

11.2) Causality

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Tables, Graphics, and Figures from

**Computational and Inferential Thinking:
The Foundations of Data Science**

Adhikari & DeNero (2019): Ch 12.3 Causality

<https://www.inferentialthinking.com/>

Treating Chronic Back Pain

Foster, Clapp, and Jabbari (2001)

Randomized Controlled Trial (RCT)

Effect of Botulinum Toxin A

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

Group	Result	Treatment	
Control	1	Treatment	1
Control	1	Treatment	0
Control	0	Treatment	0

Proportion of Patients who had Pain Relief

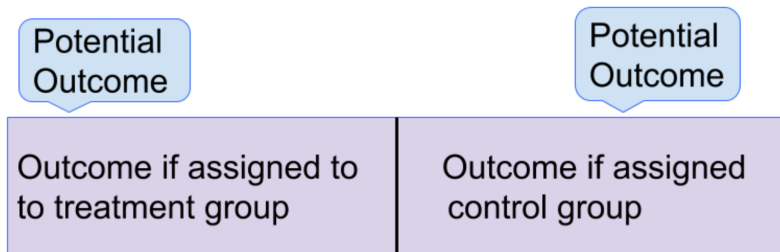
$$H_0 : p_t = p_c \text{ vs } H_A : p_t \neq p_c$$

```
import numpy as np  
bta.group('Group', np.average)
```

Group	Result average
Control	0.125
Treatment	0.6

Before Randomization

Imaginary ticket for each of the 31 participants



Potential Outcomes

16 randomly picked tickets show:

	Outcome if assigned to control group
--	--------------------------------------

The remaining 15 tickets show:

Outcome if assigned to treatment group	
--	--

```
observed_outcomes = Table.read_table(path_data + "observed_outcomes.csv")
observed_outcomes.show()
```

Group	Outcome if assigned treatment	Outcome if assigned control
Control	Unknown	1
Control	Unknown	1
Control	Unknown	0

Test Statistic

$$|0.6 - 0.125| = 0.475$$

```
observed_proportions = bta.group('Group', np.average).column(1)
observed_distance = abs(observed_proportions.item(0) \
                        - observed_proportions.item(1))
```

0.475

```
def distance(table, label, group_label):
    reduced = table.select(label, group_label)
    proportions = reduced.group(group_label, np.average).column(1)
    return abs(proportions.item(1) - proportions.item(0))
```

```
distance(bta, 'Result', 'Group')
```

0.475

Shuffle Labels

```
shuffled_labels = bta.sample(with_replacement=False).column(0)
bta_with_shuffled_labels = bta.with_column('Shuffled Label',
                                           shuffled_labels)
```

Group	Result	Shuffled Label
Control	1	Control
Control	1	Control
Control	0	Treatment

```
distance(bta_with_shuffled_labels, 'Result', 'Shuffled Label')
```

0.21666666666666667

```
distance(bta_with_shuffled_labels, 'Result', 'Group') 0.475
```


Permutation Test

```
def one_simulated_distance(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 distance(shuffled_table, label, 'Shuffled Label')

distances = make_array()
repetitions = 20000
for i in np.arange(repetitions):
    new_distance = one_simulated_distance(bta, 'Result', 'Group')
    distances = np.append(distances, new_distance)

empirical_P = np.count_nonzero(distances >= observed_distance) / repetitions
```

0.0085

```

Table().with_column('Distance', distances).hist(bins = np.arange(0, 0.7, 0.1))
plots.scatter(observed_distance, 0, color='red', s=40)
plots.title('Prediction Under the Null Hypothesis')
print('Observed Distance', observed_distance)
print('Empirical P-value:', round(empirical_P, 4) *100, '%')

```

Observed Distance 0.475

Empirical P-value: 0.8500000000000001 %

