9) Sampling and Empirical Distributions

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Reference

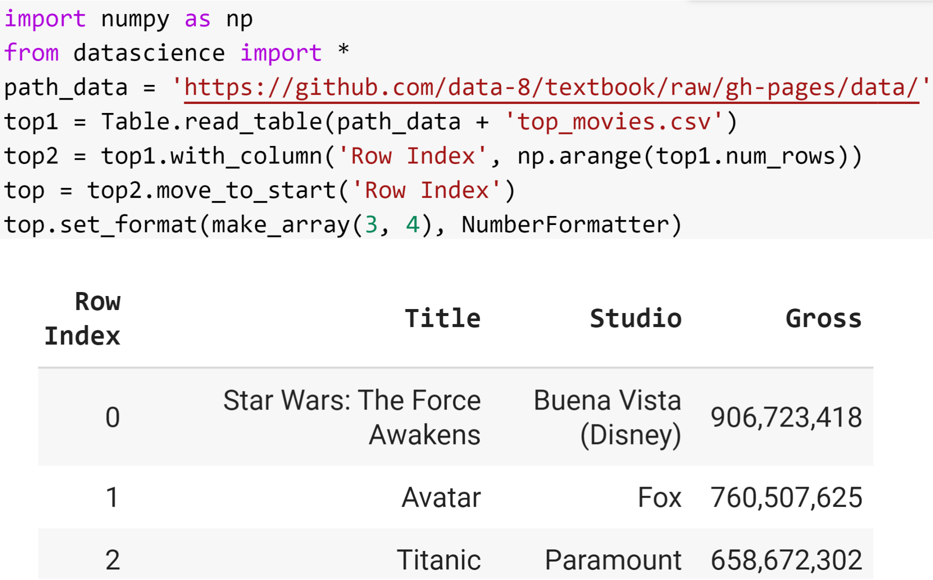
Tables, Graphics, and Figures from

Computational and Inferential Thinking: The Foundations of Data Science

Adhikari & DeNero (2019): Ch 10 Sampling and Empirical Distributions

https://www.inferentialthinking.com/

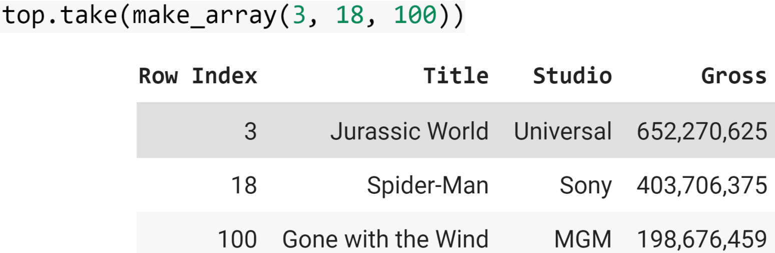
Top Movies Dataset



```
import numpy as np
from datascience import *
path_data = 'https://github.com/data-8/textbook/raw/gh-pages/data/'
top1 = Table.read_table(path_data + 'top_movies.csv')
top2 = top1.with_column('Row Index', np.arange(top1.num_rows))
top = top2.move_to_start('Row Index')
top.set_format(make_array(3, 4), NumberFormatter)
```

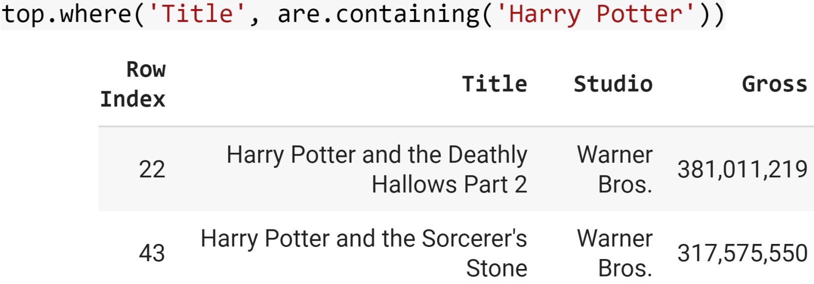
Row Index	Title	Studio	Gross
0	Star Wars: The Force Awakens	Buena Vista (Disney)	906,723,418
1	Avatar	Fox	760,507,625
2	Titanic	Paramount	658,672,302

Deterministic Samples



```
top.take(make_array(3, 18, 100))
```

Row Index	Title	Studio	Gross
3	Jurassic World	Universal	652,270,625
18	Spider-Man	Sony	403,706,375
100	Gone with the Wind	MGM	198,676,459

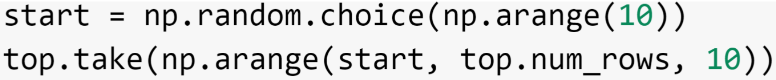


```
top.where('Title', are.containing('Harry Potter'))
```

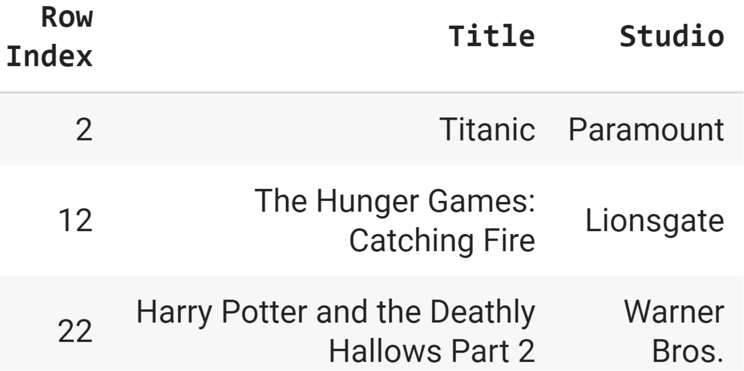
Row Index	Title	Studio	Gross
22	Harry Potter and the Deathly Hallows Part 2	Warner Bros.	381,011,219
43	Harry Potter and the Sorcerer's Stone	Warner Bros.	317,575,550

Systematic Sample

Random start among rows 0 through 9

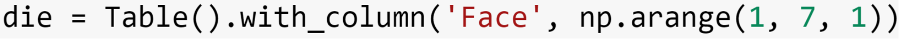


```
start = np.random.choice(np.arange(10))
top.take(np.arange(start, top.num_rows, 10))
```

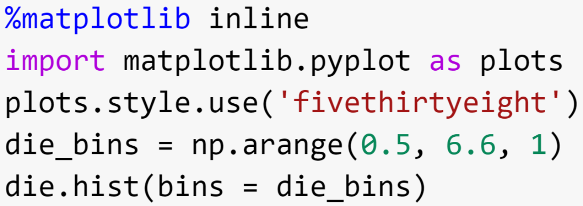


Row Index	Title	Studio
2	Titanic	Paramount
12	The Hunger Games: Catching Fire	Lionsgate
22	Harry Potter and the Deathly Hallows Part 2	Warner Bros.

Probability Distribution

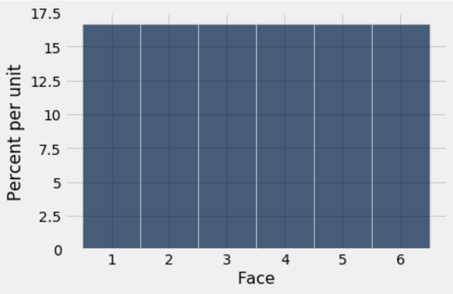


```python
die = Table().with_column('Face', np.arange(1, 7, 1))
```



```python
%matplotlib inline
import matplotlib.pyplot as plots
plots.style.use('fivethirtyeight')
die_bins = np.arange(0.5, 6.6, 1)
die.hist(bins = die_bins)
```

$(\frac{1}{6} \cong 0.17)$

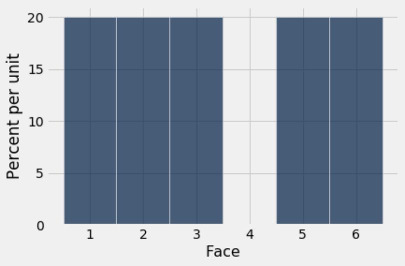


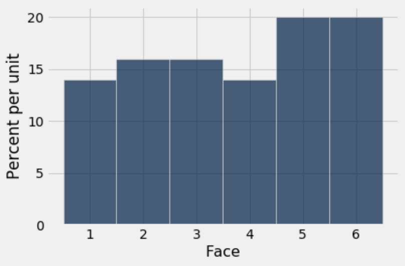
Empirical Distributions

```
def empirical_hist_die(n):
    die.sample(n).hist(bins = die_bins)
```

```
empirical_hist_die(10)
```

```
empirical_hist_die(100)
```

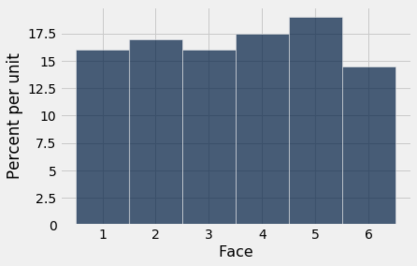




The Law of Averages

In the long run, the empirical probabilty gets closer and closer to the theoretical probability of the event

```
empirical_hist_die(1000)
```

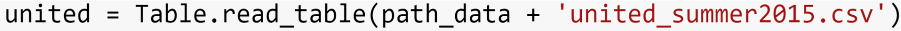


$(\frac{1}{6} \cong 0.17)$

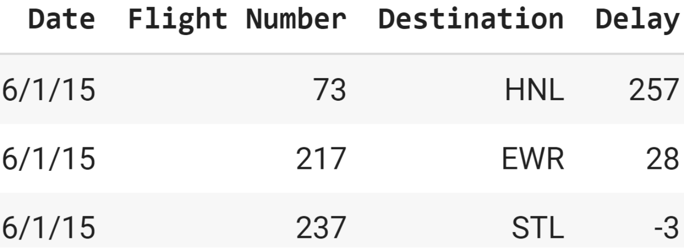
Independently and under identical conditions: every repetition is performed in the same way regardless of the results of all the other repetitions

Bureau of Transportation Statistics in US

United Airlines domestic flights departing from San Francisco in Summer of 2015



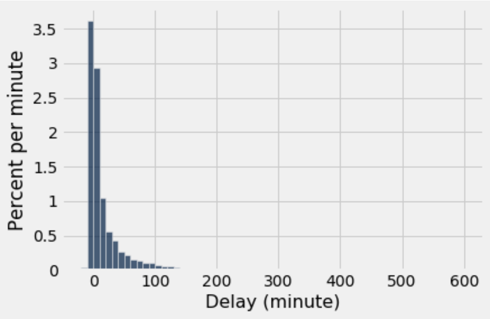
```
united = Table.read_table(path_data + 'united_summer2015.csv')
```



Date	Flight Number	Destination	Delay
6/1/15	73	HNL	257
6/1/15	217	EWR	28
6/1/15	237	STL	-3

Normal Distribution

```
delay_bins = np.append(np.arange(-20, 301, 10), 600)
united.hist('Delay', bins = delay_bins, unit = 'minute')
```

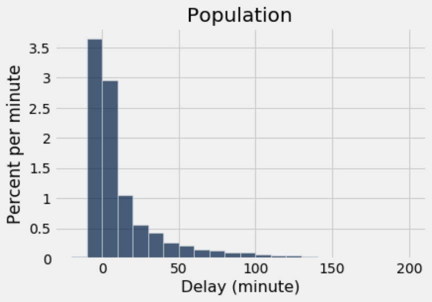


```
united.where('Delay', are.above(200)).num_rows/united.num_rows
```

```
0.008390596745027125
```

Ignore the 0.8% of flights

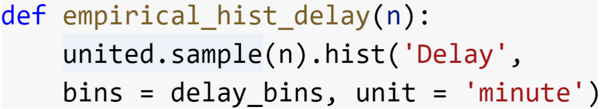
```python
delay_bins = np.arange(-20, 201, 10)
united.hist('Delay', bins = delay_bins, unit = 'minute')
plots.title('Population');
```



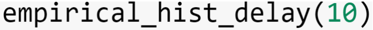
```python
united.where('Delay', are.between(0,
      10)).num_rows/united.num_rows
```

```
0.2935985533453888
```

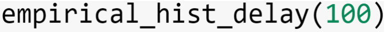
Random Sample converges to the Population



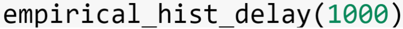
```
def empirical_hist_delay(n):
    united.sample(n).hist('Delay',
    bins = delay_bins, unit = 'minute')
```



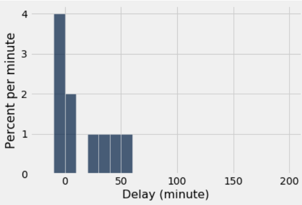
```
empirical_hist_delay(10)
```

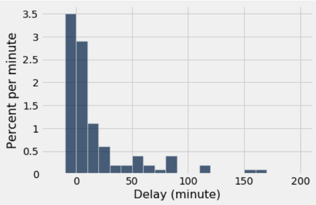


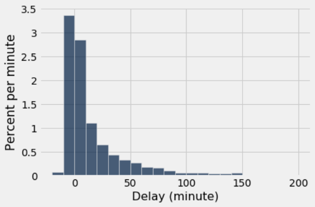
```
empirical_hist_delay(100)
```



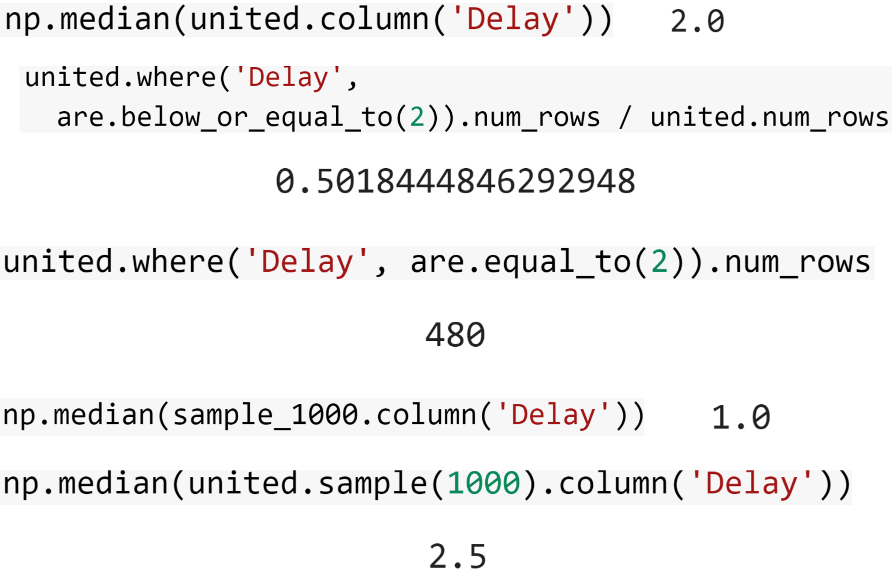
```
empirical_hist_delay(1000)
```







Parameter vs Statistic



```
np.median(united.column('Delay'))    2.0
```

```
united.where('Delay',
  are.below_or_equal_to(2)).num_rows / united.num_rows
```

```
0.5018444846292948
```

```
united.where('Delay', are.equal_to(2)).num_rows
```

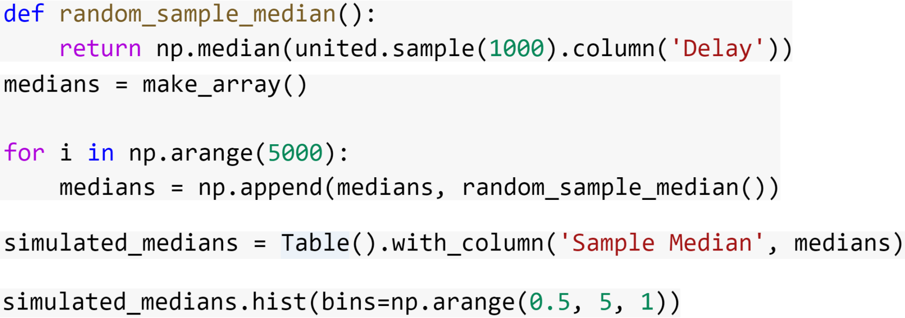
```
480
```

```
np.median(sample_1000.column('Delay'))    1.0
```

```
np.median(united.sample(1000).column('Delay'))
```

```
2.5
```

Simulating a Statistic 5,000



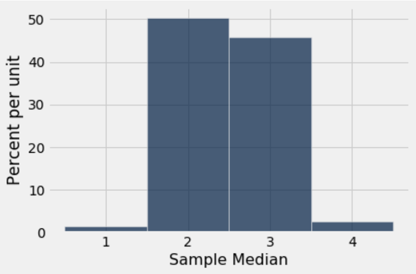
```
def random_sample_median():
    return np.median(united.sample(1000).column('Delay'))
```

```
medians = make_array()

for i in np.arange(5000):
    medians = np.append(medians, random_sample_median())
```

```
simulated_medians = Table().with_column('Sample Median', medians)
```

```
simulated_medians.hist(bins=np.arange(0.5, 5, 1))
```


Percent per unit
Sample Median