How to Set Up and Run Hypothesis Tests

Presented by Elisabeth Swan
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Our Expert: Elisabeth

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- **Master Black Belt**
- **Certified Executive Coach** at Burnham Rosen Group
- **BA in English Literature** from Columbia University/Barnard College
- **Born in the UK**

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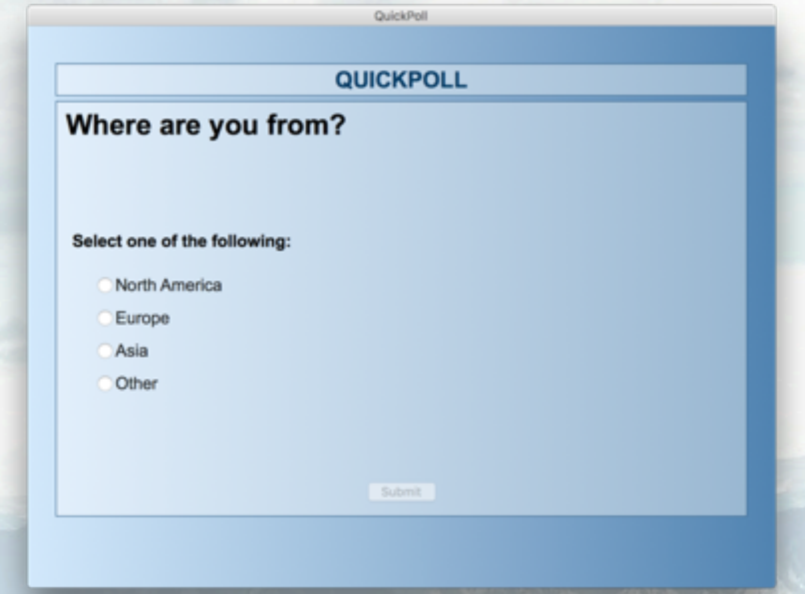
How to Interact

- Ask a question
- Answer polls

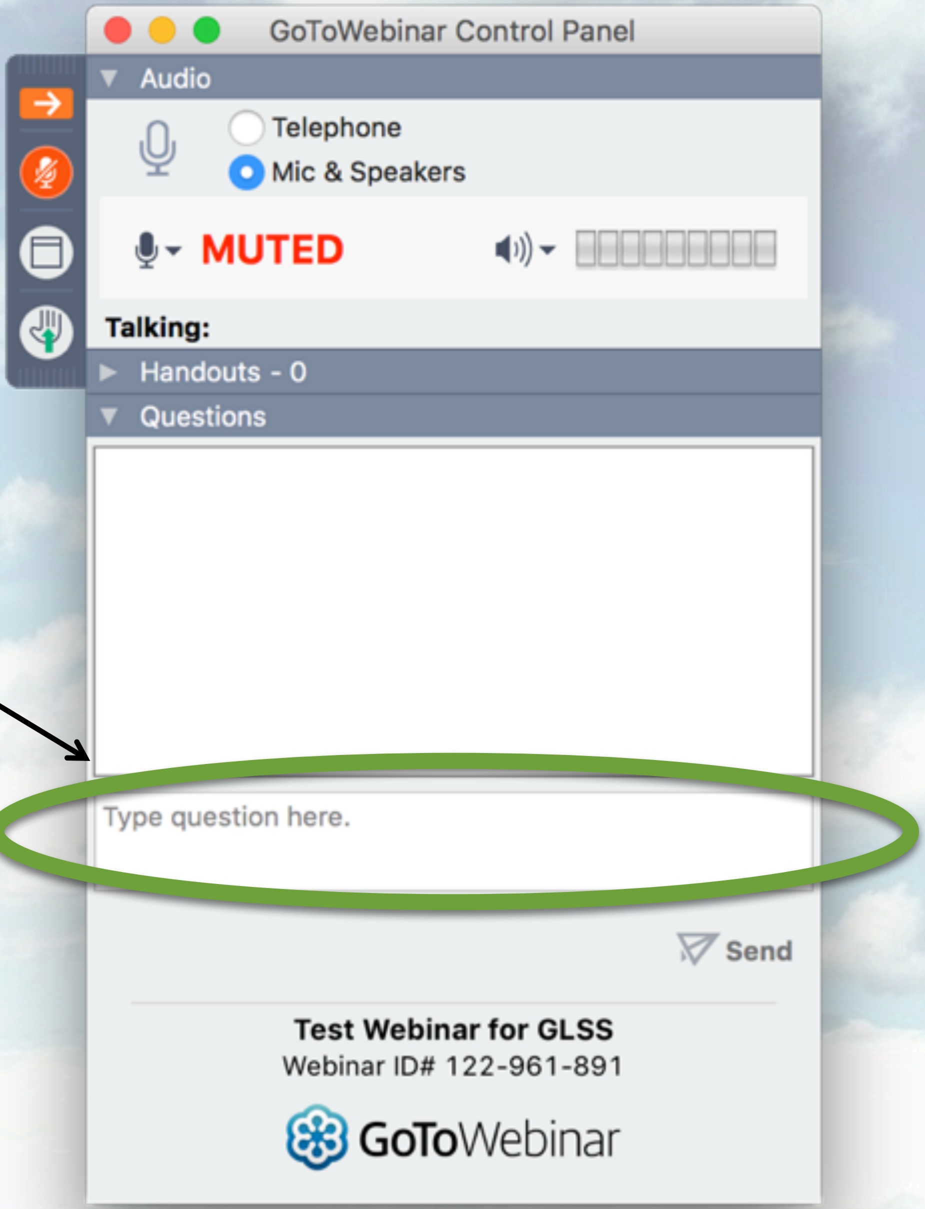

QuickPoll

QUICKPOLL

Where are you from?

Select one of the following:

○ North America
○ Europe
○ Asia
○ Other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Audio

○ Telephone
● Mic & Speakers

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Talking:

Handouts - 0

Questions

Type question here.

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Let’s Interact!

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Bahama Bistro

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Today's Agenda

- What Are Hypothesis Tests?
- Why Do We Need Them in Process Improvement?
- When Should We Use Them?
- How Do We Setup and Run Them?
- Any Words of Advice?

What Are Hypothesis Tests?

Hypothesis: Educated Guess or Theory

- Something that requires further investigation
- There are many ways to test theories
- Hypothesis Testing is a formal way to test theories

What Can Be Tested?

Prevagen improves memory in 90 Days

Swiffer 3 X more effective than a broom

Sketchers Sneakers make you lose weight

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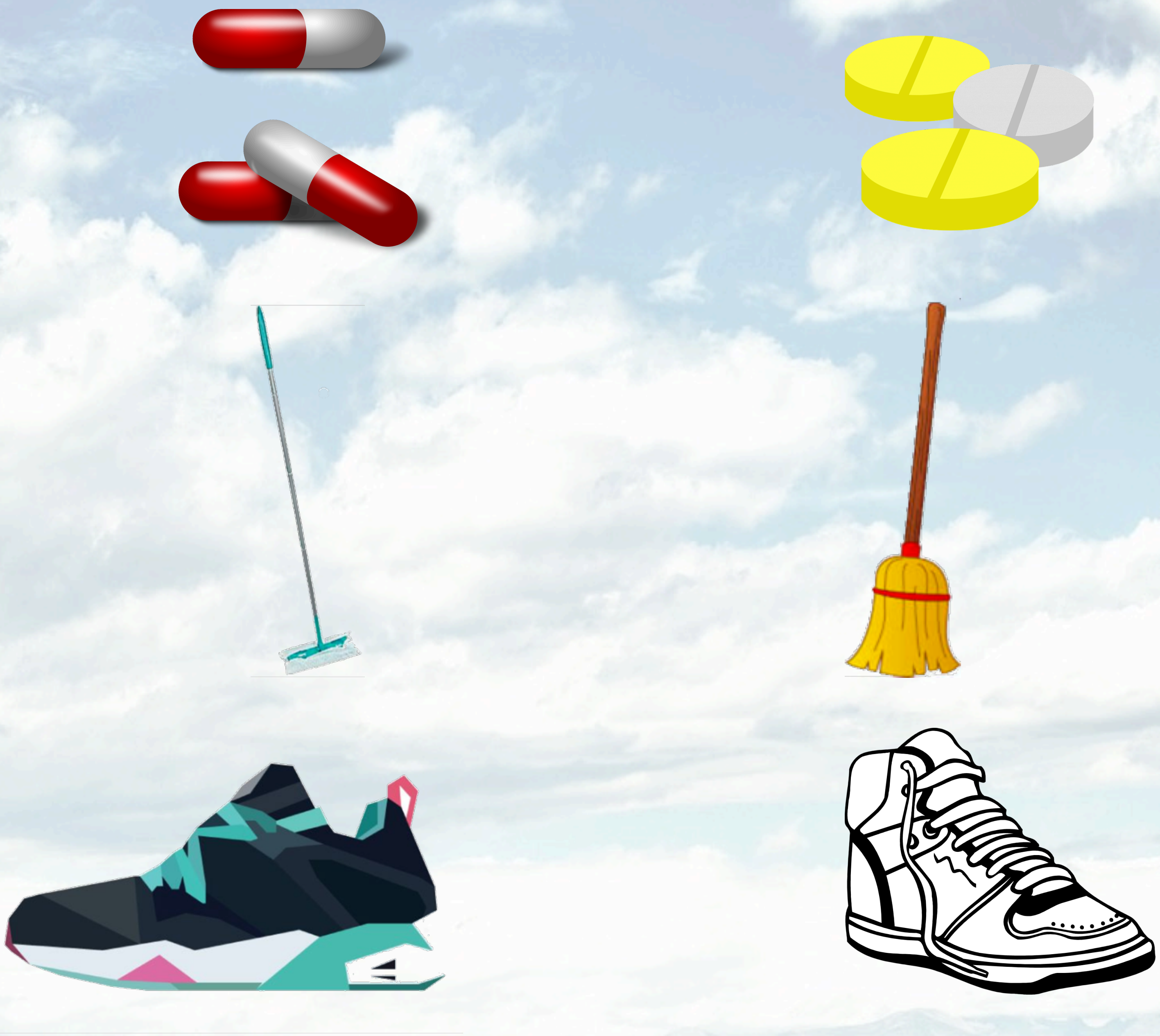
Is There a Difference?



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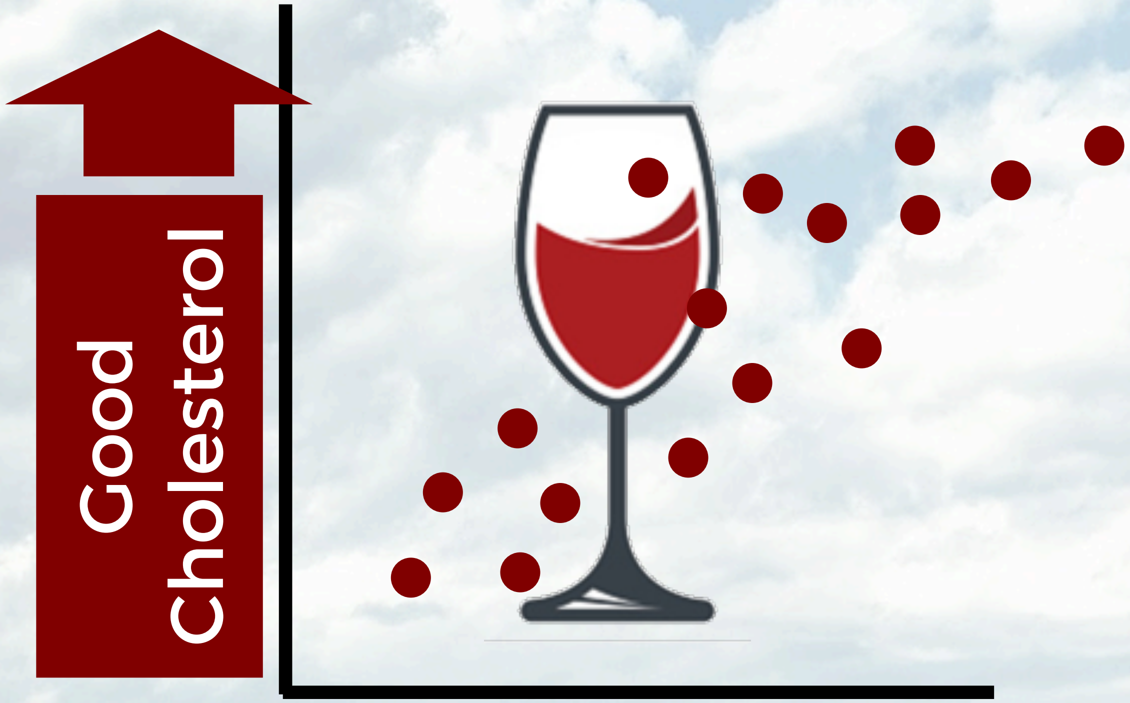
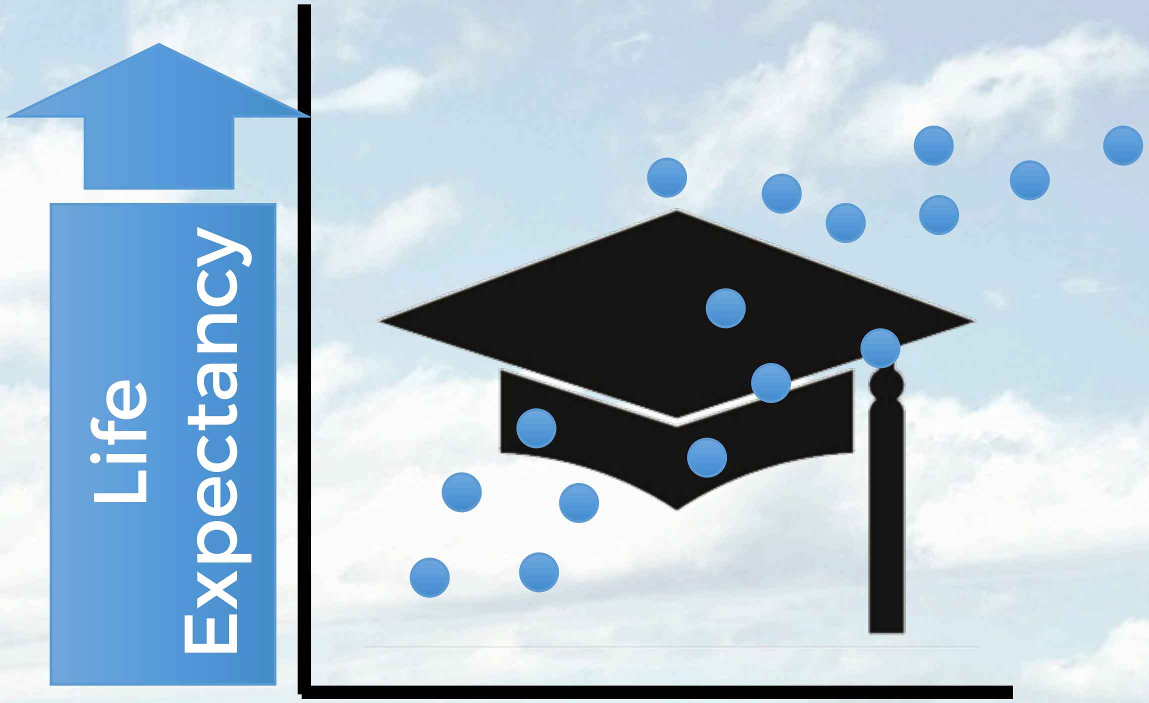
Are These Things Related?





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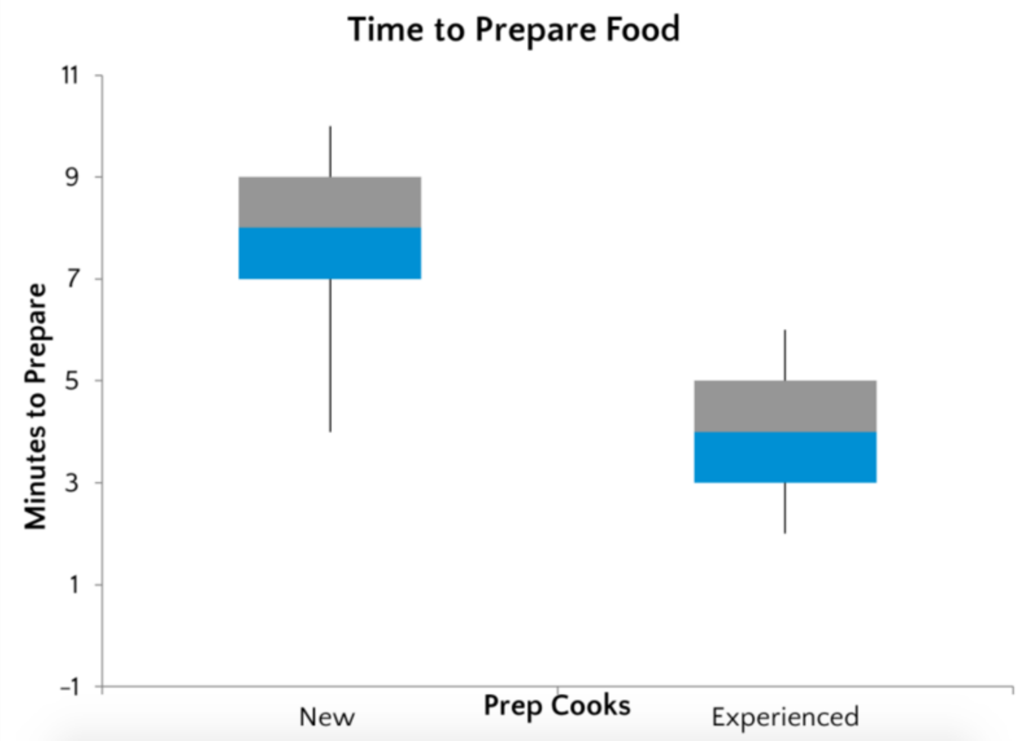
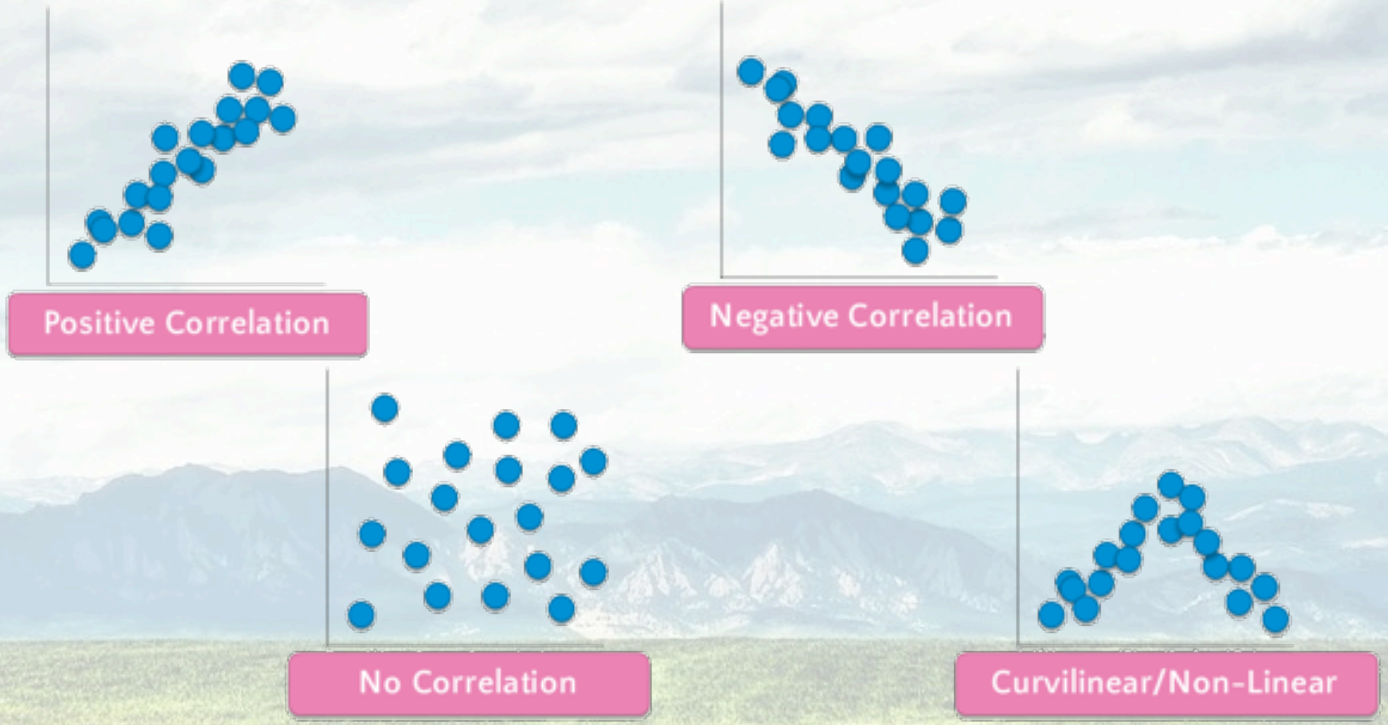
Two Types of Testing

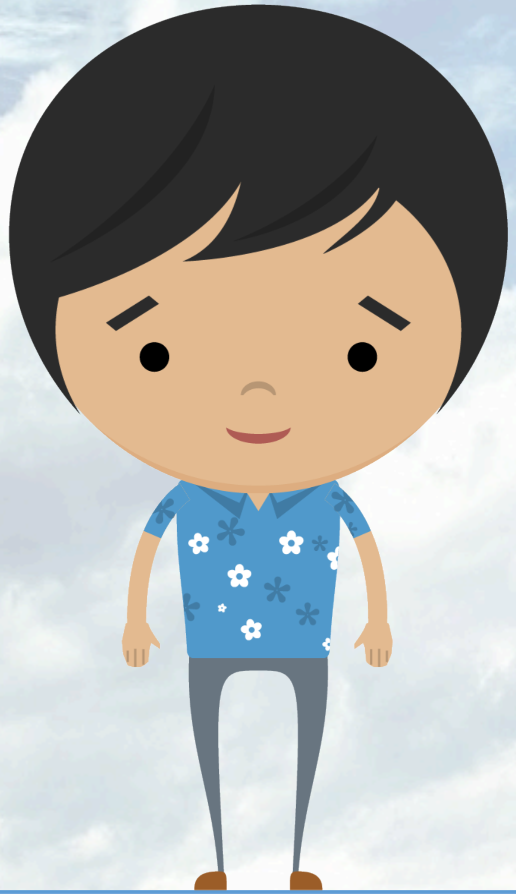
Differences



Correlation


Positive Correlation
Negative Correlation
No Correlation
Curvilinear/Non-Linear

Applying to Process Improvement



Customer Satisfaction

Y

X Speed of Service

X Menu Item Availability

Bahama Bistro
12
9
3
6

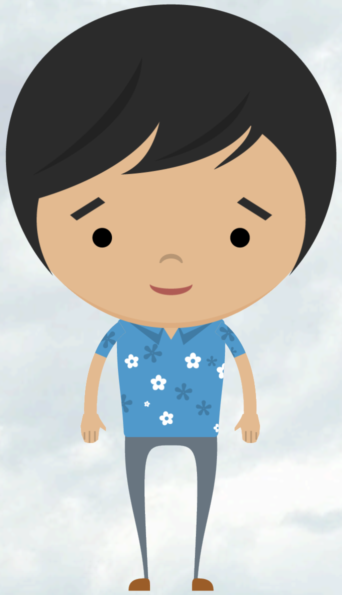
Food Freshness X

Order Accuracy X

X Ambience

Applying to Process Improvement

A way of making sure that your theories about the root causes of process issues are worth pursuing



$$Y = f(\boxed{X_1, X_2 \ldots X_n})$$

?

When Should We Run Them?

DEFINE

MEASURE

ANALYZE
Determine root cause

IMPROVE
Determine if solutions made the difference

CONTROL

Did that really work?

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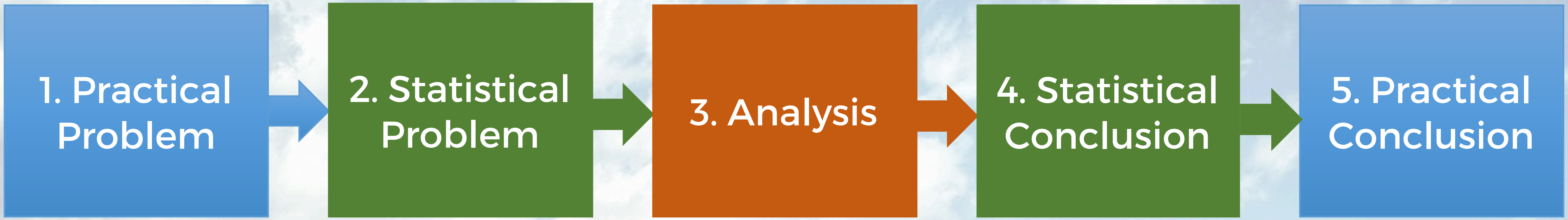
Poll #1:

How have you used Hypothesis Tests?

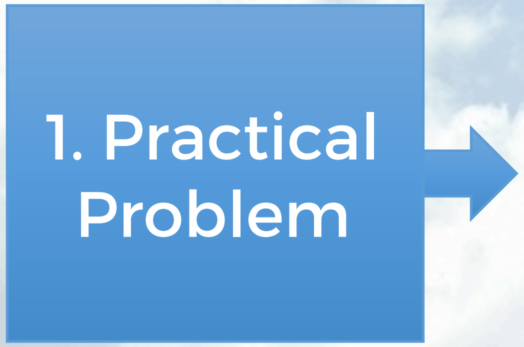
A. To verify a root cause
B. To verify that the solution made a difference
C. To test the guarantee made by a vendor
D. I haven't tried to use one yet

The Testing Process



1. Practical Problem
2. Statistical Problem
3. Analysis
4. Statistical Conclusion
5. Practical Conclusion

General Hypothesis



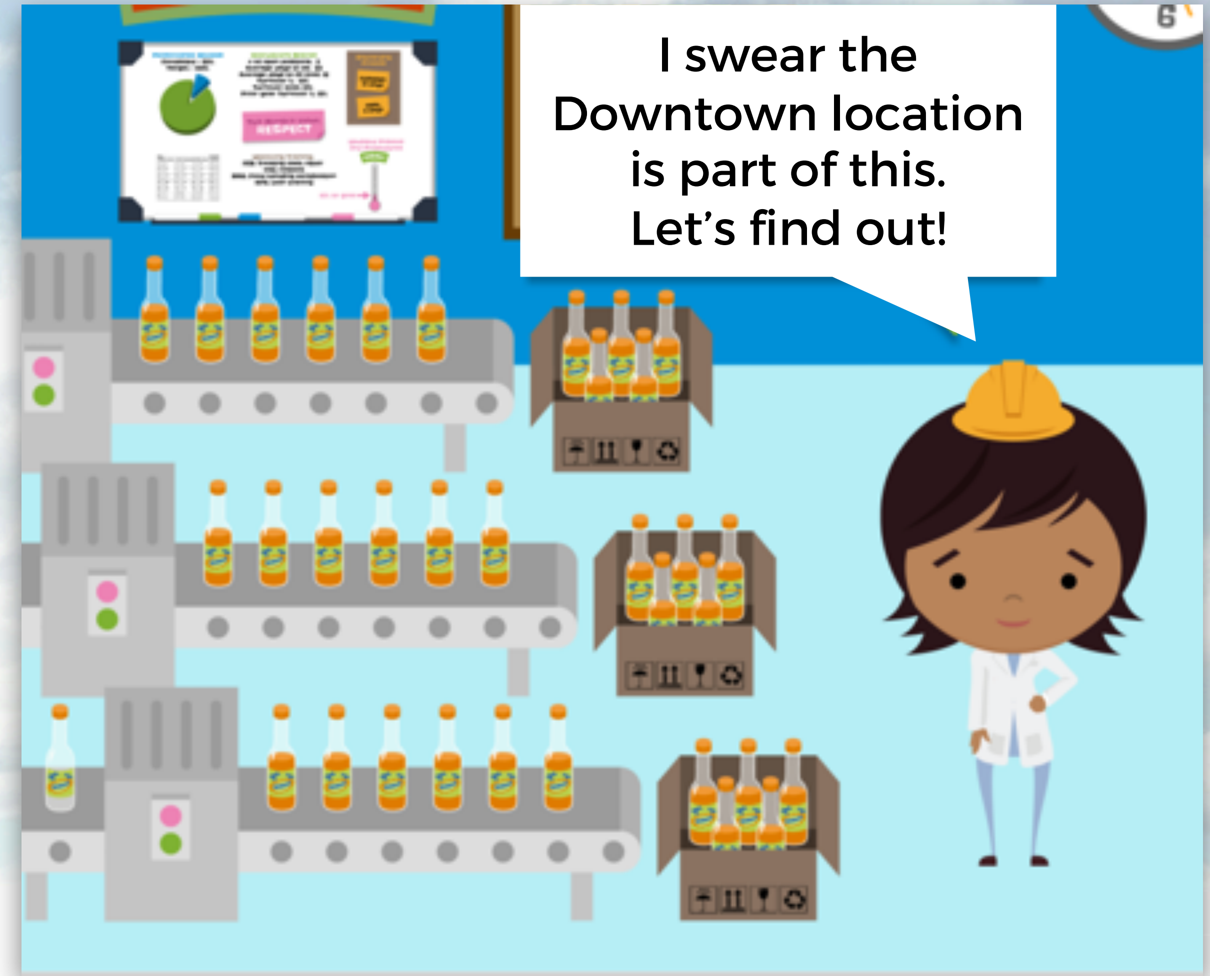
1. Practical Problem

- What's the problem?
- What type of data?
- What is the statistic of interest?

Bahama Bistro Example

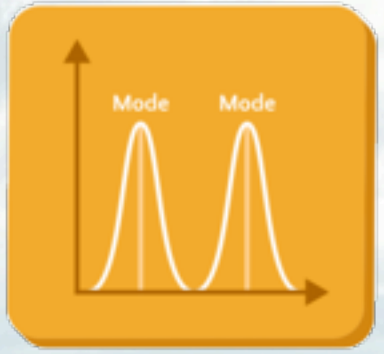
- Problem – Cannot keep up with hot sauce demand. 16% of the time, customers cannot get the hot sauce they want

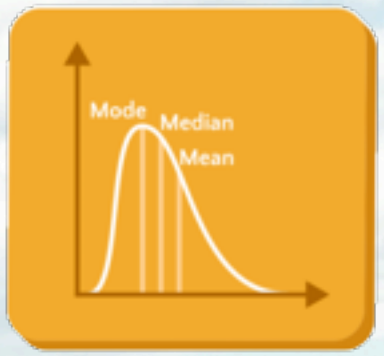
- General Hypothesis – the average hot sauce sales are higher at the Downtown location which is causing the hot sauce stock-outs

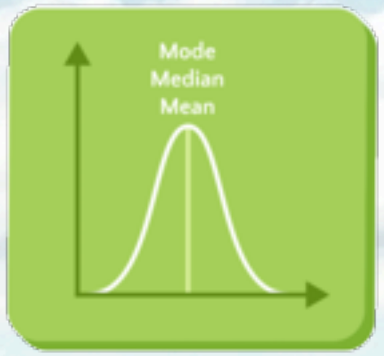

I swear the Downtown location is part of this. Let's find out!

If Continuous – Is It Normal?

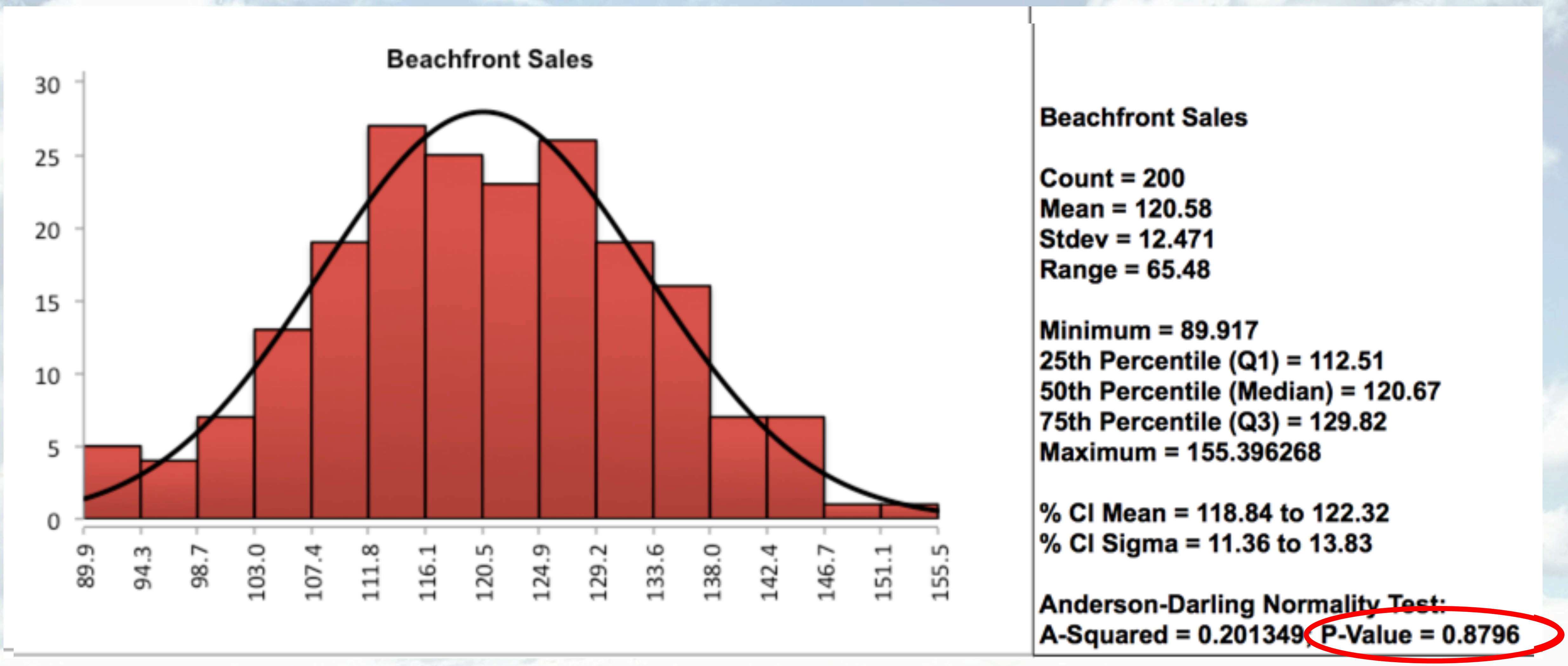
- Data Shape – Bell Curve is Normal
- Anderson Darling Test on each Data Set
  - Listed under “Basic Statistics”
- Non-Normal if P-Value < .05 (More on P-Value Shortly)




Mode
Median
Mean


Mode
Median
Mean

If Continuous – Test For Normality



Beachfront Sales

Count = 200
Mean = 120.58
Stdev = 12.471
Range = 65.48

Minimum = 89.917
25th Percentile (Q1) = 112.51
50th Percentile (Median) = 120.67
75th Percentile (Q3) = 129.82
Maximum = 155.396268

% CI Mean = 118.84 to 122.32
% CI Sigma = 11.36 to 13.83

Anderson-Darling Normality Test:
A-Squared = 0.201349, P-Value = 0.8796

Both Data Sets Are Normal

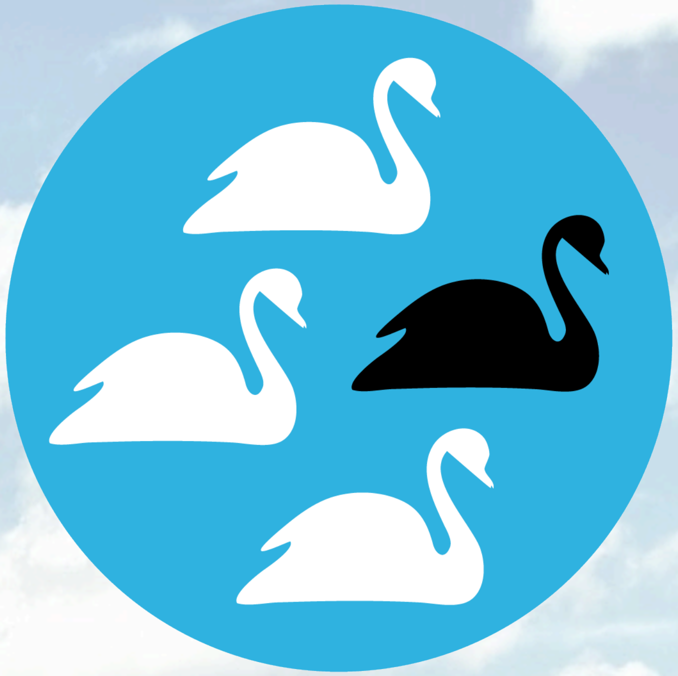
Formal Hypothesis Statements

1. Practical Problem

2. Statistical Problem

- What's the Null Hypothesis?
- What's the Alternative Hypothesis?

Why Null and Alternative?



- Theory: "All swans are white"
- Proof: hmmm – can't get all swans together in one place
- BUT: If we find one *black* swan…we can prove our theory is ***false***!

- We can use *falsification* – so we set up the Null Hypothesis and try to disprove it

Null and Alternative Theories

H_0

Ho Hum - There's no difference

Try to "reject" the Null

H_A

A HA! - There's a difference!

Then we can pursue the Alternative

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Formal Hypothesis Statements

H_0

Null: There is no difference between the average hot sauce sales at the Downtown location and the Beachfront location

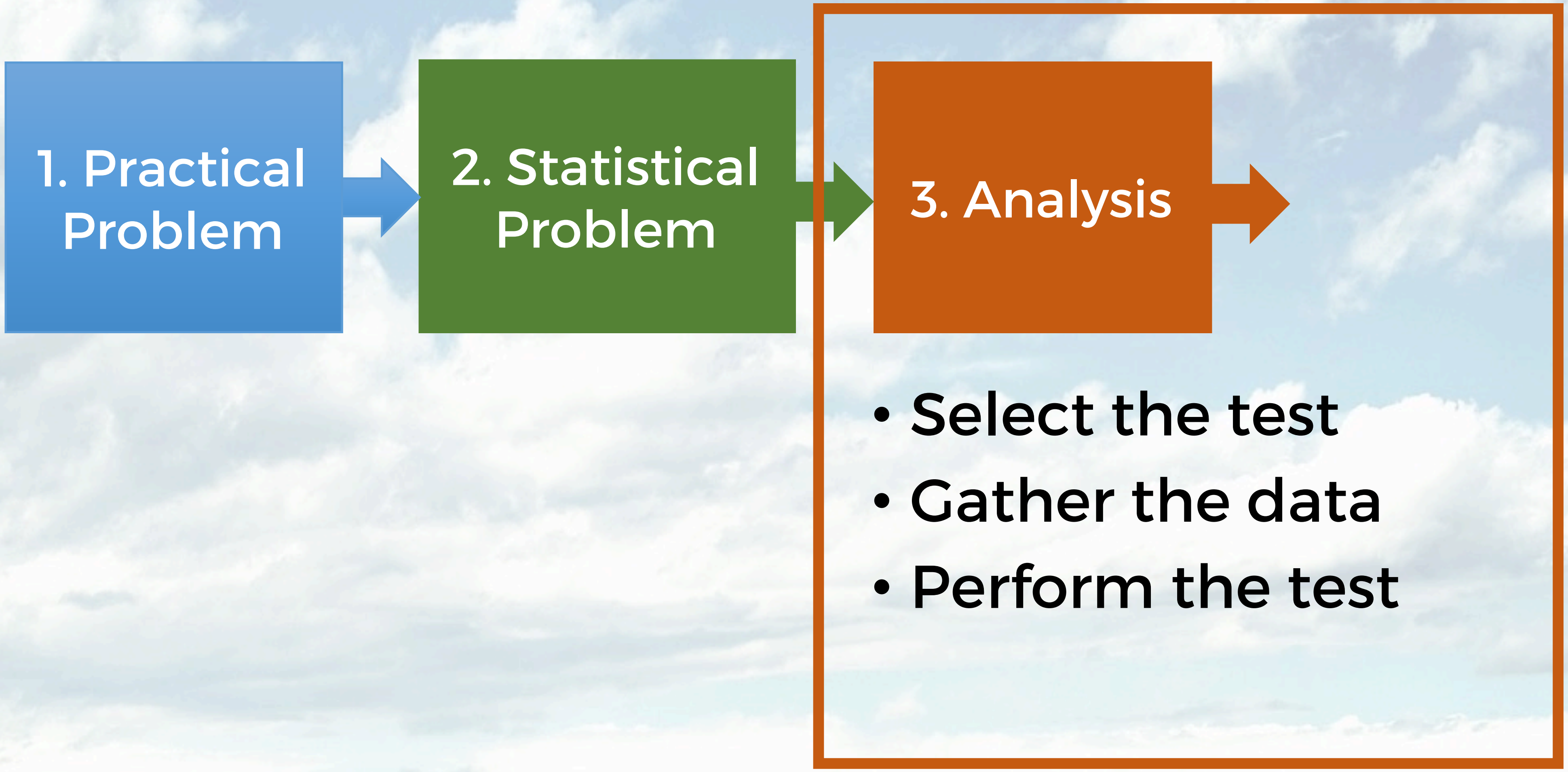
- $\mu_1 = \mu_2$

H_A

Alternative: The average hot sauce sales at the Downtown location are not equal to the average sales at the Beachfront location

- $\mu_1 \neq \mu_2$

Hypothesis Testing

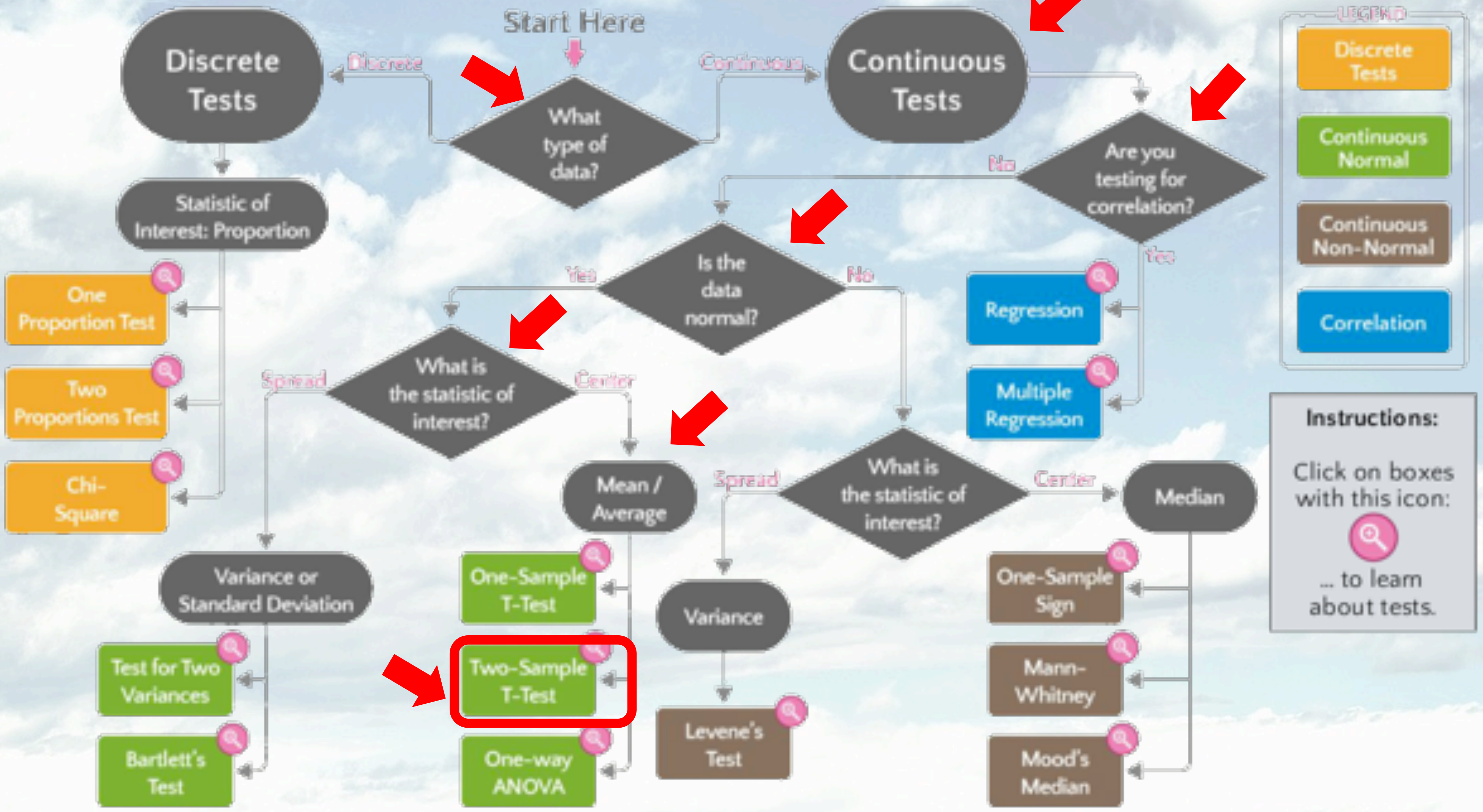

1. Practical Problem

2. Statistical Problem

3. Analysis

- Select the test
- Gather the data
- Perform the test

Select the Appropriate Test


Start Here
What type of data?
Discrete
Continuous
Discrete Tests
Continuous Tests
Statistic of Interest: Proportion
One Proportion Test
Two Proportions Test
Chi-Square
Are you testing for correlation?
No
Yes
Regression
Multiple Regression
Is the data normal?
Yes
No
What is the statistic of interest?
Spread
Center
Variance or Standard Deviation
Test for Two Variances
Bartlett's Test
Mean / Average
One-Sample T-Test
Two-Sample T-Test
One-way ANOVA
What is the statistic of interest?
Spread
Center
Variance
Levene's Test
Median
One-Sample Sign
Mann-Whitney
Mood's Median
LEGEND
Discrete Tests
Continuous Normal
Continuous Non-Normal
Correlation

Instructions:

Click on boxes with this icon: 🔍 ... to learn about tests.

Poll #2:

What are you testing?

A. Comparing two or more defect rates
B. Comparing two or more cycle times
C. Checking if 2 things correlate
D. Other
E. Not sure yet

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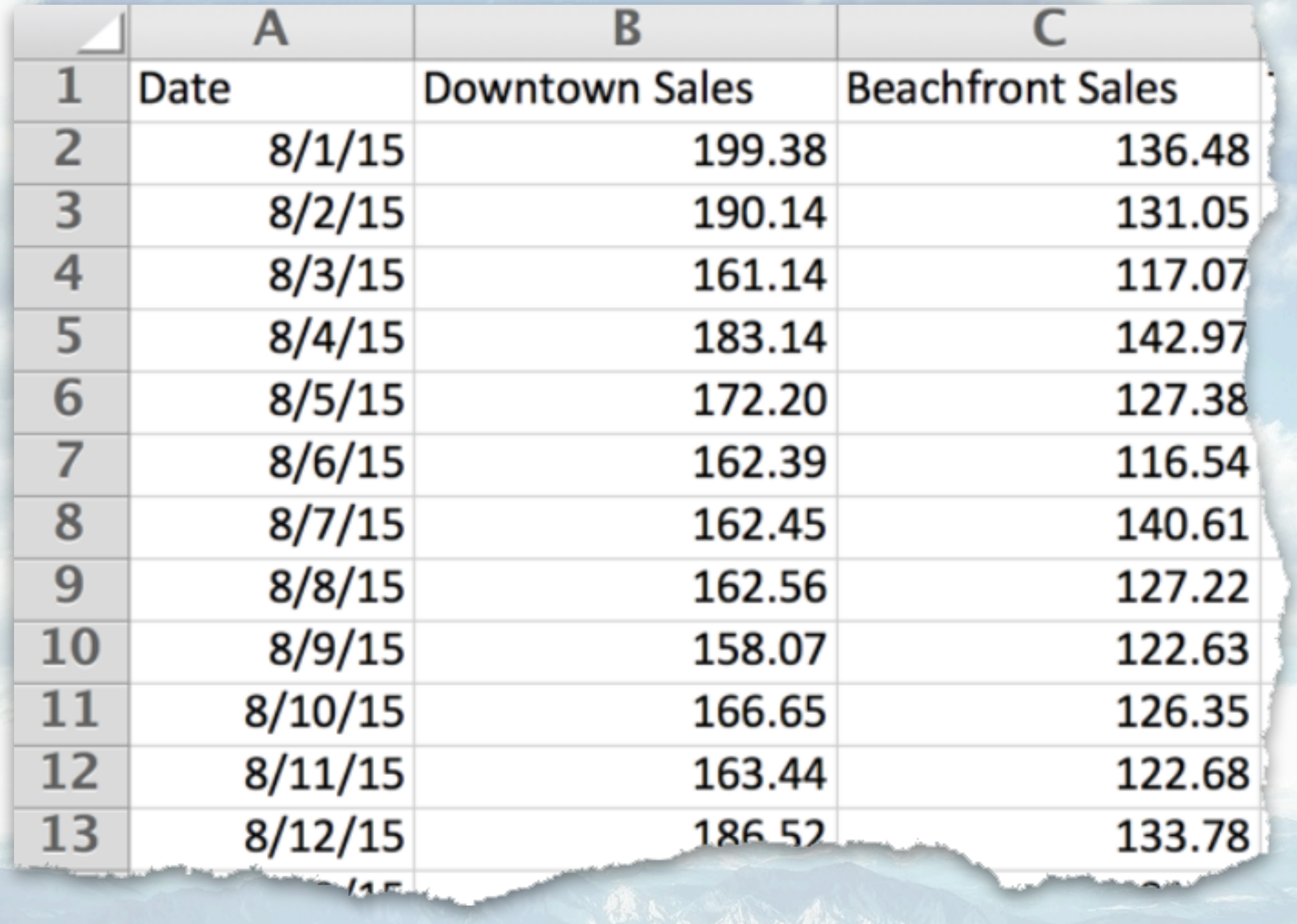
Gather The Hot Sauce Sales Data



	A	B	C
1	Date	Downtown Sales	Beachfront Sales
2	8/1/15	199.38	136.48
3	8/2/15	190.14	131.05
4	8/3/15	161.14	117.07
5	8/4/15	183.14	142.97
6	8/5/15	172.20	127.38
7	8/6/15	162.39	116.54
8	8/7/15	162.45	140.61
9	8/8/15	162.56	127.22
10	8/9/15	158.07	122.63
11	8/10/15	166.65	126.35
12	8/11/15	163.44	122.68
13	8/12/15	186.52	133.78

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Perform the Test

Minitab

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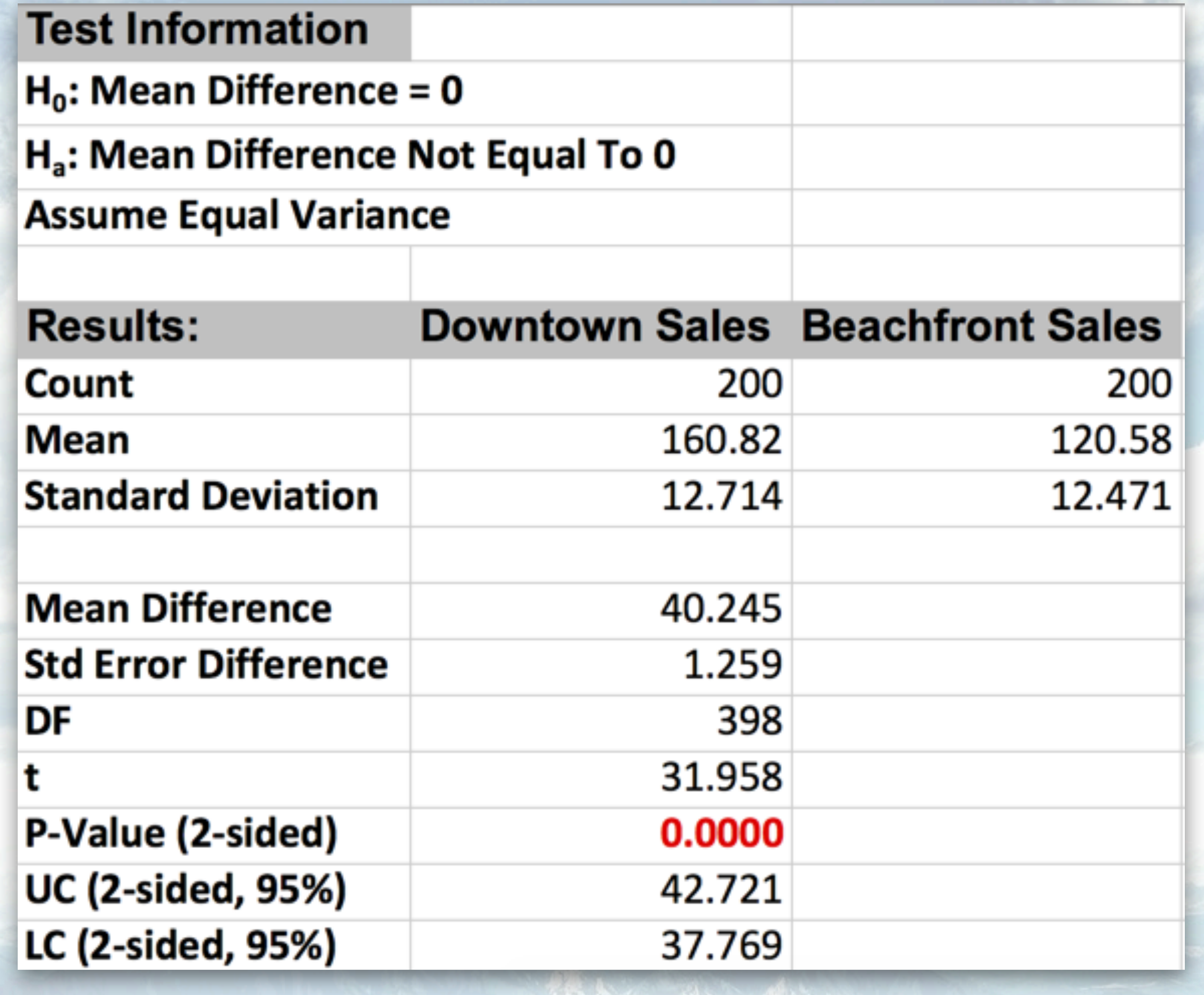
Test Results



Test Information		
H_0: Mean Difference = 0		
H_a: Mean Difference Not Equal To 0		
Assume Equal Variance		
Results:	**Downtown Sales**	**Beachfront Sales**
Count	200	200
Mean	160.82	120.58
Standard Deviation	12.714	12.471
Mean Difference	40.245	
Std Error Difference	1.259	
DF	398	
t	31.958	
P-Value (2-sided)	**0.0000**	
UC (2-sided, 95%)	42.721	
LC (2-sided, 95%)	37.769	

Accept or Reject the Null

1. Practical Problem
2. Statistical Problem
3. Analysis
4. Statistical Conclusion

- Interpret the P-Value
- Accept or Reject the Null Hypothesis

P-Value?

What is it?

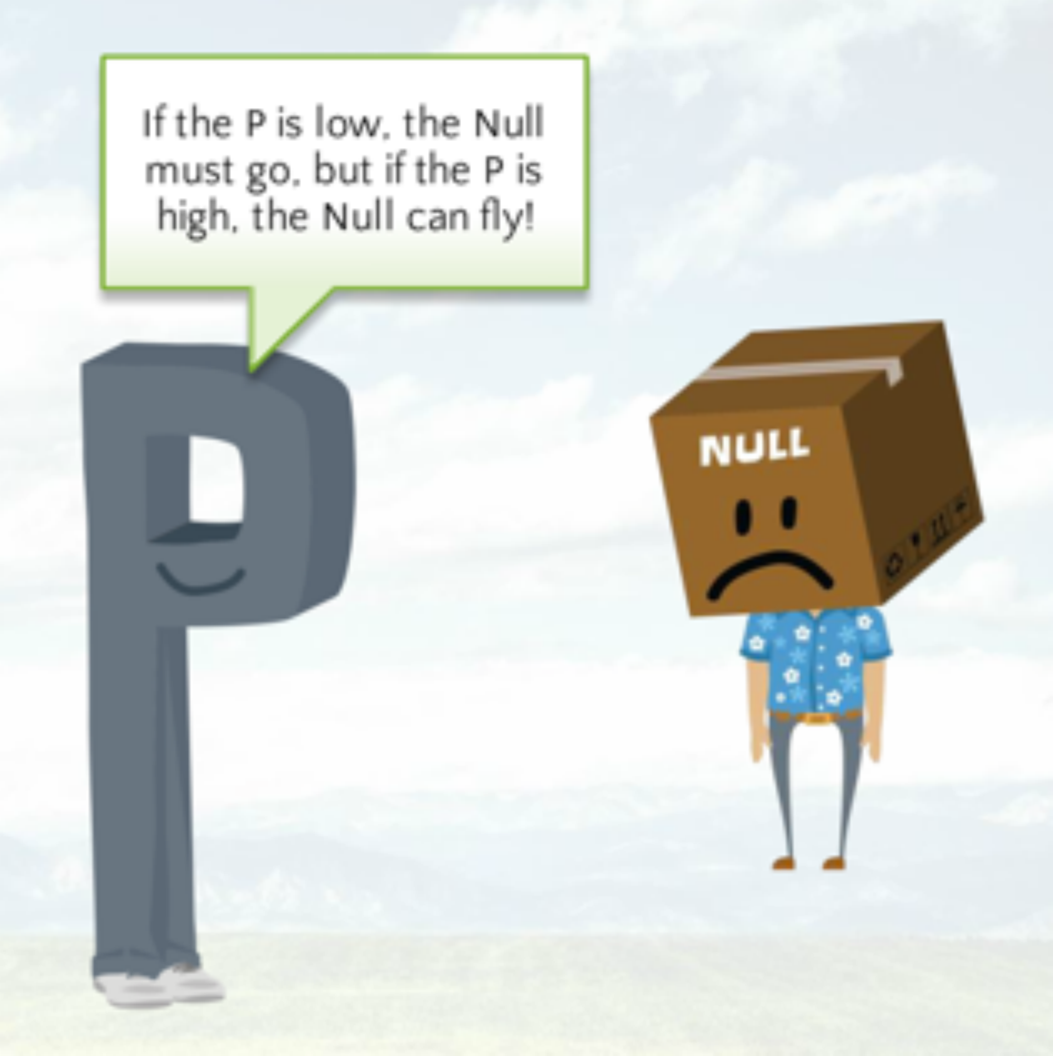
- P stands for Probability
- Can be between 0 and 1
- Boils down to the probability of the Null Hypothesis being true

"High" P-Values

- If P = .84 then there is very little reason to doubt the Null (there's no difference)

"Low" P-Values

- If P = .015 then there is very little probability the Null Hypothesis is true (reject the Null)


If the P is low, the Null must go, but if the P is high, the Null can fly!
P
NULL

"Low" is < .05

Poll #3 Mini-Quiz:

In which case would you reject the Null Hypothesis?

A. P-Value = .210
B. P-Value = .061
C. P-Value = .045
D. P-Value = .500

Confidence & Risk

Confidence Level

- 95% Confidence

“I’m 95% confident that the inferences I’m making based on testing these samples are correct”

Risk of being wrong?

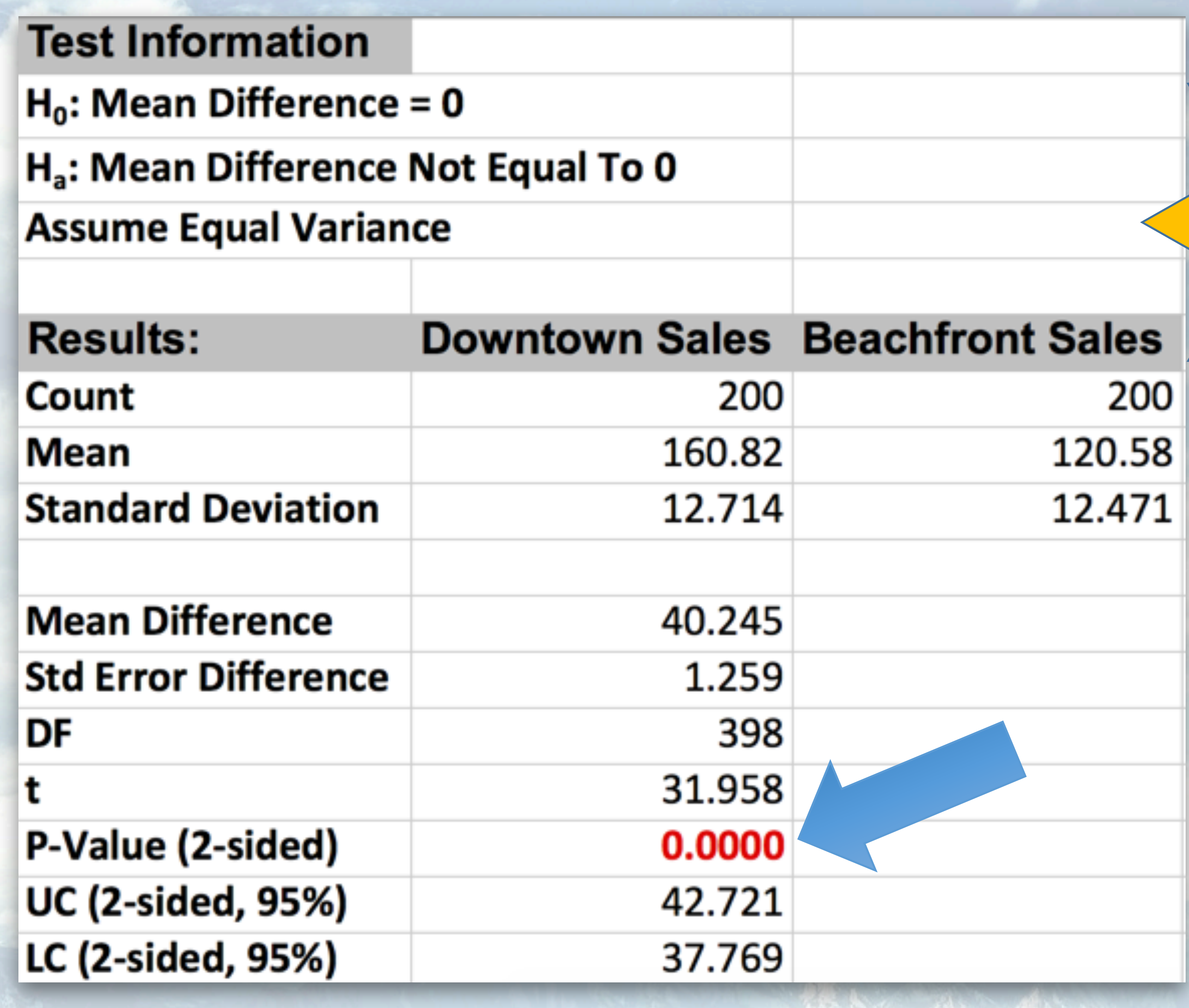
- 5%

Standard

What happens if you’re wrong?

- You might reject the Null when there really is *no* difference
- It’s possible since you’re working with samples

Statistical Conclusion



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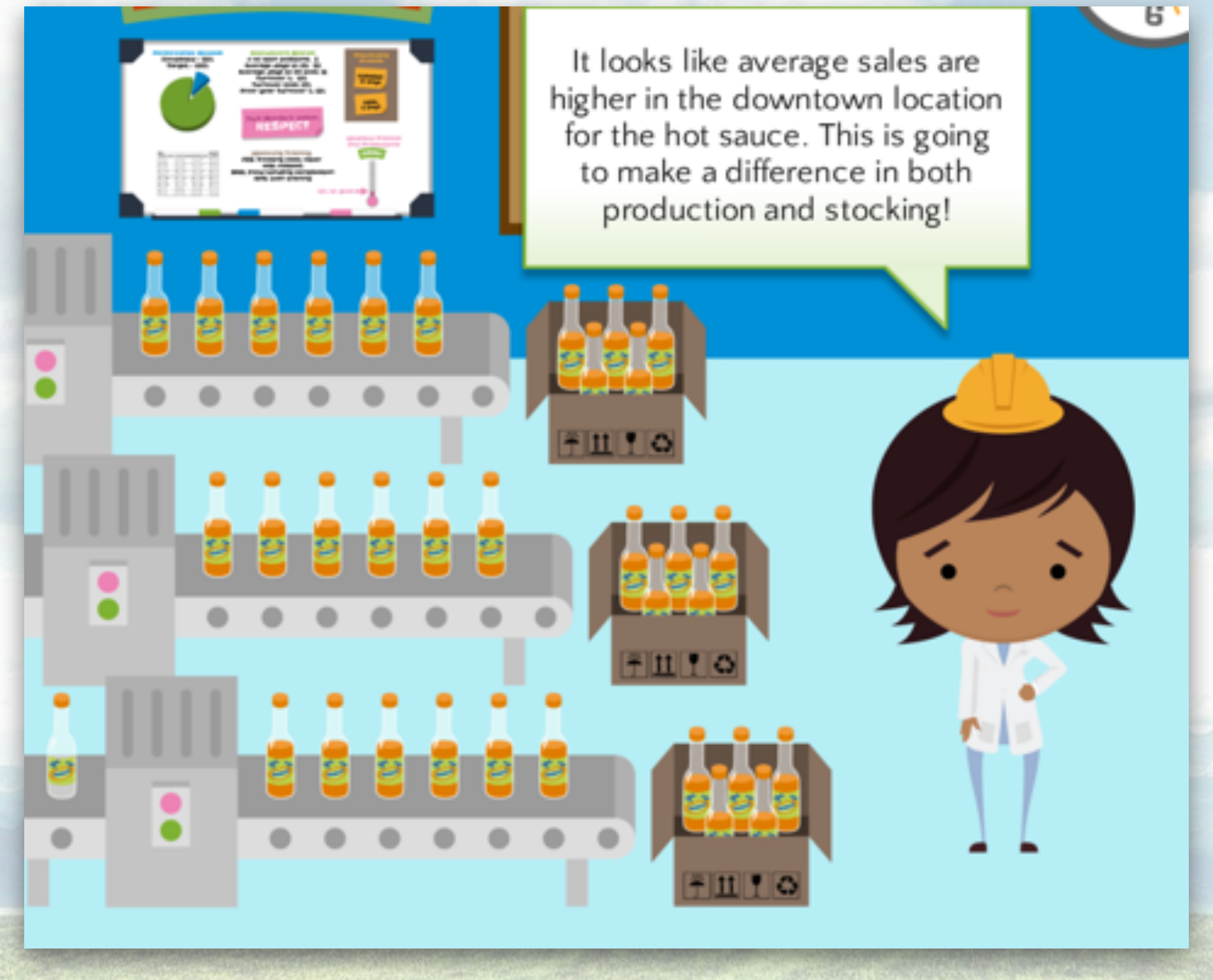
UC (2-sided, 95%)	42.721	
LC (2-sided, 95%)	37.769	

If the P is low – the Null must go – AHA!

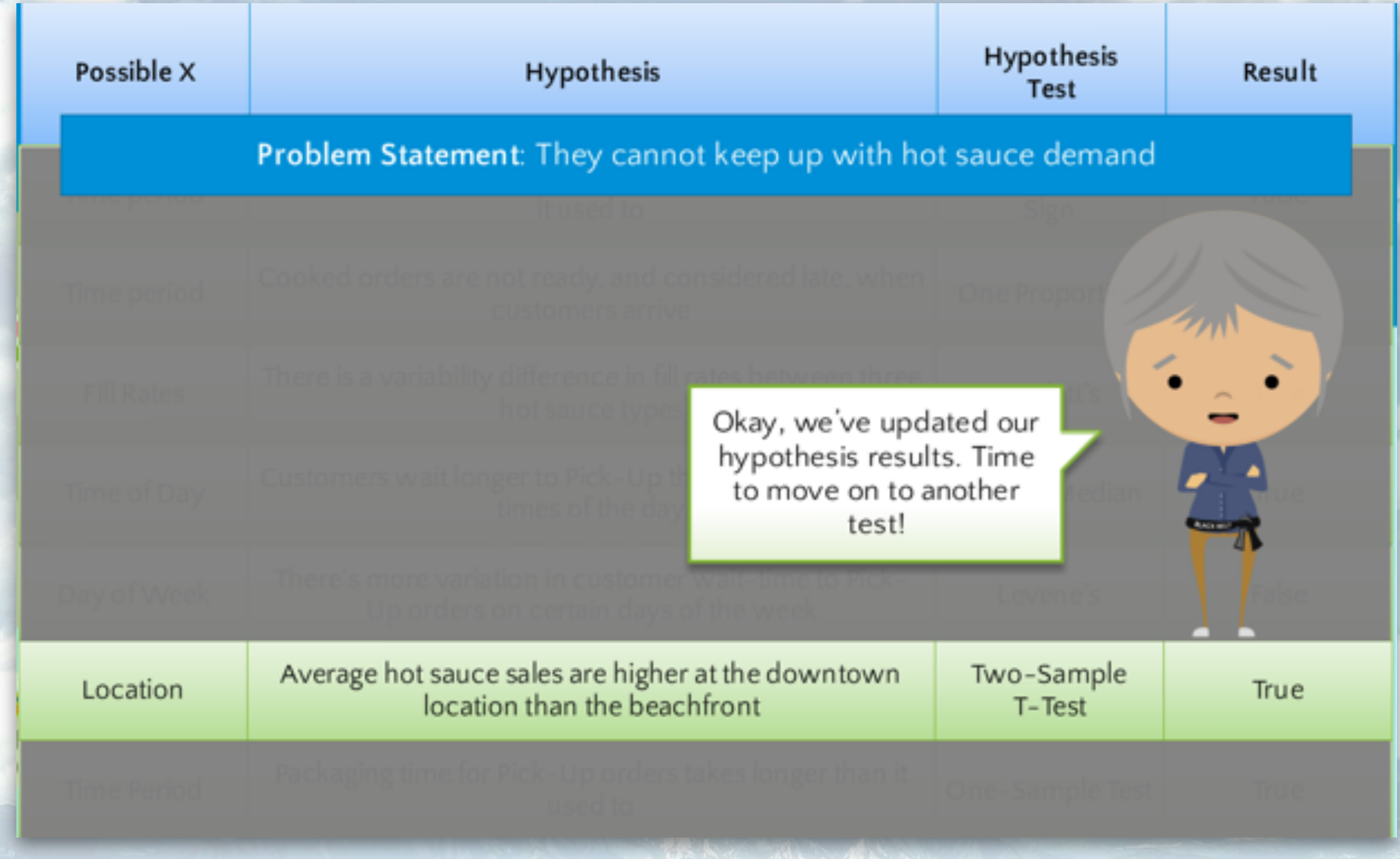
Practical Conclusion

1. Practical Problem
2. Statistical Problem
3. Analysis
4. Statistical Conclusion
5. Practical Conclusion


It looks like average sales are higher in the downtown location for the hot sauce. This is going to make a difference in both production and stocking!

- Convert statistical application into a practical application

Update The Hypothesis Testing Plan



Okay, we've updated our hypothesis results. Time to move on to another test!

Problem Statement: They cannot keep up with hot sauce demand

Possible X	Hypothesis	Hypothesis Test	Result
	it used to	Sign	
Time period	Cooked orders are not ready, and considered late, when customers arrive	One Propor	
Fill Rates	There is a variability difference in fill rates between three hot sauce types	t's	
Time of Day	Customers wait longer to Pick-Up th times of the day	edian	ue
Day of Week	There's more variation in customer wait-time to Pick-Up orders on certain days of the week	Levene's	False
Location	Average hot sauce sales are higher at the downtown location than the beachfront	Two-Sample T-Test	True
Time Period	Packaging time for Pick-Up orders takes longer than it used to	One-Sample Test	True

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Verifying Results

- Have you ever fixed a root cause that was not the culprit?
- Have you been part of in improvement effort that failed to have an impact? Proof matters.
- If you're claiming your project reduced costs, increased customer satisfaction or reduced cycle time – you have to be able to prove it.

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https://www.pinterest.com/BSAIllustration/shane-finegan/

Poll #4:

Who here has ever:

A. Addressed a root cause that was not a critical "x"?
B. Fixed a process and saw no positive results?
C. Watched as others based fixes on assumptions?
D. Experienced some combination of the above?
E. Experienced none of the above?

Why Use Tests?

Root Cause: Examples

- Are defects higher at one location? – Find out what's different
- Are a higher proportion of late shipments coming from a particular supplier? – Investigate
- Are the portion weights the same across all meals? – Could lead to mistake-proofing solutions like standard scoops

Verifying Standards: Example

- Is the average delivery time as advertised? – Renegotiate the contract

Verify Solutions: Example

- Did the changes reduce defects, cycle time, etc.? – Confirm and spread the news – build trust, confidence and momentum

Any Words of Advice?

- Clarify the practical problem you are addressing
- Use the Decision Tree to choose the right test
- Spend time setting up your Null and Alternative Hypotheses Statements
- Remember you are looking for:
  - A ***difference*** between particular strata (Who, What, Where, When)
  - ***Correlation*** between the Y and a particular X
- The P-Value is your guide – "If the P is low…"
- Hypothesis Tests are helpful when determining potential "Xs" for root cause, but they can also prove your solutions made a difference.

Today We Covered

- What Are Hypothesis Tests?
- Why Do We Need Them in Process Improvement?
- When Should We Use Them?
- How Do We Setup and Run Them?
- Any Words of Advice?

Q & A

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Elisabeth Swan

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