

# Hypothesis Testing

.

Math 122

# Hypothesis Testing Outline

- Define your parameters
- State the claim being tested in symbols.
- State the Alternative Hypothesis  $H_1$ . ( $\neq$ ,  $<$ , or  $>$ )
- State the Null Hypothesis  $H_0$ . ( $=$ )
- Decide on a test/distribution
- Find a P-value (technology)
- Conclude

# P-value and formal conclusion

- If  $\mathbf{P} \leq \mathbf{\alpha}$  then  $H_0$  is not consistent with the observations.
- Reject  $H_0$  and support  $H_1$ .

.



# P-value and formal conclusion

- If  $\mathbf{P} > \alpha$  then  $H_0$  is consistent with the observations.
- Do not reject  $H_0$  and do not support  $H_1$ .

.

# Final Conclusion

- If your **claim** is  $H_0$  then your conclusion will be
  - There is enough sample evidence to **reject** the claim.
  - There is **not** enough sample evidence to **reject** the claim.
- If your **claim** is  $H_1$  then your conclusion will be
  - The evidence **supports** the claim.
  - The sample evidence does not **support** the claim.

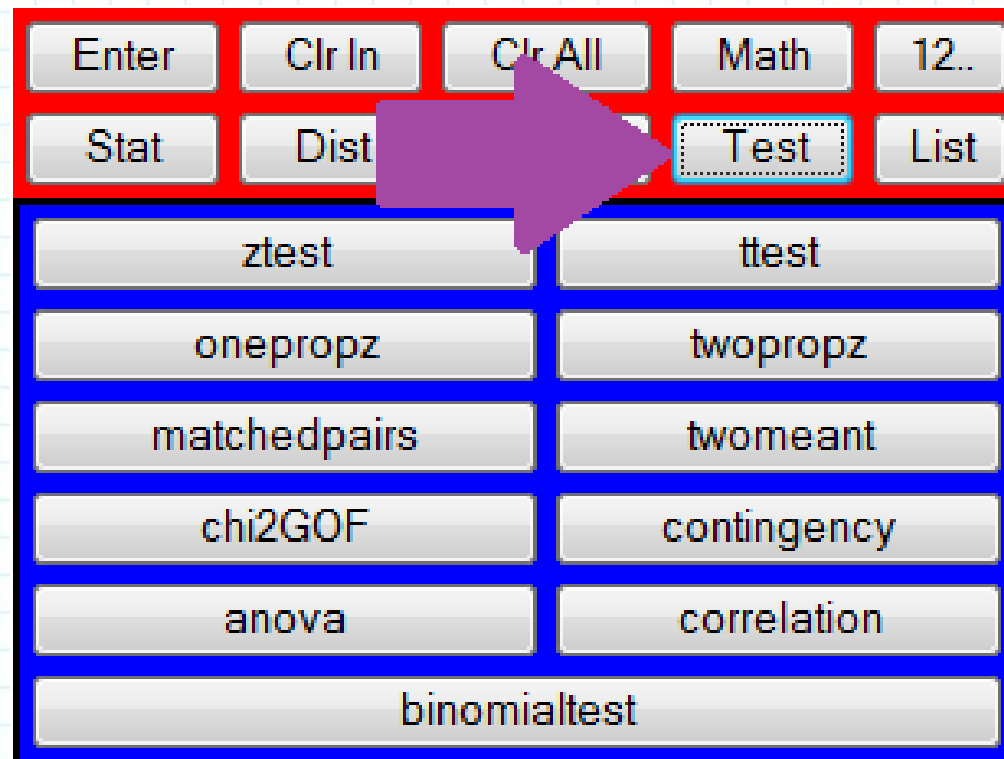
# Types of Claims We Will Test

.

(A whirlwind overview of the next 3 weeks)

All depend on some variant of the Central  
Limit Theorem





# One Proportion

- Use `onepropz`
- **Example:** In a random sample of 87 Grey Forest Glow Worms, 51 were striped. Use this data to test the claim that **most Grey Forest Glow Worms are striped.**



# onepropz

1.  $p$  = proportion of GFGW which are striped
2. Claim:  $p > 0.5$
3.  $H_1: p > 0.5$
4.  $H_0: P = 0.5$
5. P-value: 0.0539
6. Do not reject  $H_0$ . Do not support  $H_1$ .
7. There is not enough sample evidence to support the claim.

The image shows a TI-84 Plus calculator screen with the "One Proportion" test menu. The screen has a yellow background. At the top, there is a red border containing buttons for "Enter", "Clr In", "Clr All", "Math", "12..", "Stat", "Dist", "Int", "Test", and "List". Below this, the text "One Proportion" is displayed. The "H0: p =" field is set to "0.5". The "H1: p" field shows four options: " $\neq$ ", "<", ">", and "<=", with the ">" option selected. The "x=" field is set to "51" and the "n=" field is set to "87". A "Calculate" button is located at the bottom right of the screen.

Field	Value
H0: p =	0.5
H1: p	>
x =	51
n =	87

# Two Proportions

- Use twopropz
- **Example:** Among 107 male Grey Forest Glow Worms, 72 were striped. Among 96 female GFGWs, 37 were striped. Use this data to test the claim that **the proportion of male GFGWs which are striped is greater than the proportion of female GFGWs which are striped.**

# twopropz

1.  $p_1$ =proportion of male GFGW with stripes  
 $p_2$ =proportion of female GFGW with stripes
2. Claim:  $p_1 > p_2$
3.  $H_1: p_1 > p_2$
4.  $H_0: p_1 = p_2$
5. P-value=0.0000
6. Reject  $H_0$ . Support  $H_1$ .
7. The sample evidence supports the claim.

The image shows a TI-84 Plus calculator screen with the 'Two Proportions' test menu. The top of the screen has a red border with buttons for 'Enter', 'Clr In', 'Clr All', 'Math', '12..', 'Stat', 'Dist', 'Int', 'Test', and 'List'. The main screen area is yellow and displays the following text and inputs:

- Two Proportions
- H0:  $p_1 = p_2$
- H1: ☒  $p_1 \neq p_2$  ☐  $p_1 < p_2$  ☐  $p_1 > p_2$
- x1= 72
- x2= 37
- n1= 107
- n2= 96
- Calculate



# One Mean

- Use ttest
- **Example:** A sample of adult GFGWs had the lengths listed below (in inches). Use this data to test the claim that the mean length of an adult GFGW is not 1 inch.
- 0.75, 0.82, 0.97, 0.99, 1.05, 1.17, 1.28, 1.35

# ttest

1.  $\mu$  = mean length of an adult GFGW

2. Claim:  $\mu \neq 1$

3.  $H_1: \mu \neq 1$

4.  $H_0: \mu = 1$

5. P-value=0.62

The image shows a TI-84 Plus calculator screen. On the left, a list of data values is displayed under the heading 'List 0'. The values are: 0.75, 0, 0.82, 0.97, 0.99, 1.05, 1.17, 1.28, and 1.35. On the right, the 'T Test' menu is open. The 'Stats' option is selected with a radio button. The 'List' field is set to 'List 0'. The 'H0:  $\mu =$ ' field is set to '1'. The 'H1:  $\mu$ ' field has the ' $\neq$ ' option selected with a radio button. The 's =' field is set to 'xxx', the ' $\bar{X}$  =' field is set to 'xxx', and the 'n =' field is set to 'xxx'. A 'Calculate' button is visible at the bottom right of the menu.

Enter	Clr In	Clr All	Math	12..
Stat	Dist	Int	Test	List

T Test

☐ Stats, ☒ Data

List 0

H0:  $\mu =$  1

H1:  $\mu$  ☒  $\neq$  ☐  $<$  ☐  $>$

s = xxx

$\bar{X}$  = xxx

n = xxx

Calculate

6. Do not reject  $H_0$ . Do not support  $H_1$ .

7. The sample evidence does not support the claim.

# Two Independent Means

- Use twomeant
- **Example:** A random sample of 37 GFGWs had an average length of 1.11in with a standard deviation 0.09in. A random sample of 43 blue glow worms had an average length of 1.15in with a standard deviation of 0.12in. Test the claim that **these two types of worms have the same average length.**



# twomeant

1.  $\mu_1$  = mean length of GFGW  
 $\mu_2$  = mean length of blue worms
2. Claim:  $\mu_1 = \mu_2$
3.  $H_1: \mu_1 \neq \mu_2$
4.  $H_0: \mu_1 = \mu_2$
5. P-value: 0.09
6. Do not reject  $H_0$ . Do not support  $H_1$ .
7. There is not enough sample evidence to reject the claim.

A screenshot of a T-Test calculator interface. The title is 'T Test'. There are two radio buttons: 'Stats' (selected) and 'Data'. Below this, the null hypothesis is 'H0:  $\mu_1 = \mu_2$ '. The alternative hypothesis is 'H1:  $\mu_1 \neq \mu_2$ ' (selected), with other options being ' $\mu_1 < \mu_2$ ' and ' $\mu_1 > \mu_2$ '. The interface has two columns of input fields. The first column is for 'List 0' with values: n1= 37,  $\bar{X}1$ = 1.11, s1 = 0.09. The second column is for 'List 1' with values: n2= 43,  $\bar{X}2$ = 1.15, s2 = 0.12. At the bottom right is a 'Calculate' button.

Parameter	List 0	List 1
n	37	43
$\bar{X}$	1.11	1.15
s	0.09	0.12

# Matched Pairs

- Use matchedpairs
- **Example:** Below are listed the weights of several GFGWs (in oz) along with the weight of food eaten in one day by the same worm. Test the claim that a GFGW on average eats more than its body weight in a day.

Weight	0.09	0.09	0.11	0.12	0.15	0.15	0.16
Eaten	0.07	0.10	0.12	0.13	0.16	0.17	0.16

# matchedpairs

1.  $\mu_1$  = mean weight of GFGW

$\mu_2$  = mean weight of food eaten

2. Claim:  $\mu_1 < \mu_2$

3.  $H_1: \mu_1 < \mu_2$

4.  $H_0: \mu_1 = \mu_2$

5. P-value: 0.14

6. Do not reject  $H_0$ . Do not support  $H_1$ .

7. The sample evidence does not support the claim.

List 0	List 1
0.09	0.07
0.09	0.10
0.11	0.12
0.12	0.13
0.15	0.16
0.15	0.17
0.16	0.16

Matched Pairs

$H_0: \mu_1 = \mu_2$

$H_1:$  ☐  $\mu_1 \neq \mu_2$  ☒  $\mu_1 < \mu_2$  ☐  $\mu_1 > \mu_2$

First List 0

Second List 1

Calculate



# Linear Correlation

- Use correlation
- $H_0$  is always that there is no linear correlation.
- $H_1$  is always that there is linear correlation.
- **Example:** Below are listed the weights of several GFGWs (in oz) along with the weight of food eaten in one day by the same worm. Test the claim that **there is a linear correlation between a GFGW's weight and how much the worm eats in a day.**

Weight	0.09	0.09	0.11	0.12	0.15	0.15	0.16
Eaten	0.07	0.10	0.12	0.13	0.16	0.17	0.16

# scatter

scatter(0,1) will give:

```
IN7> scatter(0,1)
```

```
OUT7>
```

---

```
      .  
      . .
```

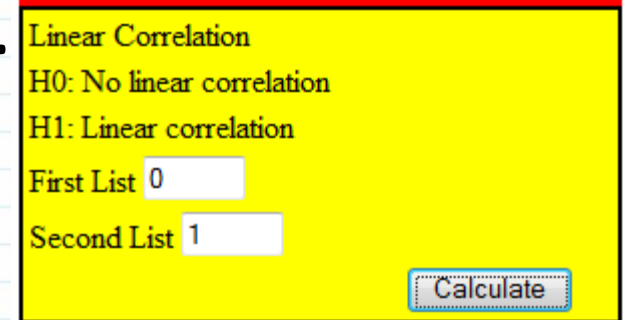
```
      .  
      .
```

```
      .
```

```
      .
```

# correlation

1. Claim: there is a linear correlation between weight and the amount of food the worm eats.
2.  $H_0$ : there is no linear correlation.
3.  $H_1$ : there is linear correlation.
4. P-value: 0.001
5. Reject  $H_0$ . Support  $H_1$ .
6. The sample evidence supports the claim that there is linear correlation.



A screenshot of a software interface for linear correlation hypothesis testing. The interface has a yellow background and a red border. It contains the following text and input fields:

- Linear Correlation
- $H_0$ : No linear correlation
- $H_1$ : Linear correlation
- First List
- Second List
-



# $\chi^2$ Goodness of Fit

- Use chi2GOF
- $H_0$  is always that the observed frequencies match the expected values.
- $H_1$  is always that the observed frequencies do not match the expected values.
- **Example:** A candy company claims that 25% of its candy is brown, 35% is red, and 40% is blue. A bag of candy contained the numbers of each color in the table below. **Test the claim that the actual frequencies of colors match the claimed distribution.**

Brown	Red	Blue
21	33	37

# chi2GOF

1. Claim: The actual frequencies match the claimed distribution.
2.  $H_0$ : Observations match claim
3.  $H_1$ : Observations do not match claim

List 0	List 1
21	0.25*91
33	0.35*91
37	0.40*91

## Chi2GOF

H0: O match E

H1: O do not match E

Observations

Expectations

Calculate

# chi2GOF

4. P-value: 0.91
5. Do not reject  $H_0$ . Do not support  $H_1$ .
6. There is not enough sample evidence to reject the claim.

List 0	List 1
21	0.25*91
33	0.35*91
37	0.40*91

## Chi2GOF

H0: O match E

H1: O do not match E

Observations

Expectations

Calculate



# Contingency Table

- Use contingency
- $H_0$  is always that the rows and columns are independent.
- $H_1$  is always that the rows and columns are dependent.
- **Example:** The genders and dietary preferences of a sample of GFGWs were observed with the results below. Test the claim that **dietary preference is dependent on gender.**

	Male	Female
Leaves	32	57
Bark	48	41

# contingency

1. Claim: Dietary preference depends on gender
2.  $H_0$ : rows and columns are independent
3.  $H_1$ : rows and columns are dependent

List 0	List 1
32	57
48	41

Contingency

H0: Independence

H1: Dependence

First List

Last List

Calculate

4. P-value: 0.0159
5. Reject  $H_0$ . Support  $H_1$ .

# ANOVA

- Use anova
- $H_0$  is always that the samples come from populations with equal means.
- $H_1$  is always that the samples do not come from populations with equal means.
- **Example:** The table below lists the lengths of samples of three colors of glow worms. Test the claim that **all three colors have the same mean length.**

Grey	0.9	0.9	1.11	1.12	1.17	1.18	1.18
Blue	0.78	0.82	0.90	0.99	0.99	1.10	
Green	1.0	1.0	1.1	1.1	1.17	1.2	1.25



# anova

1. Claim: The means are all the same.
2.  $H_0$ : The means are all equal.
3.  $H_1$ : The means are not all equal.

List 0	List 1	List 2
0.9	0.78	1.0
0.9	0.82	1.0
1.11	0.90	1.1
1.12	0.99	1.1
1.17	0.99	1.17
1.18	1.10	1.2
1.18		1.25

ANOVA

H0: All means equal

H1: Not all means equal

First List

Last List

4. P-value: 0.023
5. Reject  $H_0$ . Support  $H_1$ .