



# Hypothesis Testing and Statistical Tests

Data Boot Camp  
Lesson 7.3



# Class Objectives

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By the end of today's class you will be able to:



Understand the difference between null hypothesis and alternate hypothesis.



Apply one-sample t-test to identify significant difference between sample and population data.



Apply two sample t-test to identify significant differences between two groups.



Apply ANOVA to compare the means of three or more groups.



Perform Chi Square Test to compare distribution of categorical data.



# Instructor Demonstration

## Intro to Hypothesis Testing



**Hypothesis testing** can be confusing at times, mostly because you **must create** your **null** and **alternative hypothesis** before performing any analysis.

# What is Hypothesis? Intro to Hypothesis Testing

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- Hypothesis is an **educated guess** about something.
- **Hypothesis Statement:**
  - The Hypothesis is often expressed as an **If/Then** statement.
- **Hypothesis Testing:**
  - Hypothesis testing in statistics is a way for you to test the results of a survey or experiment to see if you have meaningful results.
  - We test against for two mutually exclusive outcomes - **null** and **alternative** hypothesis

# Intro to Hypothesis Testing

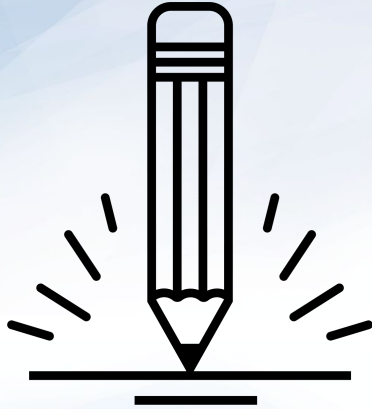
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- **Null Hypothesis ( $H_0$ ):**
  - Null hypothesis is the hypothesis that we are trying to disprove due to no statistical significance between the two variables.
  - In short, your null hypothesis assumes that your results **happened by chance**.
- **Alternative Hypothesis ( $H_a$ ):**
  - Alternative hypothesis is the opposite of the null hypothesis, it assumes there is some factor influencing the results. The hypothesis assumes your results **did not happen by chance**.

# Steps for Hypothesis Testing: Intro to Hypothesis Testing

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1. Determine the Hypothesis and Null Hypothesis.
2. Identify the appropriate statistical test.
3. Determine the acceptable significance value.
4. Compute the P-value.
5. Determine if the P-value rejects the Null Hypothesis by comparing it to the significance value (Typically  $< 0.05$ )



## Activity: Forming a Null Hypothesis

In this activity, you and your group will take two given questions and turn them into an Hypothesis and a Null Hypothesis.

**Suggested Time:**  
10 Minutes





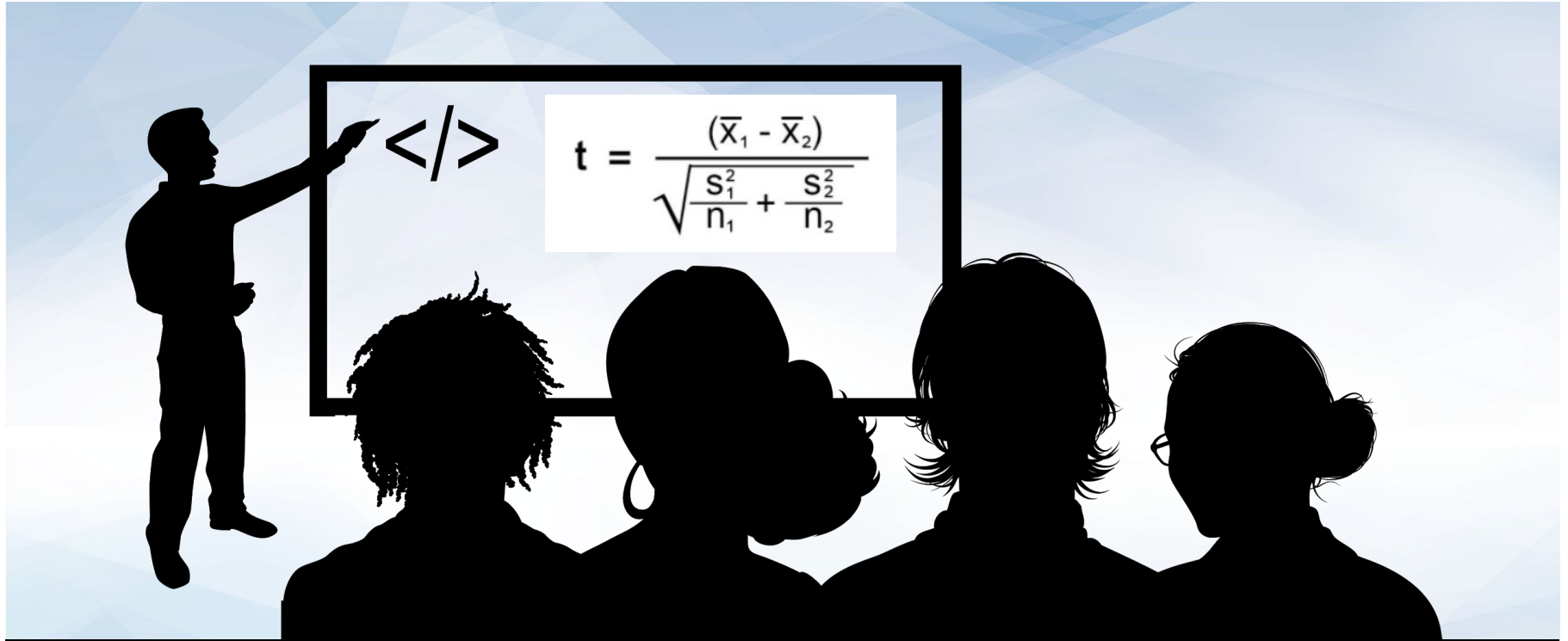
# Instructions: Activity: Forming a Null Hypothesis

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- Convert the following Questions into an Hypothesis and Null Hypothesis.
  - Does Dark Chocolate affect arterial function in healthy individuals?
  - Does Coffee have anti-aging properties?



**Time's Up!** Let's Review.



# Instructor Demonstration

## t-test

# What is a t-test?

## t-test

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- A t-test tells you how significant the differences between groups are.
- It lets you know if the differences, measured in means/average, could have happened by chance.
- **One Sample t-test:**
  - Determines whether the sample mean statistically differ from a known or hypothesized population mean.
- **Independent t-test:**
  - Also known as **two sample t-test** , determines whether there is a statistically significant difference between the means in **two unrelated** groups.
- Assumptions:
  - The samples are independent.
  - Each sample is from a normally distributed population.
  - The population standard deviations of the groups are all equal (maybe).

# t-test

## Calculating t-test

$$t = \frac{(\bar{X}_1 - \bar{X}_2)}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

- **$\bar{X}_1$**  = mean of the first data set.
- **$\bar{X}_2$**  = mean of the second data set.
- **$S_1^2$**  = standard deviation of the first data set.
- **$S_2^2$**  = standard deviation of the second data set.
- **$N_1$**  = number of elements in the first data set.
- **$N_2$**  = number of elements in the second data set.



# What type of t-test Should I use?

## t-test

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- There are couple of things to consider before performing t-test:
  - Whether the compared groups come from a single population or two distinct populations.
  - Whether you want to test the difference in a specific direction.



### - **One Sample t-test**

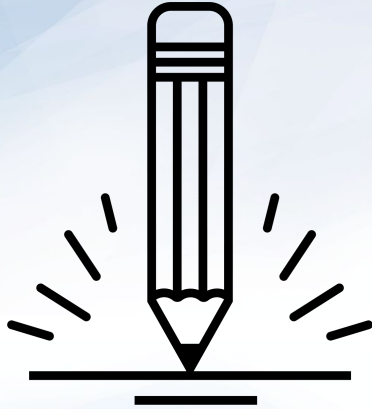
- One group being compared against a standard value.
- e.g. comparing gasoline octane level to a standard octane level.

### - **Independent t-test**

- Groups coming from two distinct populations.
- e.g. different countries, different species.

# <Time to Code>





## Activity: t-test

In this activity, you will use a t-test to compare the difference in Adult Sardine Vertebrae counts from two different locations.

**Suggested Time:**  
15 Minutes





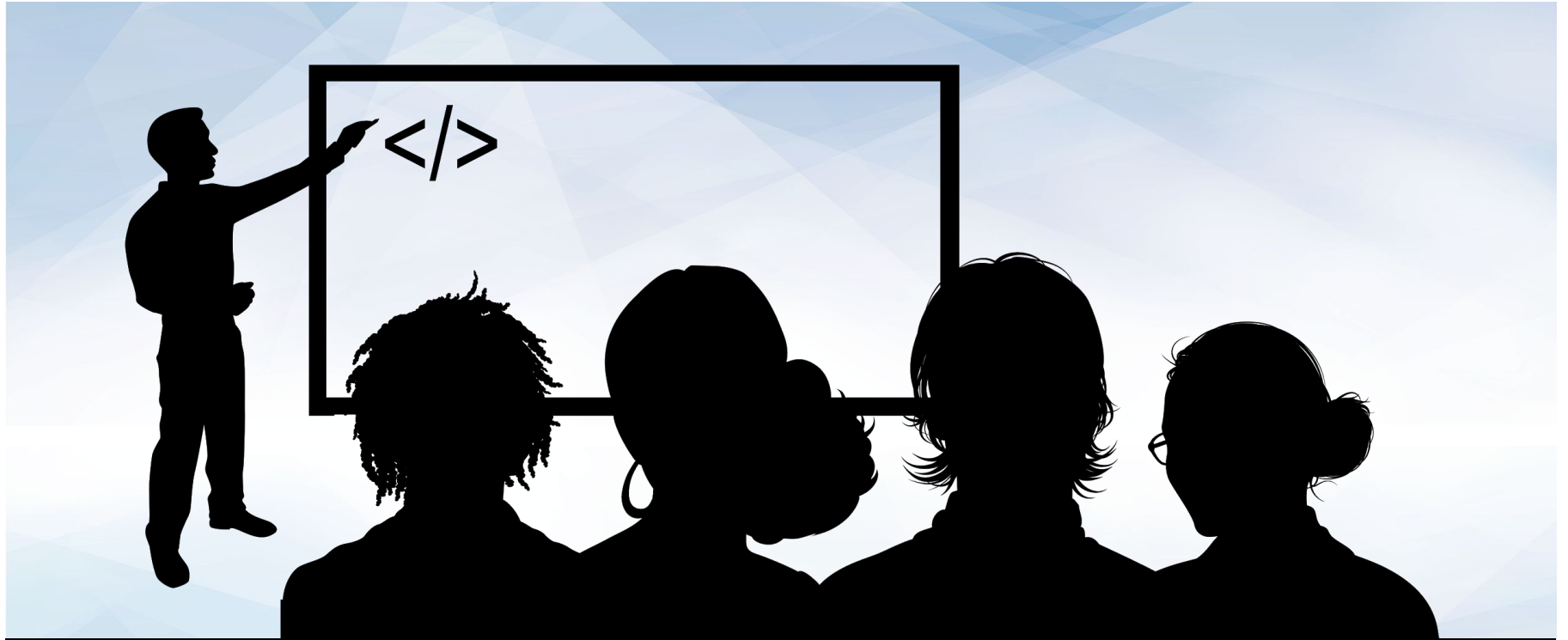
# Instructions: Activity: t-test

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- Calculate the mean for each population.
- Use a t-test to determine if there is a statistically significant difference in the number of vertebrae of Adult Sardines in Alaska vs. San Diego.
- It is up to you to determine if you should use a One Sample or an Independent t-test.



**Time's Up!** Let's Review.



# Instructor Demonstration

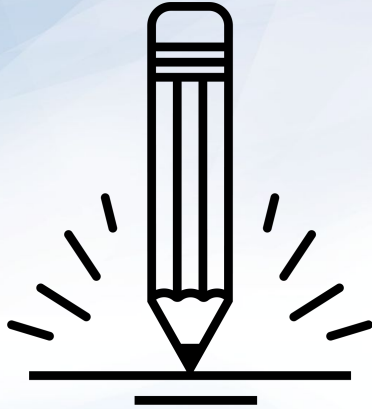
## ANOVA

# What's ANOVA?

# ANOVA

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- ANalysis Of VAriance (ANOVA) is a test to compare the means of multiple groups.
- In short, **ANOVA** is an extension of a t-test. As we previously covered, with t-test you can test **two** groups to see if there is a difference in means.
- An **ANOVA** test can be used to find out if survey or experiment results are significant.
- The null hypothesis in ANOVA is that there is no difference between the groups. Any significant difference will result in a low p-value.
- Same assumptions as the t-test



## **Activity: ANOVA**

In this activity, you will use ANOVA to compare the differences in Pain Threshold for people with different hair colors.

**Suggested Time:**  
10 Minutes

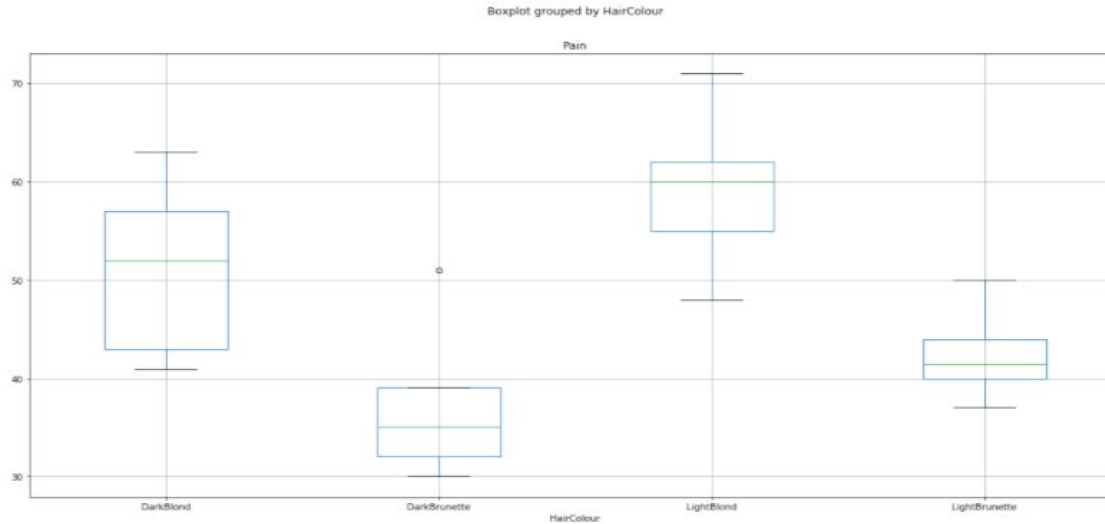


# Instructions: Activity: ANOVA

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- Perform a one-way ANOVA test to determine if there are any significant differences in Hair Color vs. Pain Threshold.
- Create a Boxplot to show the distribution of pain tolerances for each hair color.

Out[4]: <matplotlib.axes.\_subplots.AxesSubplot at 0x112628978>





**Time's Up!** Let's Review.



# Instructor Demonstration

## Chi Square



# The Chi-Square Test

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## What's used for?



To answer the question: Is the distribution of frequencies in the dataset meaningful?



In other words, does the data match our expectations?



In still other words, do we reject the null hypothesis or fail to reject it?

# The Chi-Square Test

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**Example:** Out of 300 dinosaurs,



220 eat  
everything



55 eat  
only meat



25 eat  
only plants

## **Null hypothesis:**

No statistical significance exists in the distribution of omnivores, carnivores, and herbivores. That is, this data can be explained by random distribution.



**The chi-square test can help us reject or fail to reject the null hypothesis.**

# The Chi-Square Python Function

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How is the chi-square test used:

01

Determine chi-square value.

02

Determine degree of freedom.

03

Choose a p-value.

04

Determine critical value.

05

Make a decision.

# Degree of Freedom

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To determine the degree of freedom (df), take the number of rows and subtract 1:

**Omnivores:** 220  
**Carnivores:** 55  
**Herbivores:** 25

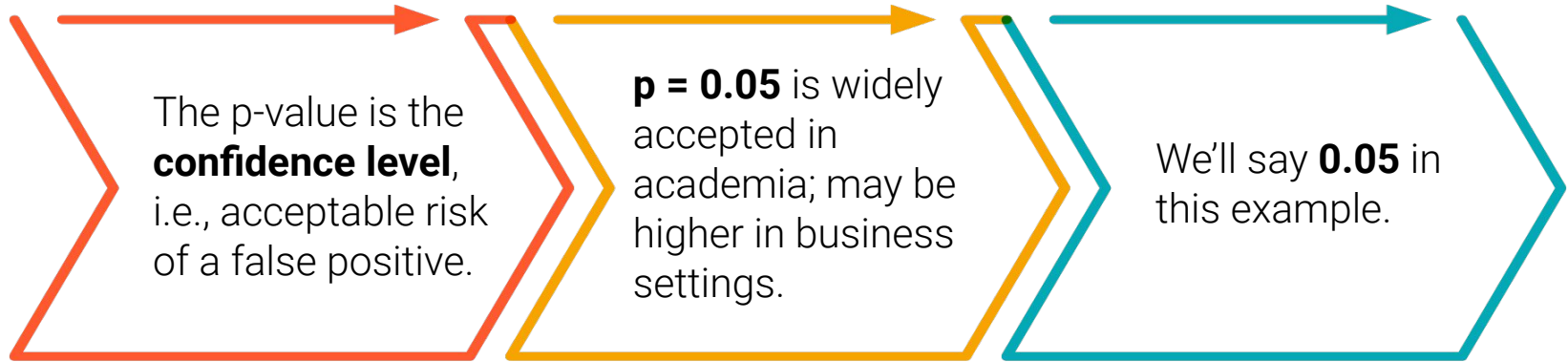
There are three rows, so the degree of freedom is

$$3 - 1 = 2$$

The degree of freedom is the number of figures required to fill out the table (like Sudoku).

If we have two of the numbers, we can figure out the value of the third.

# P-value threshold



Importance of Findings	Significance Level	Probability of Being Wrong
Low	0.1	1 in 10
<b>Normal</b>	<b>0.05</b>	<b>5 in 100</b>
High	0.01	1 in 100
Very high	0.001	1 in 1,000
Extreme	0.0001	1 in 10,000

# The Chi-Square Test Formula

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## A few more considerations:



The chi-squared test is used to test categorical variables; it can't be used on continuous data.



The categories must be mutually exclusive.



We have covered using the chi-square test formula to test goodness of fit.



It can also be used to test independence. (Feel free to explore this on your own.)

# Using the Chi-Squared Test In Python

01

Import the **scipy.stats** module.

```
# The statistical module used to run chi square test  
import scipy.stats as stats
```

02

Determine the **critical value**.

```
# The degree of freedom is 3-1 = 2  
# With a p-value of 0.05, the confidence level is 1.00-0.05 = 0.95.  
critical_value = stats.chi2.ppf(q = 0.95, df = 2)
```

```
# The critical value  
critical_value
```

```
5.99146454710798
```

03

Run the **chi-squared test**.

```
# Run the chi square test with stats.chisquare()  
stats.chisquare(df['observed'], df['expected'])
```

```
Power_divergenceResult(statistic=220.5, pvalue=1.3153258948574585e-48)
```



## Activity: Chi-Square

In this activity, you will perform the Chi-Square test:  
First in Python, then by hand.

**Suggested Time:**  
10 Minutes





# Instructions: Activity: Chi-Square

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- You are the owner of four cafés in a town of avid coffee drinkers.
- Using a Chi-square goodness-of-fit test, determine whether the results suggest that customers are more likely to frequent one cafe over another.
- Perform the necessary calculations by using Python.
- Then perform the calculations by hand to verify your findings.
- Use a p-value of 0.05.
- Consult a Chi-square table to find your critical value:  
<https://www.medcalc.org/manual/chi-square-table.php>
- On your student repository, open: [Stu-Cafes.ipynb](#)



**Time's Up!** Let's Review.



Countdown timer

**40:00**

(with alarm)



## TRADING PLATFORM

ETH USD LTC

190.34 +3.44  
199.31 +0.31 +0.05% 19:55 Jun 01.06



SELL

BUY

Last Trade: 19:01 (+\$144.41) -0.44%				Last Trade: 19:01 (+\$144.41) -0.44%			
Market Cap	34.00 (+4.12%)	Higt	4.801.21 (+4.12%)	Market Cap	34.00 (+4.12%)	Higt	4.801.21 (+4.12%)
Mined Coins	34.00 (+4.12%)	Low	\$1.421.33 (-1.41%)	Mined Coins	34.00 (+4.12%)	Low	\$1.421.33 (-1.41%)



UP  
23%

DOWN  
14%



*The  
End*