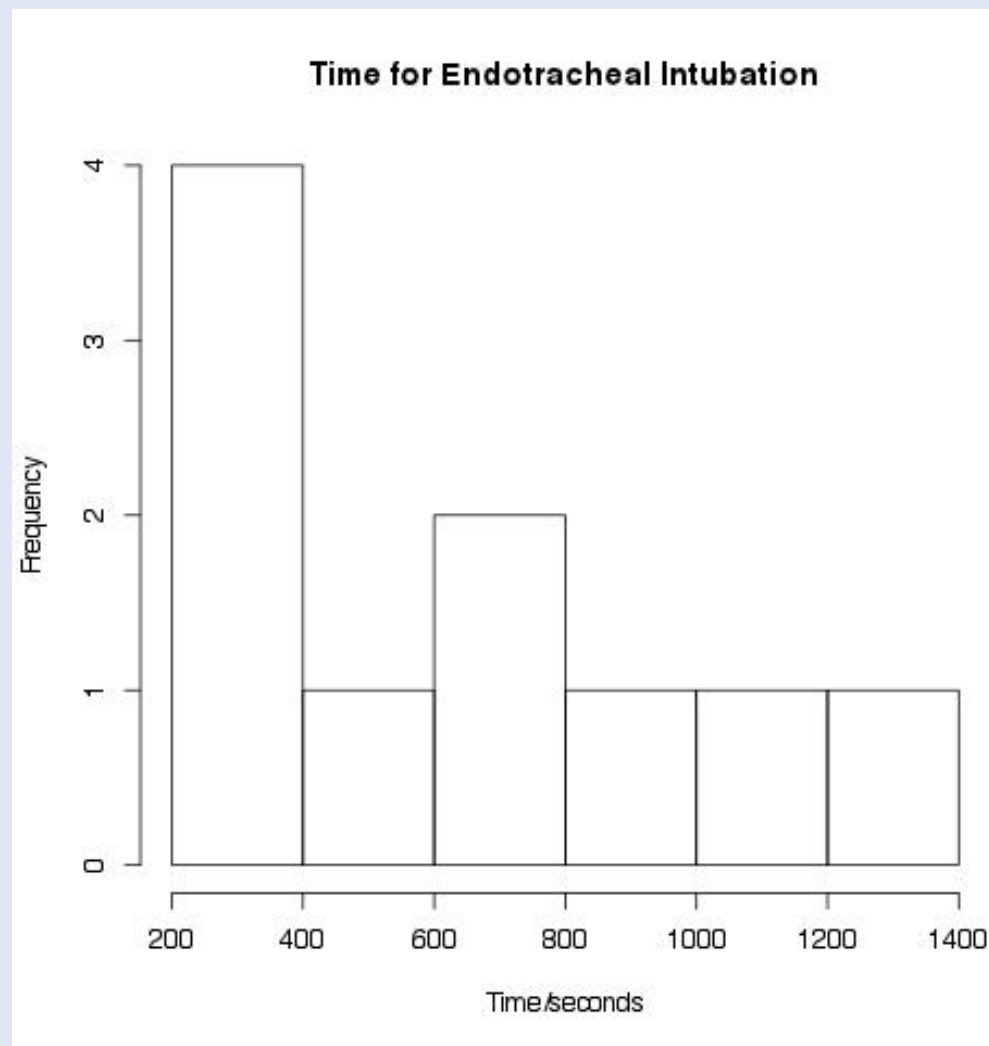


Intubation Times

3. Define test statistic

- How do we know if the population is normal or not?

PLOT!!



Intubation Times

3. Define test statistic

Univariate



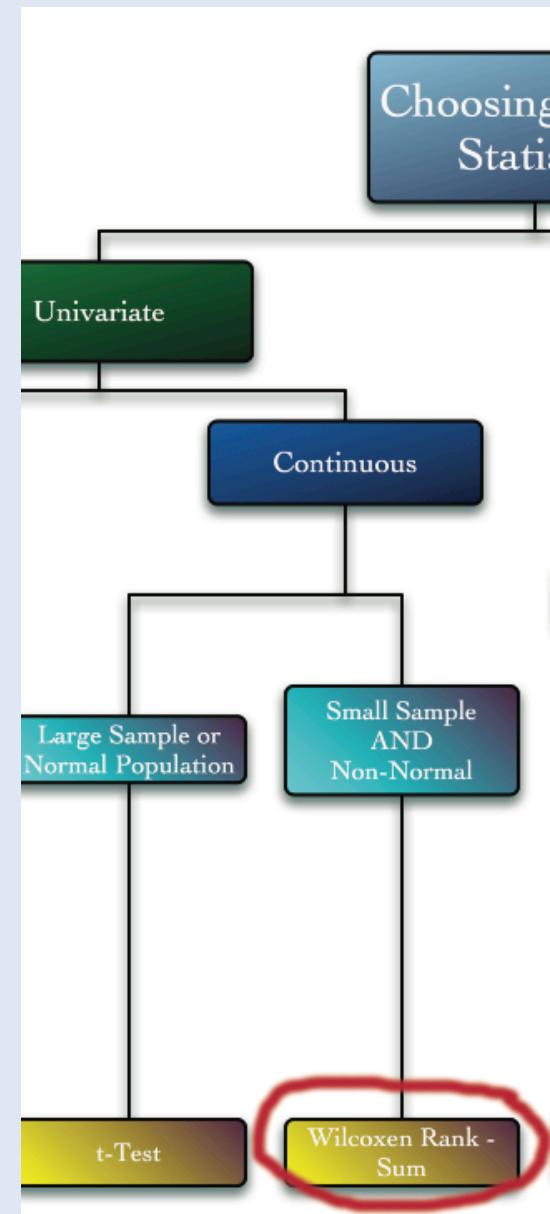
Continuous



Small and non-normal

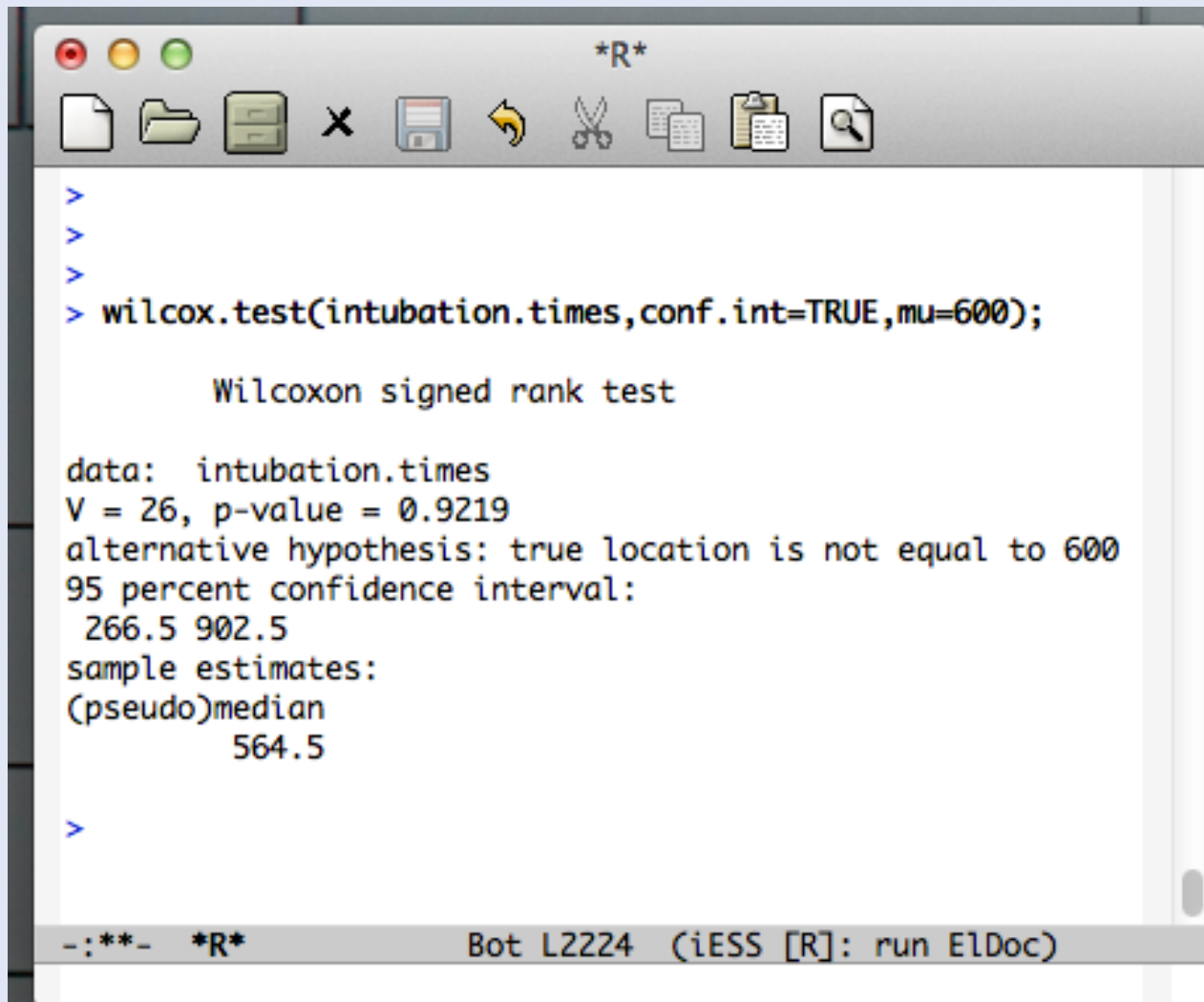


Wilcoxon Signed Rank



Intubation Times

5. Calculate Test Statistic



```
>
>
>
> wilcox.test(intubation.times, conf.int=TRUE, mu=600);

      Wilcoxon signed rank test

data:  intubation.times
V = 26, p-value = 0.9219
alternative hypothesis: true location is not equal to 600
95 percent confidence interval:
 266.5 902.5
sample estimates:
(pseudo)median
      564.5

>
```

Bot L2224 (iESS [R]: run E1Doc)

Intubation Times

6. State if H_0 will be rejected
 - Unable to reject

Intubation Times

7. State Conclusions in context

The median time for intubation was 564 seconds (95% CI: 266-902 seconds). There is no evidence to suggest that the median time for intubation is different from the current standard of 10 minutes.

Univariate Hypothesis Testing

Questions

Objectives

- Understand the steps for statistical hypothesis testing
- Choose an appropriate statistical tests for various univariate statistical problems

Quiz Answers

Quiz Answer: Part I

1. Identify parameter of interest
2. Determine null and alternative hypothesis
3. Define the test statistic***
4. State rejection region
5. Calculate test statistic
6. Decide if H_0 will be rejected
7. State conclusion in context

Quiz Answer Part II

1. A researcher is investigating the number of patients who are successfully evacuated from a disaster scene in comparison to the number of patients who were not successfully evacuated. Of 342 victims, 121 were successfully evacuated while 221 were not.

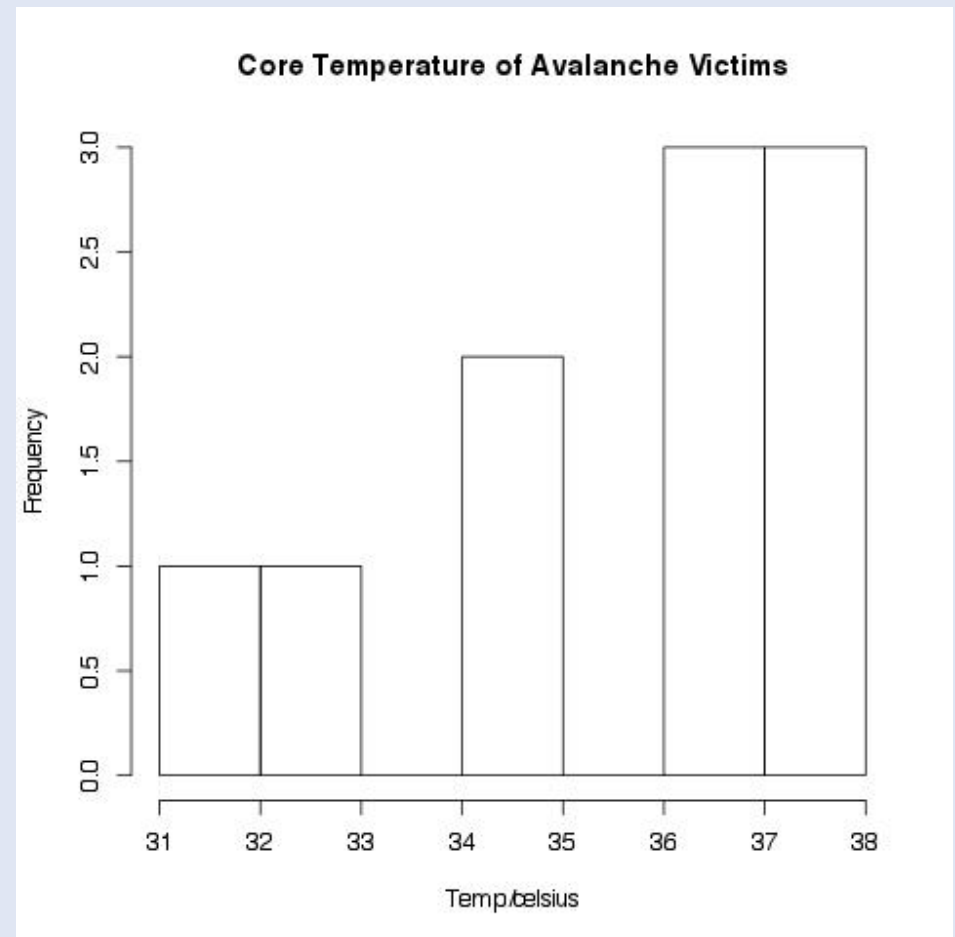
Quiz Answer Part II

1. A researcher is investigating the number of patients who are successfully evacuated from a disaster scene in comparison to the number of patients who were not successfully evacuated. Of 342 victims, 121 were successfully evacuated while 221 were not.

Proportion Test

Quiz Part II

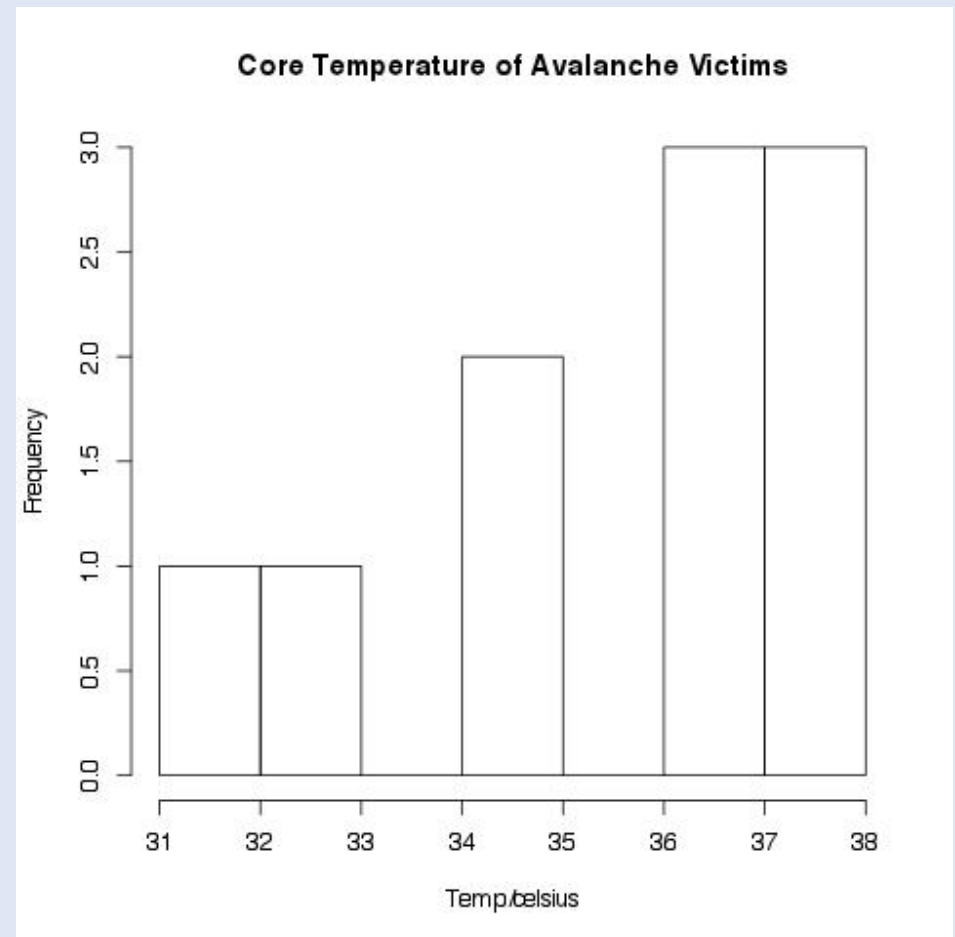
2. A researcher is investigating the effect of hypothermia on victims of an avalanche. He believes that the true average temperature of these victims is lower than 37.5 celsius. He has data from 10 victims.



Quiz Part II

2. A researcher is investigating the effect of hypothermia on victims of an avalanche. He believes that the true average temperature of these victims is lower than 37.5 celsius. He has data from 10 victims.

Wilcoxon Signed Rank



Quiz Part II

 3. A researcher wishes to describe the time it takes to complete successful triage among disaster victims of a simulation exercise. She has the time in seconds for successful triage for 35 victims.

Quiz Part II

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t-Test

Math Lesson

How does the signed rank test work?

➤ 30.4 31.5 30.5 37.3 37.6 37.2 37.1

1. Identify parameter of interest
2. Determine null and alternative hypothesis
3. Define the test statistic***
4. State rejection region
5. Calculate test statistic
6. Decide if H_0 will be rejected
7. State conclusion in context