11.1) A/B Testing

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Reference

Tables, Graphics, and Figures from

Computational and Inferential Thinking: The Foundations of Data Science

Adhikari & DeNero (2019): Ch 12.1 A/B Testing

https://www.inferentialthinking.com/

Stat Labs by Deborah Nolan and Terry Speed

```
from datascience import *
path_data = 'https://github.com/data-8/textbook/raw/gh-pages/data/'
births = Table.read_table(path_data + 'baby.csv')
```

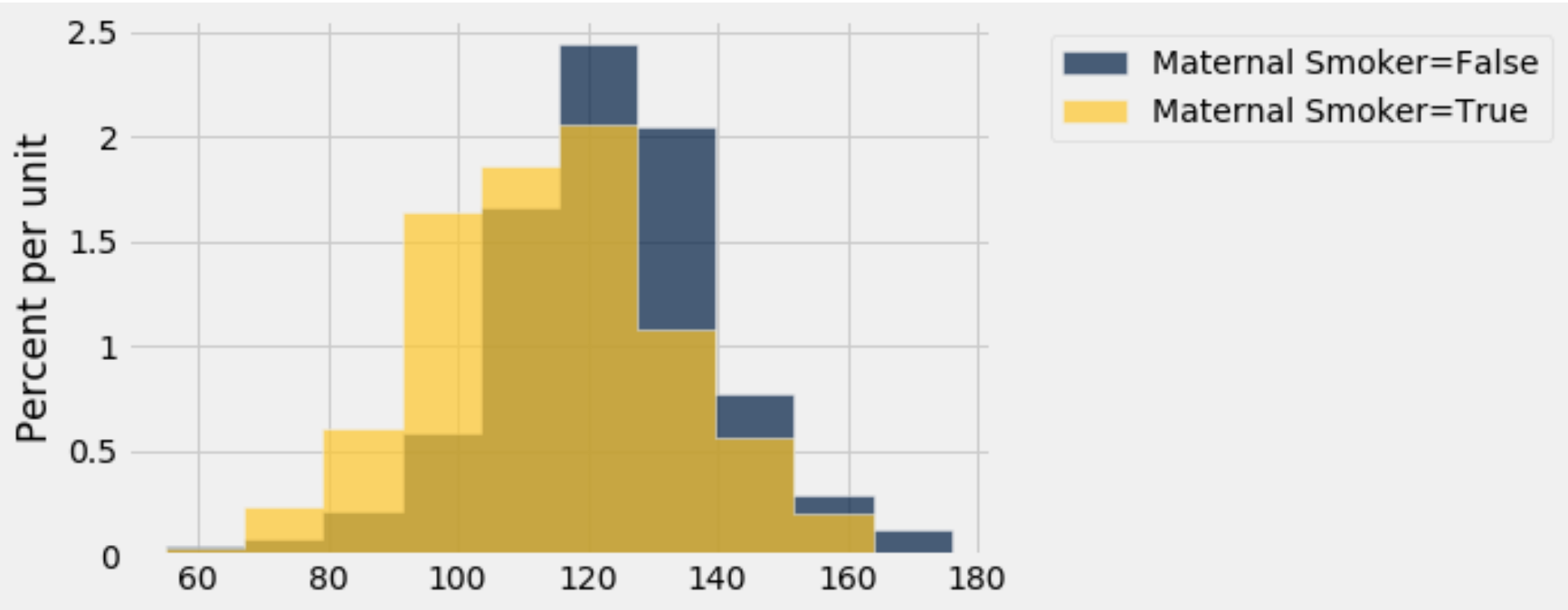
Birth Weight	Gestational Days	Maternal Age	Maternal Height	Maternal Pregnancy Weight	Maternal Smoker
120	284	27	62	100	False
113	282	33	64	135	False
128	279	28	64	115	True

```
smoking_and_birthweight = births.select('Maternal Smoker',
                                        'Birth Weight')
smoking_and_birthweight.group('Maternal Smoker')
```

Maternal Smoker	count
False	715
True	459

```
%matplotlib inline
import matplotlib.pyplot as plots
plots.style.use('fivethirtyeight')
smoking_and_birthweight.hist('Birth Weight', group = 'Maternal Smoker')
```

$$H_0 : \mu_s = \mu_{ns} \text{ vs } H_A : \mu_s < \mu_{ns}$$



Test Statistic

```
import numpy as np
means_table = smoking_and_birthweight.group('Maternal Smoker',
                                            np.average)
```

Maternal Smoker	Birth Weight average
False	123.085
True	113.819

```
means = means_table.column(1)
observed_difference = means.item(1) - means.item(0)
observed_difference
```

```
-9.266142572024918
```

Difference between the Means

```
def difference_of_means(table, label, group_label):
    reduced = table.select(label, group_label)
    means_table = reduced.group(group_label, np.average)
    means = means_table.column(1)
    return means.item(1) - means.item(0)

difference_of_means(births, 'Birth Weight', 'Maternal Smoker')
```

```
-9.266142572024918
```

Random Permutations

```
shuffled_labels = smoking_and_birthweight.sample\
    (with_replacement = False).column(0)
original_and_shuffled = smoking_and_birthweight.with_column\
    ('Shuffled Label', shuffled_labels)
```

Maternal Smoker	Birth Weight	Shuffled Label
False	120	True
False	113	True
True	128	True

Predicting the Statistic Under the H_0

```
shuffled_only = original_and_shuffled.drop('Maternal Smoker')
shuffled_group_means = shuffled_only.group('Shuffled Label',
                                           np.average)
```

Shuffled Label	Birth Weight average
False	119.352
True	119.634

```
difference_of_means(original_and_shuffled, 'Birth Weight',
                                           'Shuffled Label')
```

```
0.2815393756570188
```

```
difference_of_means(original_and_shuffled, 'Birth Weight',
                                           'Maternal Smoker')
```

```
-9.266142572024918
```

Simulation

```
def one_simulated_difference(table, label, group_label):
    shuffled_labels = table.sample(with_replacement = False
                                   ).column(group_label)
    shuffled_table = table.select(label).with_column(
        'Shuffled Label', shuffled_labels)
    return difference_of_means(shuffled_table,
                               label, 'Shuffled Label')
```

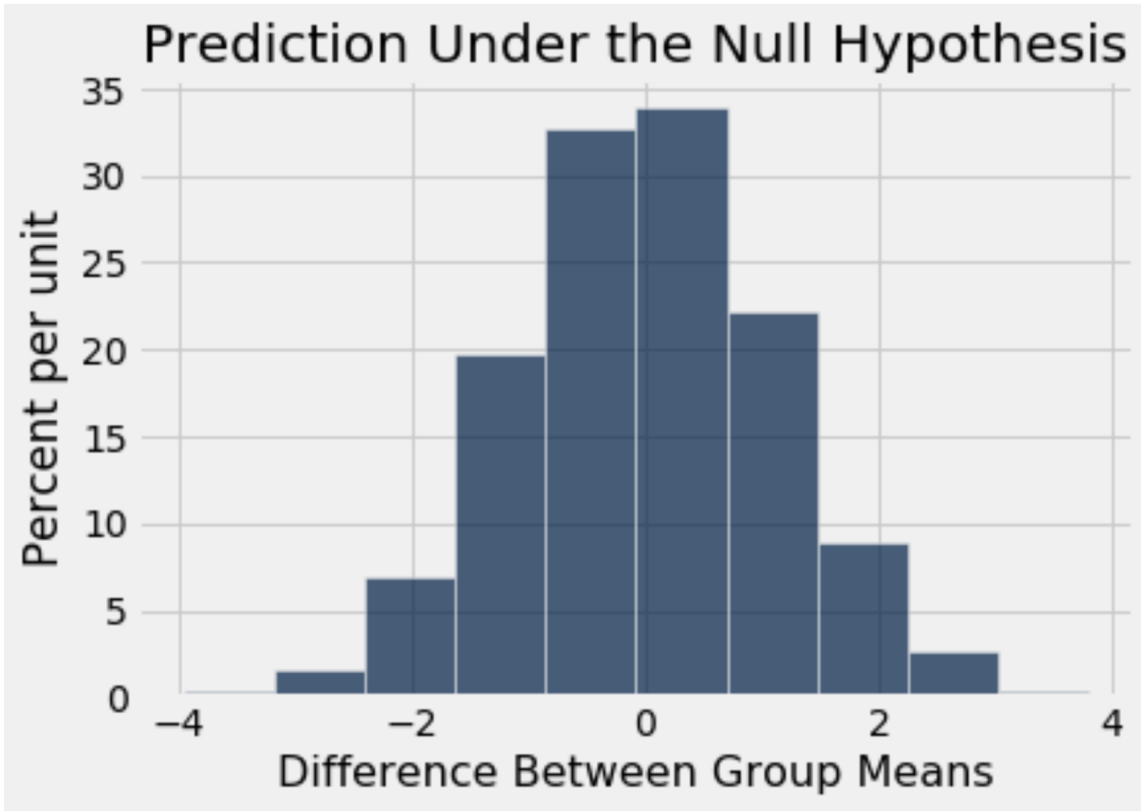
```
one_simulated_difference(births, 'Birth Weight', 'Maternal Smoker')
```

```
0.13129484894190568
```

```
differences = make_array()
repetitions = 5000
for i in np.arange(repetitions):
    new_difference = one_simulated_difference(births, 'Birth Weight',
                                              'Maternal Smoker')
    differences = np.append(differences, new_difference)
```

```
Table().with_column('Difference Between Group Means', differences).hist()
print('Observed Difference:', observed_difference)
plots.title('Prediction Under the Null Hypothesis');
```

```
Observed Difference: -9.266142572024918
```

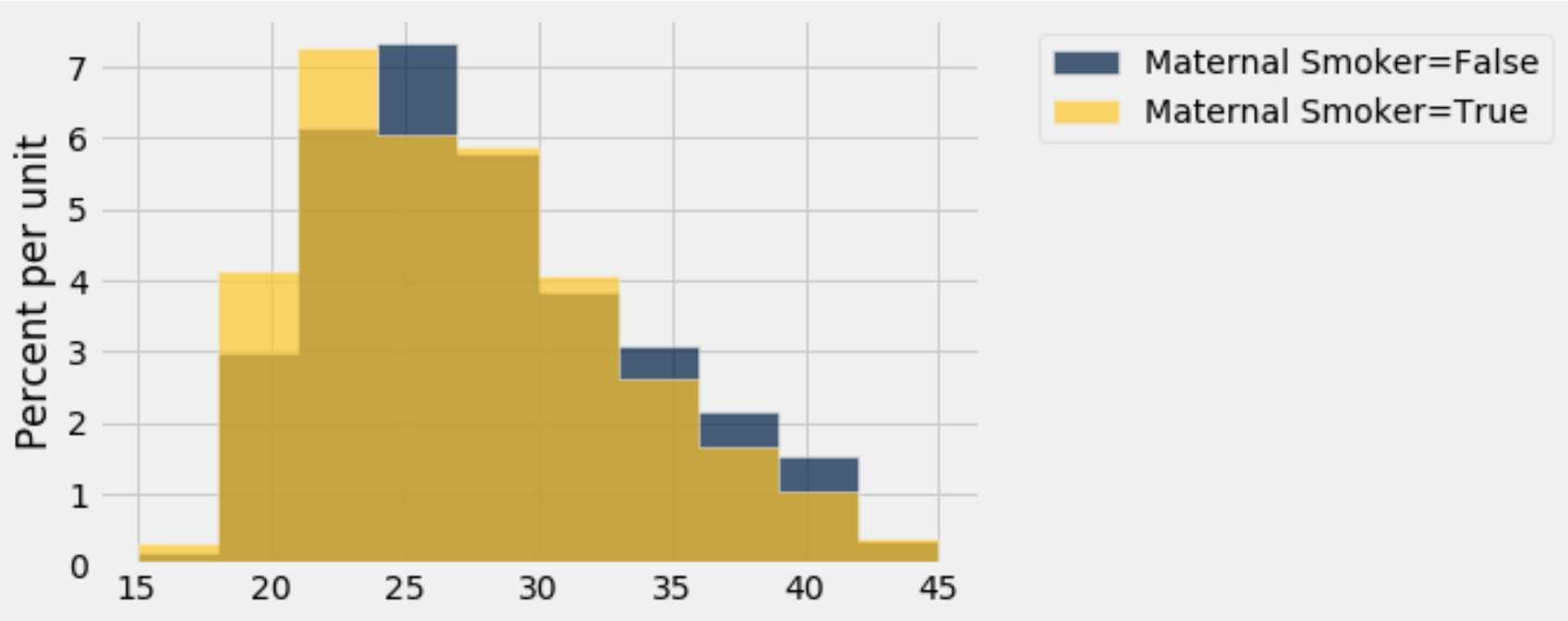



```
empirical_P = np.count_nonzero\
  (differences <= observed_difference) / repetitions
```

```
0.0
```

Another Permutation Test

```
smoking_and_age = births.select('Maternal Smoker', 'Maternal Age')
smoking_and_age.hist('Maternal Age', group = 'Maternal Smoker')
```



Simulating 5,000 Values of the Statistic

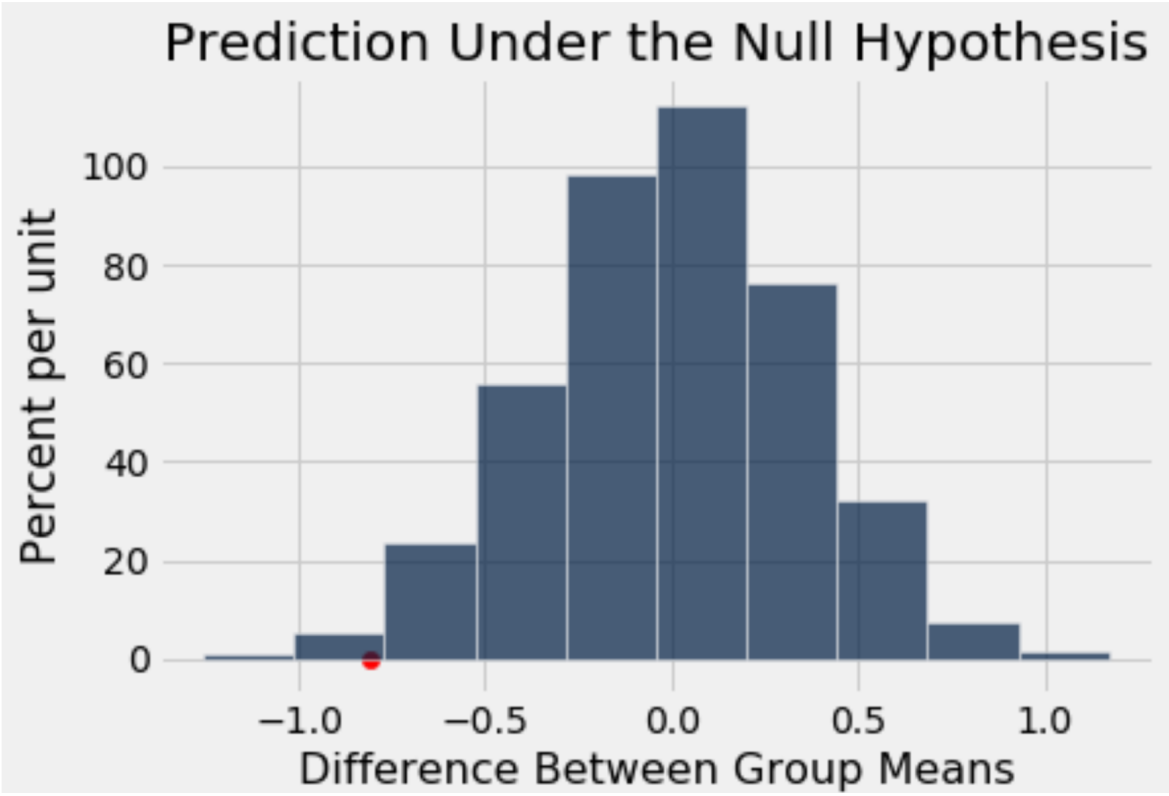
```
observed_age_difference = difference_of_means(births,
                    'Maternal Age', 'Maternal Smoker')
```

```
-0.8076725017901509
```

```
age_differences = make_array()
repetitions = 5000
for i in np.arange(repetitions):
    new_difference = one_simulated_difference(births, 'Maternal Age',
                                              'Maternal Smoker')
    age_differences = np.append(age_differences, new_difference)
```

```
Table().with_column('Difference Between Group Means', age_differences).hist(
plots.scatter(observed_age_difference, 0, color='red', s=40)
plots.title('Prediction Under the Null Hypothesis')
print('Observed Difference:', observed_age_difference)
```

```
Observed Difference: -0.8076725017901509
```




```
empirical_P = np.count_nonzero\
(age_differences <= observed_age_difference) / 5000 0.0108
```