

Lecture 11: Chapter 8

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UAB Mathematics

6 July 15

§8.1 Hypotheses

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- The average weight of tennis balls manufactured by Wilson is less than 100 grams.
- A paper claims that most American consumers know that the Kindle is a e-book reader.
- A sample of 103 human body temperatures can be used to test whether or not the mean body temperature for humans is 98.6°F .

§8.2 Basic Hypothesis Testing

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Example

From the previous, testing that the average weight of tennis balls manufactured by Wilson is less than 100 grams would be equivalent to testing the statement

$$\mu < 100,$$

where μ is the average weight of Wilson tennis balls.

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To test a hypothesis, we use the rare event rule which we have discussed previously:

If under the given assumption, the probability of a particular observed event is extremely small, we reject the assumption.

First we must form a hypothesis. Use these general rules:

- The **null** hypothesis H_0 should always be that a population parameter is equal to some value.
- The **alternative** hypothesis H_1 should either be that the same parameter is not equal to, less than, or greater than the value above.

§8.2 Example

Translate into a null hypothesis and an alternative hypothesis the following claim:

The proportion of students at UAB who have taken a math class is at least 65%.

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H_0 is easy. $H_0 : p = 0.65$. What should the other hypothesis be? Well, it can't be that $p \geq 0.65$ because that **includes** the null hypothesis. The alternative hypothesis, then, is $H_1 : p < 0.65$, so rejecting the null hypothesis is equivalent to supporting the claim whereas failing to reject the null hypothesis is equivalent to not supporting the claim.

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- Testing using a critical value. This method is essentially the same as constructing a confidence interval, except we may have one sided intervals now.
- Testing using a P -value, which describes the area lying beyond a test statistic in a one- or two-sided manner.

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A **test statistic** is the result of converting a sample statistic into a value used to test the null hypothesis.

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Proportion p	Mean μ with σ	Mean μ w/o σ	Std. Dev. σ
$z = \frac{\hat{p} - p}{\sqrt{\frac{pq}{n}}}$	$z = \frac{\bar{x} - \mu}{\frac{\sigma}{\sqrt{n}}}$	$t = \frac{\bar{x} - \mu}{\frac{s}{\sqrt{n}}}$	$\chi^2 = \frac{(n-1)s^2}{\sigma^2}$

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The significance of a P -test is called α . We reject the null hypothesis if $p \leq \alpha$ and fail to reject it if $p > \alpha$.

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- If the alternative hypothesis is a left-tailed (“less than”) statement, then the P -value is the area to the left of the statistic ω using the appropriate distribution.
- If the alternative hypothesis is a right-tailed (“greater than”) statement, then the P -value is the area to the right of the statistic ω using the appropriate distribution.

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- If the alternative hypothesis is a left-tailed (“less than”) statement, then the P -value is the area to the left of the statistic ω using the appropriate distribution.
- If the alternative hypothesis is a right-tailed (“greater than”) statement, then the P -value is the area to the right of the statistic ω using the appropriate distribution.
- If the alternative hypothesis is a two-tailed (“not equal to”) statement, then the P -value is the area outside of the interval $(-\omega, \omega)$ (if ω is positive) or $(\omega, -\omega)$ (if ω is negative). In the case of a χ^2 test, we will have an interval (ω_1, ω_2) .

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Definition (Type II Error)

This is the error of failing to reject a false null hypothesis.

This would be like concluding that the proportion was not greater than 50% when that was actually the case.

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We use β to denote the probability of making a Type II Error, i.e. it is the probability of failing to reject a false null hypothesis.

The confidence of a test is $1 - \alpha$ (the probability of failing to reject a true null hypothesis), and the power of a test is $1 - \beta$ (the probability of rejecting a false null hypothesis).

§8.3 Example (Proportion)

A survey showed that, among the 514 human resource managers polled, 93% said that the appearance of a job applicant was important. Use a 10% significance level to test the claim that at least 95% of human resources managers think that a job applicant's appearance is important.

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And because $P(x < -1.882) = 0.0299$, we get that we must reject the null hypothesis.

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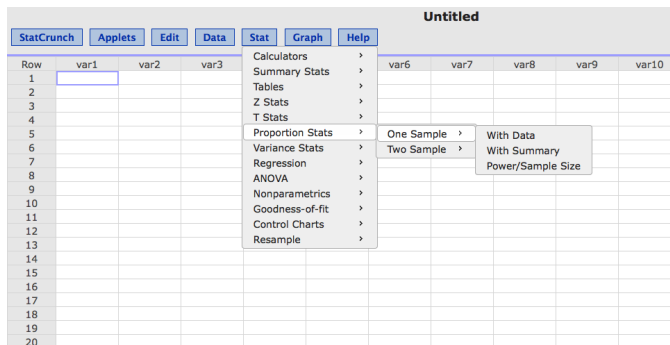
And because $P(x < -1.882) = 0.0299$, we get that we must reject the null hypothesis. In this case, this means that the data does **not** support our original claim!

§8.3 Using StatCrunch for Hypothesis Testing

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The screenshot shows the StatCrunch interface with the 'Stat' menu open. The menu path is: Stat > Proportion Stats > One Sample > With Data. The spreadsheet has columns labeled var1 through var10 and rows numbered 1 through 20. The 'Stat' menu options are: Calculators, Summary Stats, Tables, Z Stats, T Stats, Proportion Stats, Variance Stats, Regression, ANOVA, Nonparametrics, Goodness-of-fit, Control Charts, and Resample. The 'One Sample' submenu options are: With Data, With Summary, and Power/Sample Size.

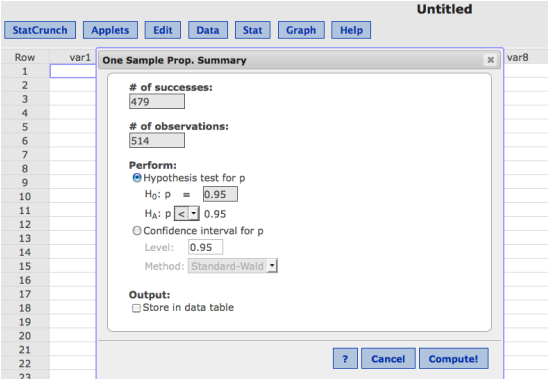
Row	var1	var2	var3	var6	var7	var8	var9	var10
1								
2								
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The screenshot shows the StatCrunch interface with a dialog box titled "One Sample Prop. Summary" open over a data table. The dialog box contains the following fields and options:

- # of successes:** 479
- # of observations:** 514
- Perform:**
 - Hypothesis test for p
 - $H_0: p = 0.95$
 - $H_A: p < 0.95$
 - Confidence interval for p
 - Level: 0.95
 - Method: Standard-Wald
- Output:**
 - Store in data table

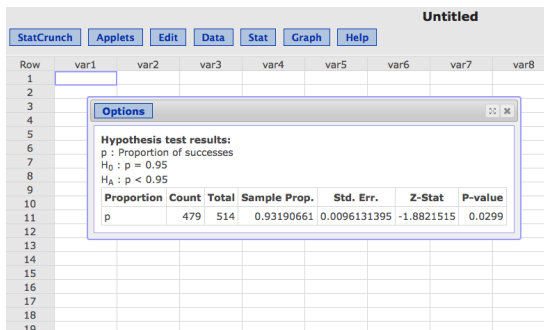
Buttons at the bottom of the dialog include "?", "Cancel", and "Compute!".

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The screenshot shows the StatCrunch software interface. At the top, there are menu buttons: StatCrunch, Applets, Edit, Data, Stat, Graph, and Help. Below the menus is a data grid with columns labeled var1 through var8 and rows numbered 1 through 19. An 'Options' dialog box is open, displaying the results of a hypothesis test for a proportion. The dialog box contains the following text:

Hypothesis test results:
p : Proportion of successes
 $H_0 : p = 0.95$
 $H_A : p < 0.95$

Proportion	Count	Total	Sample Prop.	Std. Err.	Z-Stat	P-value
p	479	514	0.93190661	0.0096131395	-1.8821515	0.0299

At the bottom right of the slide, there are navigation icons for back, forward, and search.

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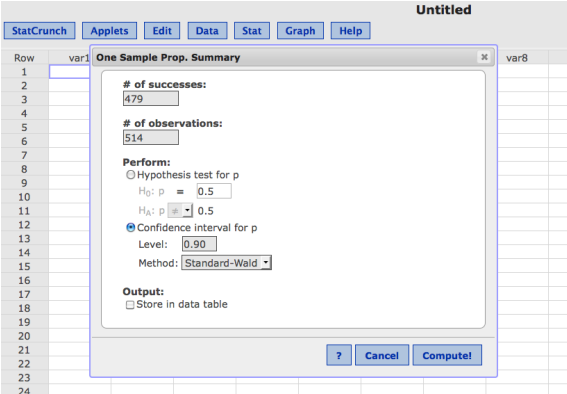
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- # of observations:** 514
- Perform:**
 - Hypothesis test for p
 - $H_0: p = 0.5$
 - $H_A: p \neq 0.5$
 - Confidence interval for p
 - Level: 0.90
 - Method: Standard-Wald
- Output:**
 - Store in data table

Buttons at the bottom of the dialog box include "?", "Cancel", and "Compute!".

§8.3 Using StatCrunch for Hypothesis Testing

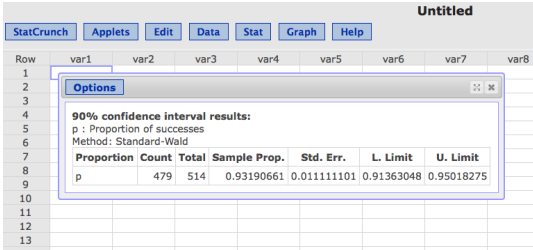
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The screenshot shows the StatCrunch interface with a data table and an 'Options' dialog box. The data table has columns labeled var1 through var8 and rows numbered 1 through 13. The 'Options' dialog box displays the following information:

90% confidence interval results:
p : Proportion of successes
Method: Standard-Wald

Proportion	Count	Total	Sample Prop.	Std. Err.	L. Limit	U. Limit
p	479	514	0.93190661	0.011111101	0.91363048	0.95018275

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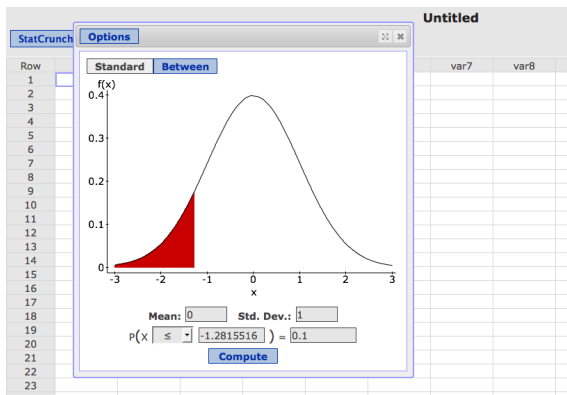
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§8.3 Importance of Using an Appropriate Test

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Notice the Confidence Interval Method resulting in failing to reject the null hypothesis because it is inherently **two-tailed**. **You must change the significance/confidence level when testing and one-tailed claim!** We needed a one-tailed test because our alternative hypothesis was one-tailed.

§8.4 Example (Mean)

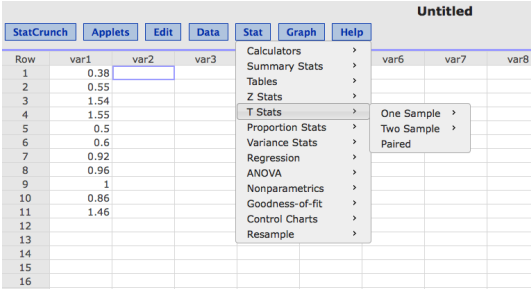
Use a 0.05 significance level to test the claim that the data below comes from a normally distributed population with mean less than 1.

0.38, 0.55, 1.54, 1.55, 0.50, 0.60, 0.92, 0.96, 1.00, 0.86, 1.46.

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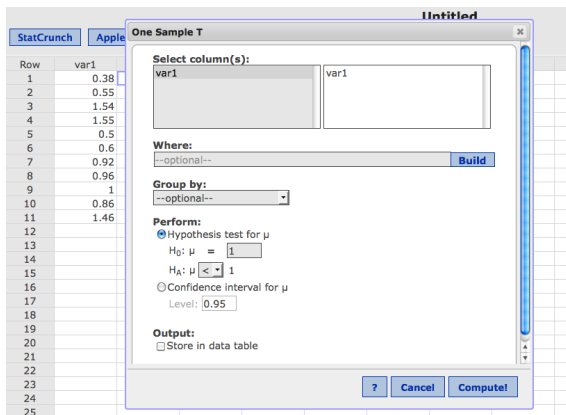
The screenshot shows the StatCrunch software interface. At the top, there are menu buttons: StatCrunch, Applets, Edit, Data, Stat, Graph, and Help. Below these is a data table with 16 rows and 8 columns. The first column is labeled 'Row' and contains numbers 1 through 16. The next three columns are labeled 'var1', 'var2', and 'var3'. The data values are: Row 1: 0.38; Row 2: 0.55; Row 3: 1.54; Row 4: 1.55; Row 5: 0.5; Row 6: 0.6; Row 7: 0.92; Row 8: 0.96; Row 9: 1; Row 10: 0.86; Row 11: 1.46; Rows 12-16 are empty. The 'Stat' menu is open, showing options: Calculators, Summary Stats, Tables, Z Stats, T Stats, Proportion Stats, Variance Stats, Regression, ANOVA, Nonparametrics, Goodness-of-fit, Control Charts, and Resample. The 'T Stats' option is selected, and a sub-menu is open showing 'One Sample', 'Two Sample', and 'Paired' options.

Row	var1	var2	var3	var6	var7	var8
1	0.38					
2	0.55					
3	1.54					
4	1.55					
5	0.5					
6	0.6					
7	0.92					
8	0.96					
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The screenshot shows the StatCrunch interface with a data table and a dialog box for a One Sample T test.

Row	var1
1	0.38
2	0.55
3	1.54
4	1.55
5	0.5
6	0.6
7	0.92
8	0.96
9	1
10	0.86
11	1.46
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
25	

One Sample T dialog box settings:

- Select column(s):** var1
- Where:** --optional--
- Group by:** --optional--
- Perform:**
 - Hypothesis test for μ
 - $H_0: \mu =$
 - $H_A: \mu$ 1
 - Confidence interval for μ
 - Level:
- Output:**
 - Store in data table

Buttons: ? Cancel Compute!

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StatCrunch Applets Edit Data Stat Graph Help

Untitled

Row	var1	var2	var3	var4	var5	var6	var7
1	0.38						
2	0.55						
3	1.54						
4	1.55						
5	0.5						
6	0.6						
7	0.92						
8	0.96						
9	1						
10	0.86						
11	1.46						
12							
13							

Options

Hypothesis test results:
 μ : Mean of variable
 $H_0 : \mu = 1$
 $H_A : \mu < 1$

Variable	Sample Mean	Std. Err.	DF	T-Stat	P-value
var1	0.93818182	0.12749915	10	-0.48485172	0.3191

§8.4 Example (Mean)

Use a 0.05 significance level to test the claim that the data below comes from a normally distributed population with mean less than 1 and standard deviation 0.03.

0.38, 0.55, 1.54, 1.55, 0.50, 0.60, 0.92, 0.96, 1.00, 0.86, 1.46.

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The screenshot shows the StatCrunch software interface. At the top, there are menu tabs: StatCrunch, Applets, Edit, Data, Stat, Graph, and Help. The main window is titled "Untitled" and contains a data table with columns labeled var1, var2, var3, var6, var7, var8, and var9. The data is as follows:

Row	var1	var2	var3	var6	var7	var8	var9
1	0.38						
2	0.55						
3	1.54						
4	1.55						
5	0.5						
6	0.6						
7	0.92						
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16							

The "Stat" menu is open, showing options: Calculators, Summary Stats, Tables, Z Stats, T Stats, Proportion Stats, Variance Stats, Regression, ANOVA, Nonparametrics, Goodness-of-fit, Control Charts, and Resample. The "Z Stats" option is selected, and a sub-menu is open with options: One Sample, Two Sample, With Data, With Summary, and Power/Sample Size.

§8.4 Example (Mean)

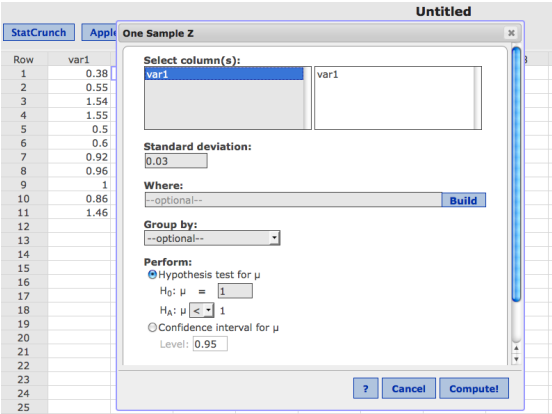
Use a 0.05 significance level to test the claim that the data below comes from a normally distributed population with mean less than 1 and standard deviation 0.03.

0.38, 0.55, 1.54, 1.55, 0.50, 0.60, 0.92, 0.96, 1.00, 0.86, 1.46.

§8.4 Example (Mean)

Use a 0.05 significance level to test the claim that the data below comes from a normally distributed population with mean less than 1 and standard deviation 0.03.

0.38, 0.55, 1.54, 1.55, 0.50, 0.60, 0.92, 0.96, 1.00, 0.86, 1.46.



The screenshot shows the StatCrunch interface with a data table and a dialog box for a One Sample Z test. The data table has 25 rows and one column labeled 'var1'. The dialog box is titled 'One Sample Z' and contains the following fields:

- Select column(s):** 'var1' is selected in the left pane and listed in the right pane.
- Standard deviation:** 0.03
- Where:** --optional-- (with a Build button)
- Group by:** --optional-- (with a dropdown arrow)
- Perform:**
 - Hypothesis test for μ
 - $H_0: \mu =$ 1
 - $H_A: \mu <$ 1
 - Confidence interval for μ
 - Level: 0.95

Buttons at the bottom of the dialog include '?', 'Cancel', and 'Compute!'.

§8.4 Example (Mean)

Use a 0.05 significance level to test the claim that the data below comes from a normally distributed population with mean less than 1 and standard deviation 0.03.

0.38, 0.55, 1.54, 1.55, 0.50, 0.60, 0.92, 0.96, 1.00, 0.86, 1.46.

§8.4 Example (Mean)

Use a 0.05 significance level to test the claim that the data below comes from a normally distributed population with mean less than 1 and standard deviation 0.03.

0.38, 0.55, 1.54, 1.55, 0.50, 0.60, 0.92, 0.96, 1.00, 0.86, 1.46.

StatCrunch Applets Edit Data Stat Graph Help

Row	var1	var2	var3	var4	var5	var6	var7
1	0.38						
2	0.55						
3	1.54						
4	1.55						
5	0.5						
6	0.6						
7	0.92						
8	0.96						
9	1						
10	0.86						
11	1.46						

Options

Hypothesis test results:
 μ : Mean of variable
 H_0 : $\mu = 1$
 H_A : $\mu < 1$
Standard deviation = 0.03

Variable	n	Sample Mean	Std. Err.	Z-Stat	P-value
var1	11	0.93818182	0.0090453403	-6.8342571	<0.0001

§8.4 Example (Standard Deviation)

Use a 0.01 significance level to test the claim that the data below comes from a normally distributed population with standard deviation equal to 2.6.

70, 71, 69.25, 68.5, 69, 70, 71, 70, 70, 69.5

§8.4 Example (Standard Deviation)

Use a 0.01 significance level to test the claim that the data below comes from a normally distributed population with standard deviation equal to 2.6.

70, 71, 69.25, 68.5, 69, 70, 71, 70, 70, 69.5

The screenshot shows the StatCrunch software interface. The main window is titled "Untitled" and contains a data table with 16 rows and 4 columns (var1, var2, var3, var4). The data in the first column (var1) is: 70, 71, 69.25, 68.5, 69, 70, 71, 70, 70, 69.5, followed by empty cells for rows 11-16. A menu is open over the "Stat" button, listing various statistical tests. The "Variance Stats" option is selected, and a sub-menu is open showing "One Sample", "Two Sample", and "Homogeneity" options. The "One Sample" option is further expanded to show "With Data", "With Summary", and "Power/Sample Size" sub-options.

Row	var1	var2	var3	var4
1	70			
2	71			
3	69.25			
4	68.5			
5	69			
6	70			
7	71			
8	70			
9	70			
10	69.5			
11				
12				
13				
14				
15				
16				

§8.4 Example (Standard Deviation)

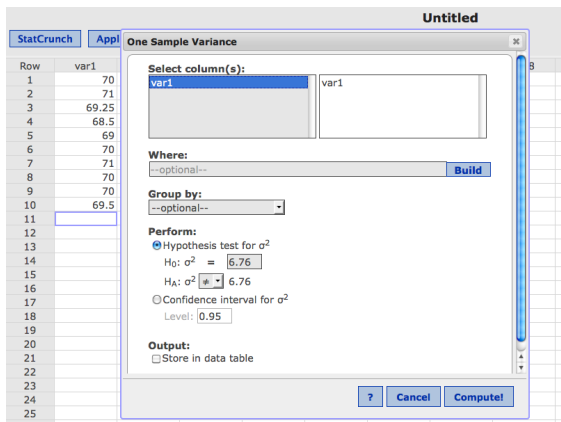
Use a 0.01 significance level to test the claim that the data below comes from a normally distributed population with standard deviation equal to 2.6.

70, 71, 69.25, 68.5, 69, 70, 71, 70, 70, 69.5

§8.4 Example (Standard Deviation)

Use a 0.01 significance level to test the claim that the data below comes from a normally distributed population with standard deviation equal to 2.6.

70, 71, 69.25, 68.5, 69, 70, 71, 70, 70, 69.5



The screenshot shows the StatCrunch interface with a data table and a dialog box for a one-sample variance test.

Row	var1
1	70
2	71
3	69.25
4	68.5
5	69
6	70
7	71
8	70
9	70
10	69.5
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
25	

One Sample Variance

Select column(s):
var1

Where:
--optional-- **Build**

Group by:
--optional--

Perform:
 Hypothesis test for σ^2
 $H_0: \sigma^2 =$
 $H_A: \sigma^2$
 Confidence interval for σ^2
Level:

Output:
 Store in data table

? Cancel Compute

§8.4 Example (Standard Deviation)

Use a 0.01 significance level to test the claim that the data below comes from a normally distributed population with standard deviation equal to 2.6.

70, 71, 69.25, 68.5, 69, 70, 71, 70, 70, 69.5

§8.4 Example (Standard Deviation)

Use a 0.01 significance level to test the claim that the data below comes from a normally distributed population with standard deviation equal to 2.6.

70, 71, 69.25, 68.5, 69, 70, 71, 70, 70, 69.5

The screenshot shows the StatCrunch interface with a data table and an 'Options' dialog box. The data table contains the following values:

Row	var1	var2	var3	var4	var5	var6	var7
1	70						
2	71						
3	69.25						
4	68.5						
5	69						
6	70						
7	71						
8	70						
9	70						
10	69.5						
11							
12							
13							

The 'Options' dialog box displays the following hypothesis test results:

Hypothesis test results:
 σ^2 : Variance of variable
 $H_0 : \sigma^2 = 6.76$
 $H_A : \sigma^2 \neq 6.76$

Variable	Sample Var.	DF	Chi-Square Stat	P-value
var1	0.63958333	9	0.85151627	0.0006