

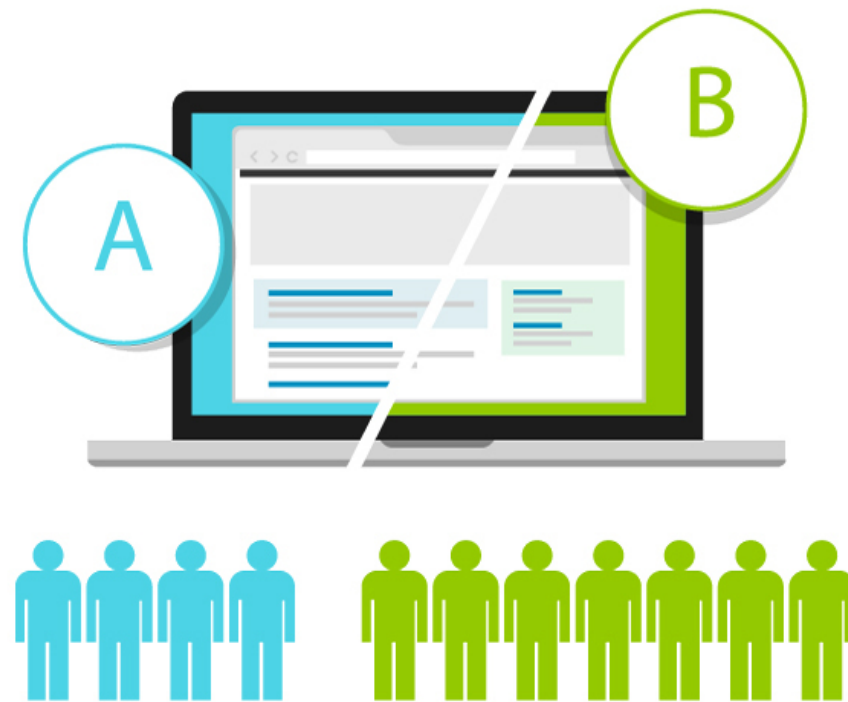


CUSTOMER ANALYTICS & A/B TESTING IN PYTHON

# Analyzing the A/B test results

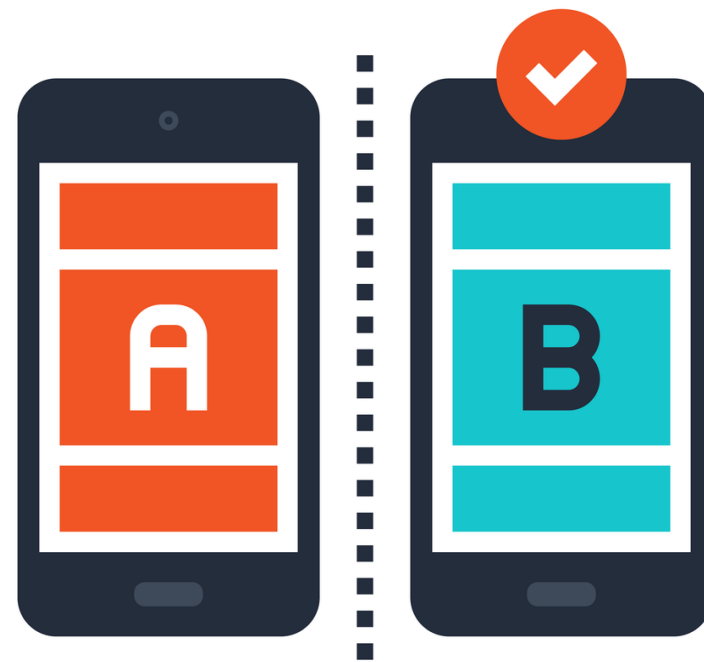
**Ryan Grossman**  
Data Scientist, EDO

# Analyzing A/B Test Results





# Evaluating our Test



**A/B TESTING**



# Test Results

```
In [1]: test_demographics = pd.read_csv('test_demographics.csv')
```

```
In [2]: test_results = pd.read_csv('ab_test_results.csv')
```

```
In [3]: test_results.date = pd.to_datetime(test_results.date)
```

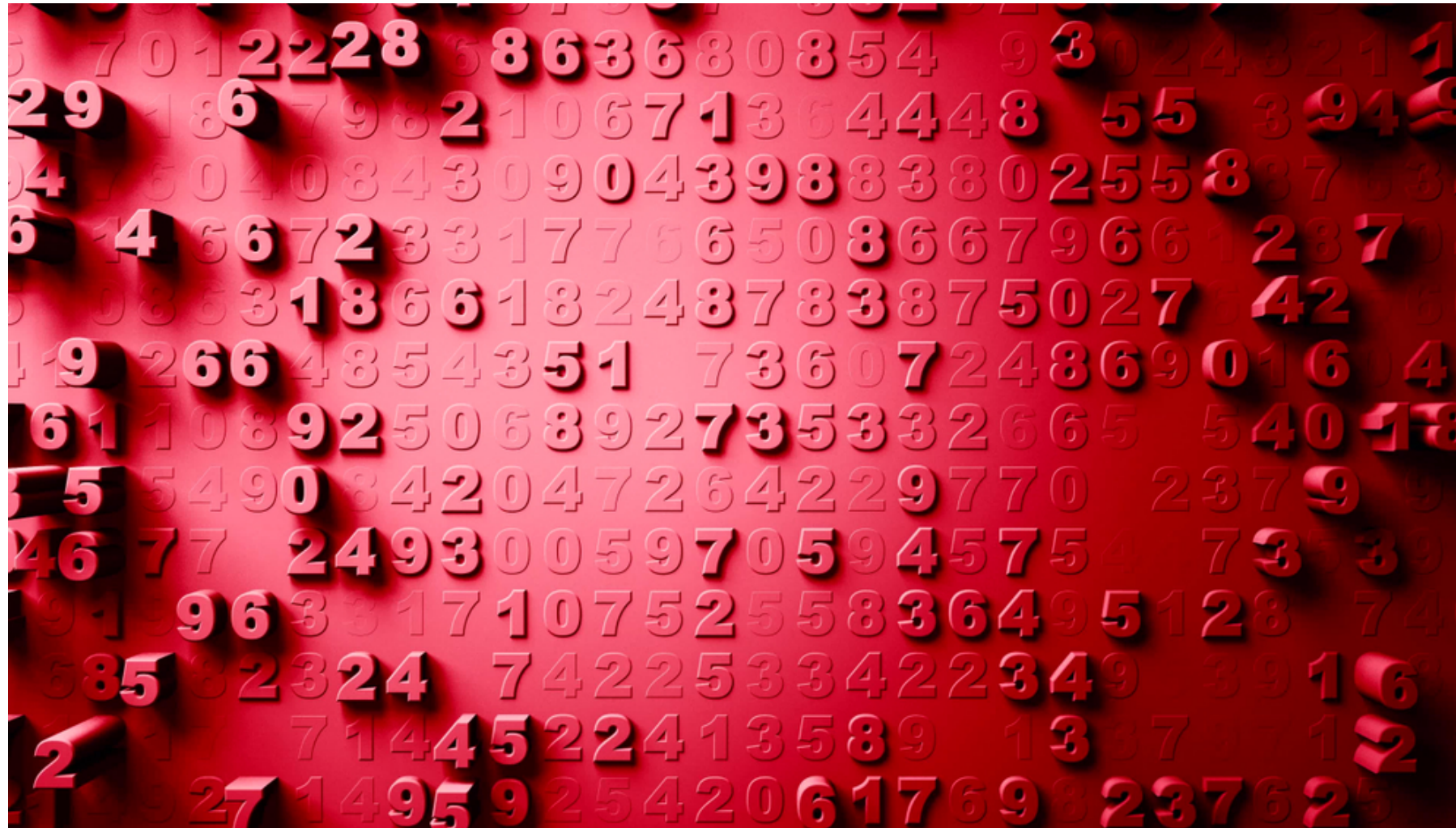
```
In [4]: test_results.head(n=5)
```

```
Out[4]:
```

| uid        | date       | purchase | sku | price | group |   |
|------------|------------|----------|-----|-------|-------|---|
| 90554036.0 | 2018-02-27 | 14:22:12 | 0   | NaN   | NaN   | C |
| 90554036.0 | 2018-02-28 | 08:58:13 | 0   | NaN   | NaN   | C |
| 90554036.0 | 2018-03-01 | 09:21:18 | 0   | NaN   | NaN   | C |
| 90554036.0 | 2018-03-02 | 10:14:30 | 0   | NaN   | NaN   | C |
| 90554036.0 | 2018-03-03 | 13:29:45 | 0   | NaN   | NaN   | C |



# Confirming Test Results





# Confirming Test Results

```
In [5]: test_results_grpd = test_results.groupby(by=['group'],  
                                                as_index=False)
```

```
In [6]: test_results_grpd.uid.count()
```

```
Out[6]:
```

|   | group | uid   |
|---|-------|-------|
| 0 | C     | 48236 |
| 1 | V     | 49867 |



# Confirming Test Results

```
In [7]: test_results_demo = test_results.merge(test_demo,
                                                how='inner', on='uid')

In [8]: test_results_grpd = test_results_demo.groupby(by=
                                                ['country', 'gender', 'device', 'group'],
                                                as_index=False)

In [9]: test_results_grpd.uid.count()
```

Out[9]:

| country | gender | device | group | uid  |
|---------|--------|--------|-------|------|
| BRA     | F      | and    | C     | 5070 |
| BRA     | F      | and    | V     | 4136 |
| BRA     | F      | iOS    | C     | 3359 |
| BRA     | F      | iOS    | V     | 2817 |
| BRA     | M      | and    | C     | 3562 |
| BRA     | M      | and    | V     | 3673 |
| BRA     | M      | iOS    | C     | 2940 |
| BRA     | M      | iOS    | V     | 3109 |
| CAN     | F      | and    | C     | 747  |
| CAN     | F      | and    | V     | 806  |
| CAN     | F      | iOS    | C     | 447  |



# Finding The Test & Control Group Conversion Rates

```
In [10]: test_results_grpd = test_results_demo.groupby(
          by=['group'], as_index=False)

In [11]: test_results_summary = test_results_grpd.agg(
          {'purchase': ['count', 'sum']})

In [12]: test_results_summary

Out[12]:
   group  purchase
count  sum
0      C    48236    1657
1      V    49867    2094

In [13]: test_results_summary['conv'] = (
          test_results_summary.purchase['sum'] /
          test_results_summary.purchase['count'])

In [14]: test_results_summary

Out[14]:
   group  purchase  conv
count  sum
0      C    48236    1657    0.034351
1      V    49867    2094    0.041984
```







# p-Values

## **p-value:**

- Probability under the Null Hypothesis of obtaining a result as or more extreme than the one observed.
- Represents a measure of the evidence against retaining the Null Hypothesis.



# Interpreting a p-Value

| p-value            | Conclusion                                       |
|--------------------|--|
| <b>&lt; 0.01</b>   | very strong evidence against the Null Hypothesis |
| <b>0.01 - 0.05</b> | strong evidence against the Null Hypothesis      |
| <b>0.05 - 0.10</b> | very weak evidence against the Null Hypothesis   |
| <b>&gt; 0.1</b>    | small to no evidence against the Null Hypothesis |

# Next Steps





## CUSTOMER ANALYTICS & A/B TESTING IN PYTHON

**Let's practice!**



CUSTOMER ANALYTICS & A/B TESTING IN PYTHON

# Understanding statistical significance

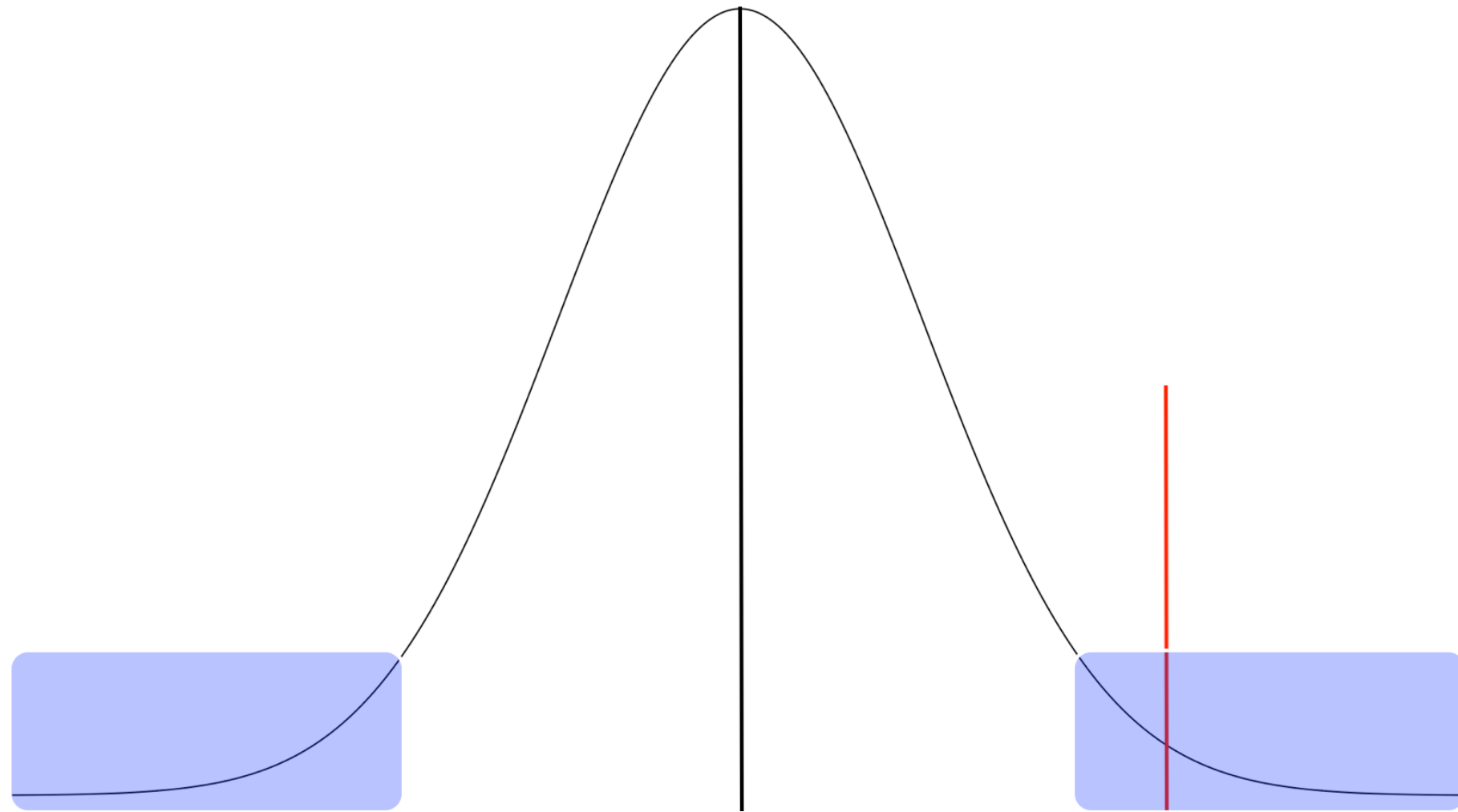
**Ryan Grossman**  
Data Scientist, EDO

# Next Steps In Our Analysis





# Revisiting Statistical Significance





# p-value Function

```
def get_pvalue(con_conv, test_conv, con_size, test_size,):  
    lift = - abs(test_conv - con_conv)  
  
    scale_one = con_conv * (1 - con_conv) * (1 / con_size)  
    scale_two = test_conv * (1 - test_conv) * (1 / test_size)  
    scale_val = (scale_one + scale_two)**0.5  
  
    p_value = 2 * stats.norm.cdf(lift, loc = 0, scale = scale_val )  
  
    return p_value
```



# Calculating our p-value

```
In [1]: con_conv = 0.034351
In [2]: test_conv = 0.041984
In [3]: con_size = 48236
In [4]: test_size = 49867

In [5]: p_value = get_pvalue(con_conv, test_conv, con_size, test_size)

In [6]: p_value

Out[6]: 4.2572974855869089e-10
```



# Finding the Test Power

```
In [7]: get_power(test_size, con_conv, test_conv, 0.95)
```

```
Out[7]: 0.99999259413722819
```



# CONFIDENCE INTERVAL





# Confidence Intervals

## Confidence Interval

- Provides contextualization of the estimation process.
- The conversion rate is a fixed quantity, the estimation is what is variable.



# Confidence Intervals

## Two Sided Confidence Interval

- $\mu \pm \Phi \left( \alpha + \frac{1-\alpha}{2} \right) * \sigma$
- $\mu$ : Estimated Mean
- $\sigma$ : Estimated Standard Deviation
- $\alpha$ : Desired Confidence Interval Width



# Calculating Confidence Intervals

```
def get_ci(lift, alpha, sd):  
    val = abs(stats.norm.ppf((1 - alpha)/2))  
  
    lwr_bnd = lift - val * sd  
    upr_bnd = lift + val * sd  
  
    return_val = (lwr_bnd, upr_bnd)  
    return(return_val)
```



# Calculating Confidence Intervals

```
In [8]: lift = test_conv - con_conv
```

```
In [9]: sd = ((test_conv * (1 - test_conv)) / test_size +  
              (con_conv * (1 - con_conv)) / con_size)**0.5
```

```
In [10]: get_ci(lift, 0.95, sd)
```

```
Out[10]: (0.0052371462948578272, 0.010028853705142175)
```



# Next Steps





## CUSTOMER ANALYTICS & A/B TESTING IN PYTHON

**Let's practice!**



CUSTOMER ANALYTICS & A/B TESTING IN PYTHON

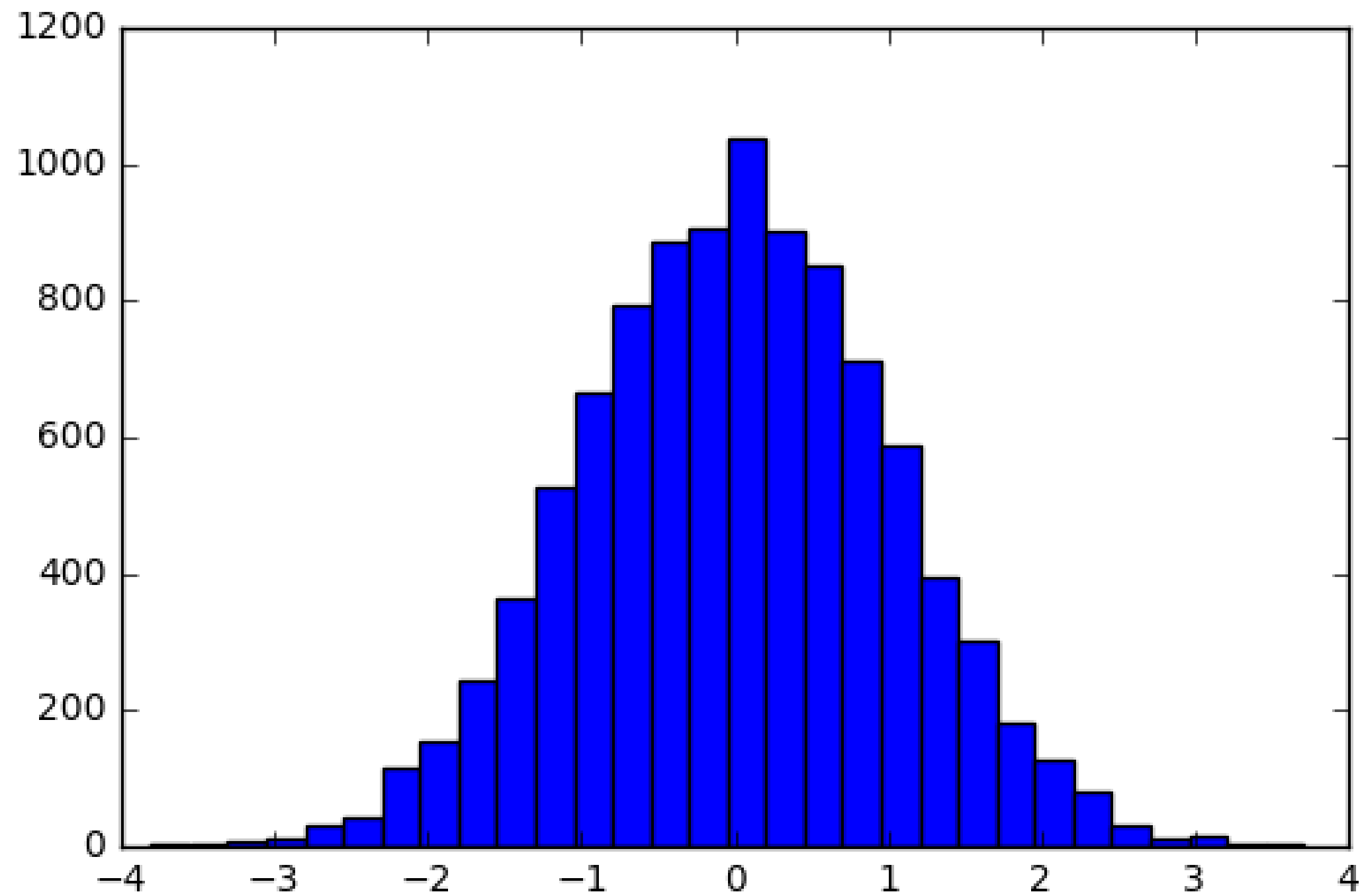
# Interpreting your test results

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Data Scientist, EDO

# Communicating Your Test Results

|                                    | Test Group | Control Group |
|------------------------------------|------------|---------------|
| Sample Size                        | 7030       | 6970          |
| Run Time                           | 2 Weeks    | 2 Weeks       |
| Mean                               | 3.12       | 2.69          |
| Variance                           | 3.20       | 2.64          |
| Estimated Lift: 0.56 *             |            |               |
| Confidence Interval 0.56 $\pm$ 0.4 |            |               |

*\* Significant at the 0.05 Level*





# Generating Histograms - Data

```
In [1]: test_results_rollup.head(n=10)
```

```
Out[1]:
```

| uid        | group | purchase |
|------------|-------|----------|
| 11128497.0 | V     | 0.000000 |
| 11145206.0 | V     | 0.050000 |
| 11163353.0 | C     | 0.150000 |
| 11215368.0 | C     | 0.000000 |
| 11248473.0 | C     | 0.157895 |
| 11258429.0 | V     | 0.086957 |
| 11271484.0 | C     | 0.071429 |
| 11298958.0 | V     | 0.157895 |
| 11325422.0 | C     | 0.045455 |
| 11340821.0 | C     | 0.040000 |

# Generating Histograms - Code

```
In [2]: variant_results_rollup = test_results_rollup[
        test_results_rollup.group == 'V']

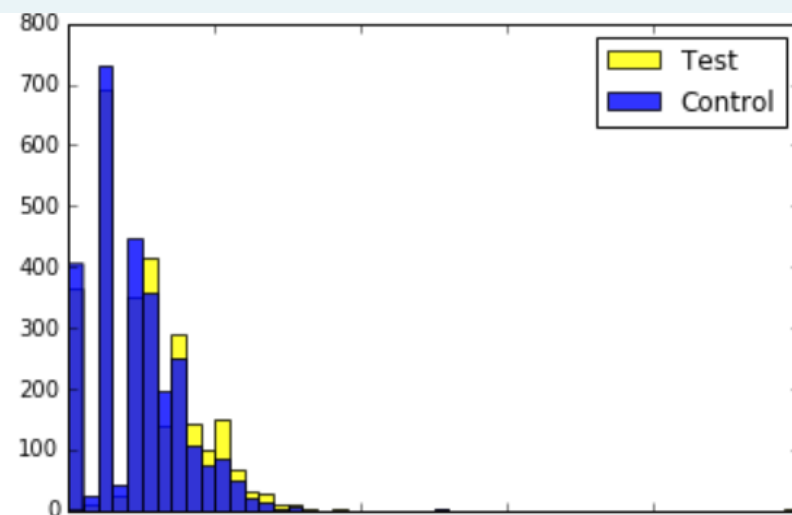
In [3]: control_results_rollup = test_results_rollup[
        test_results_rollup.group == 'C']

In [4]: plt.hist(variant_results_rollup['purchase'],
                 color = 'yellow', alpha = 0.8, bins = 50, label = 'Test')

In [5]: plt.hist(control_results_rollup['purchase'],
                 color = 'blue', alpha = 0.8, bins = 50, label = 'Control')

In [6]: plt.legend(loc='upper right')

In [7]: plt.show()
```

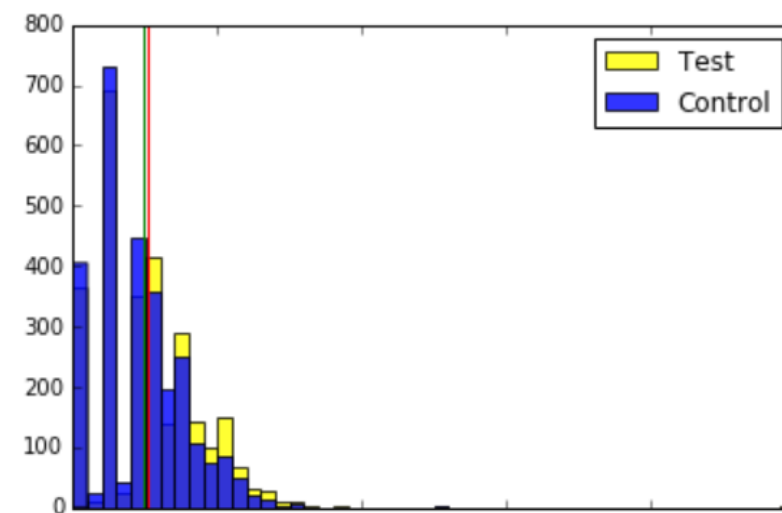


# Adding Lines & Annotations

```
In [8]: plt.axvline(x = np.mean(variant_results_rollup.purchase), color = 'red')
```

```
In [9]: plt.axvline(x= np.mean(test_results_rollup.purchase), color = 'green')
```

```
In [10]: plt.show()
```







# Plotting the Distribution

```
In [11]: mean_control = 0.090965
In [12]: mean_test = 0.102005
In [13]: var_control = (mean_control * (1 - mean_control)) / 58583
In [14]: var_test = (mean_test * (1 - mean_test)) / 56350

In [15]: control_line = np.linspace(-3 * var_control**0.5 +
                                     mean_control, 3 * var_control**0.5 +
                                     mean_control, 100)

In [16]: test_line = np.linspace(-3 * var_test**0.5 +
                                   mean_test, 3 * var_test**0.5 +
                                   mean_test, 100)
```

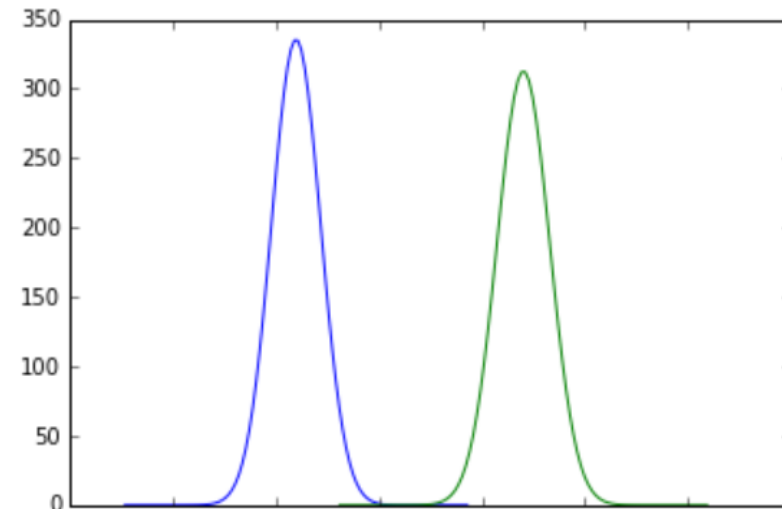


# Plotting the Distribution

```
In [17]: plt.plot(control_line, mlab.normpdf(control_line,  
      mean_control, var_control**0.5))
```

```
In [18]: plt.plot(test_line, mlab.normpdf(test_line,  
      mean_test, var_test**0.5))
```

```
In [19] plt.show()
```





# Plotting the Difference of Distributions

```
In [20]: lift = mean_test - mean_control
```

```
In [21]: var = var_test + var_control
```

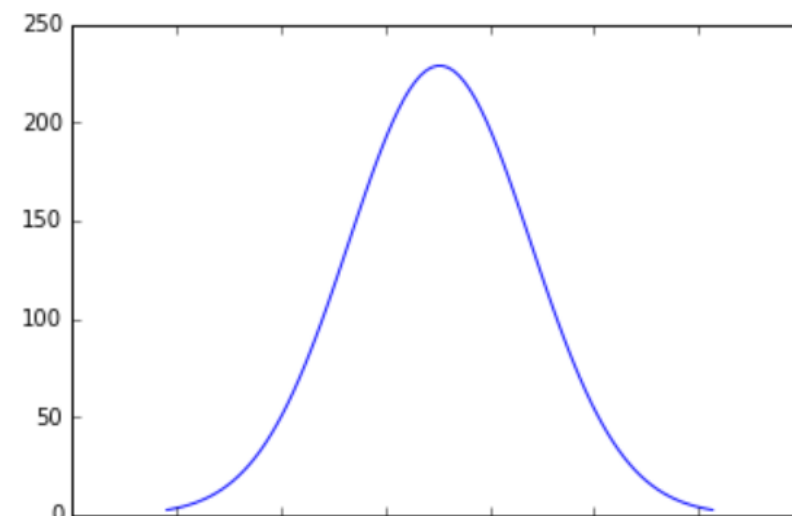


# Plotting the Difference of Distributions

```
In [22]: diff_line = np.linspace(-3 * var**0.5 +  
    lift, 3 * var**0.5  
    + lift, 100)
```

```
In [23]: plt.plot(diff_line, mlab.normpdf(diff_line,  
    lift, var**0.5))
```

```
In [24] plt.show()
```





# Plotting the Confidence Interval

```
In [25]: section = np.arange(0.007624, 0.01445 , 1/10000)
```

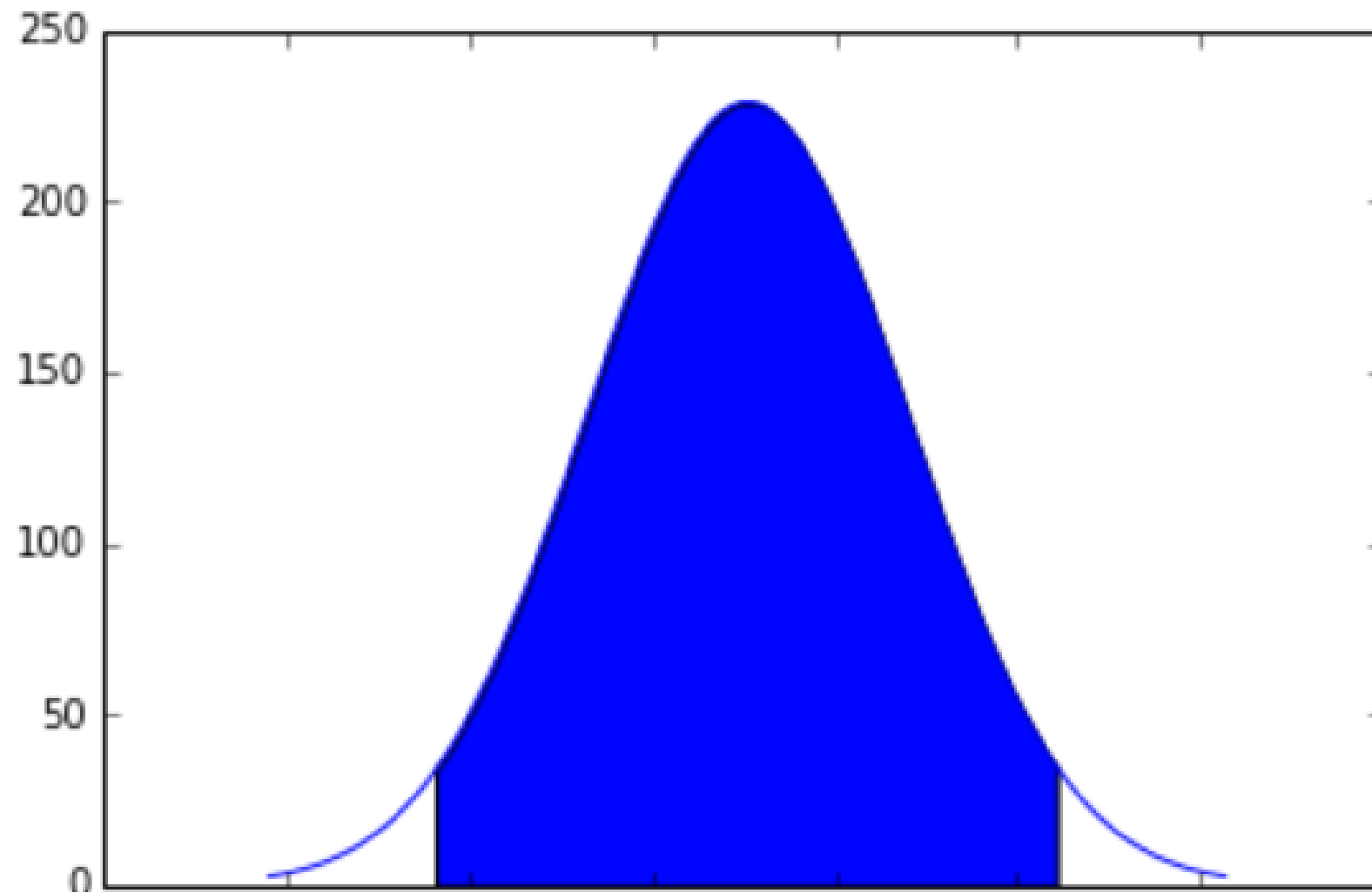
```
In [26]: plt.fill_between(section,  
                          mlab.normpdf(section,  
                          lift, var**0.5))
```

```
In [27]: plt.plot(diff_line,mlab.normpdf(diff_line,  
                                          lift, var**0.5))
```

```
In [28]: plt.show()
```



# Plotting the Confidence Interval





## CUSTOMER ANALYTICS & A/B TESTING IN PYTHON

**Let's practice!**



## CUSTOMER ANALYTICS & A/B TESTING IN PYTHON

# Finale

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## CUSTOMER ANALYTICS & A/B TESTING IN PYTHON

**Let's practice!**