simulation

March 20, 2020

[2]:
```
import numpy as np
import pandas as pd
import os
from wechat_red_bag_simulation.sim_competition import RedBag
from matplotlib import pyplot as plt
%matplotlib inline
import matplotlib as mpl
mpl.rcParams['figure.dpi']= 120

import seaborn as sns
sns.set(style="whitegrid")

img_dir = 'images'
```

1 Algorithm for generating money

[3]:
```
def sim_trial(n_players: int, money: float, trial_i: int):
    """
    :return: [order, money, trial]
    """
    rb = RedBag(n_players, money)
    money = np.asarray([rb.get_money() for _ in range(n_players)]).
 ↪reshape(n_players, 1)
    trial = np.ones((n_players, 1), dtype=int) * trial_i
    order = np.arange(n_players, dtype=int).reshape(n_players, 1)
    return np.hstack([order, money, trial])


def sim_trials(n_trials=200, n_players=10, money=66.0):
    np.random.seed(1024)
    data = np.vstack([sim_trial(n_players, money, i) for i in range(n_trials)])
    data = pd.DataFrame(data, columns=['order', 'money', 'trial'])
    data = data.astype({'order': int, 'money': float, 'trial': int})
    return data

data = sim_trials()
```

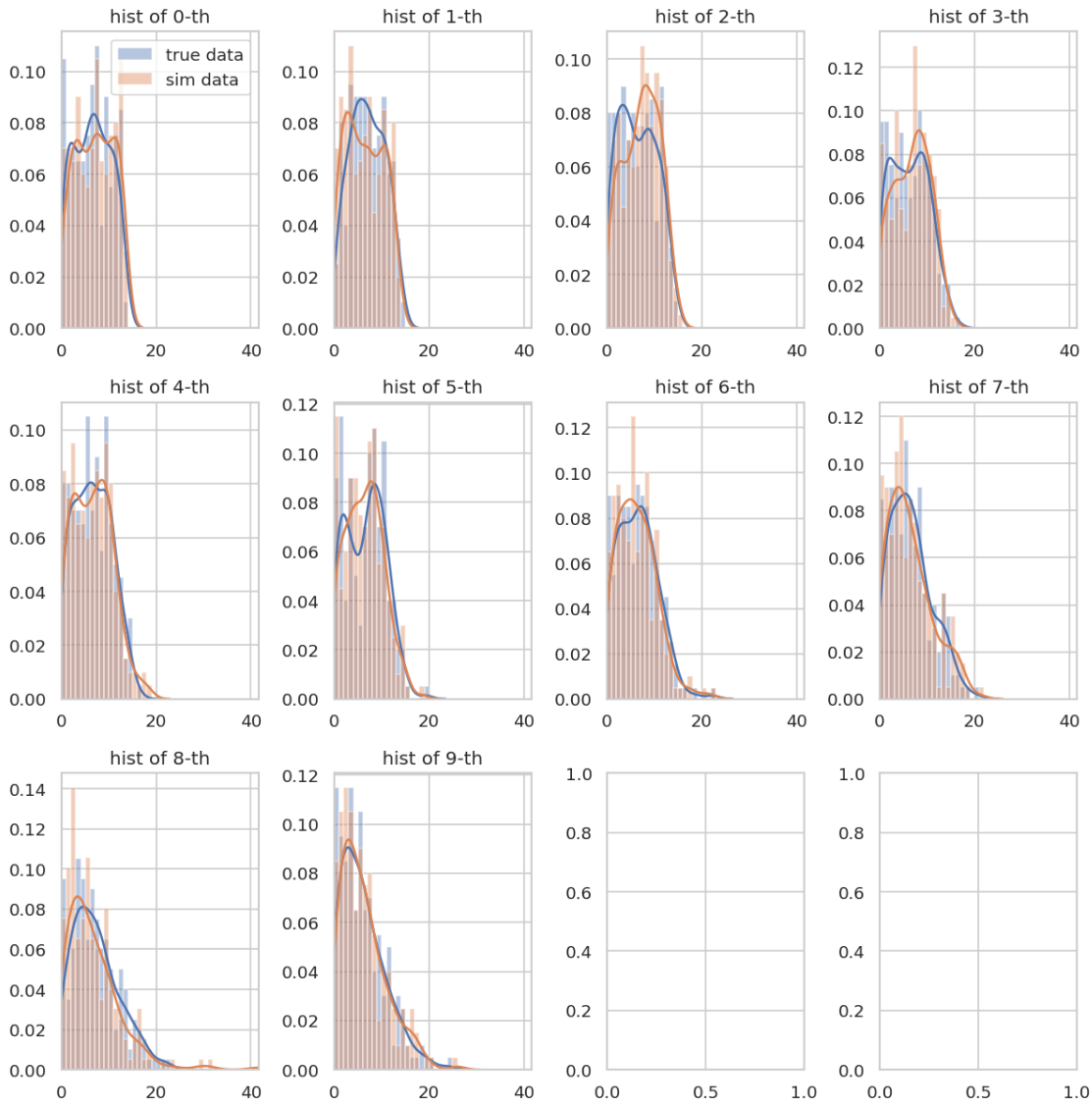
```
data
```

[3]:

	order	money	trial
0	0	8.54	0
1	1	12.72	0
2	2	5.80	0
3	3	7.32	0
4	4	6.31	0
...	...	...	...
1995	5	8.19	199
1996	6	3.84	199
1997	7	7.12	199
1998	8	9.17	199
1999	9	0.30	199

[2000 rows x 3 columns]

[4]:
```
def plot_hist_for_players(data1, data2, bin_size: float = 1.0):
    fig, axs = plt.subplots(3, 4)
    fig.set_size_inches(10.24, 10.24)
    axs = axs.flat
    xlim = max(np.max(data1.money), np.max(data2.money))
    bins = np.arange(0.0, xlim + 0.1, step=bin_size)
    for i in range(10):
        _data1 = data1[data1.order == i].money.values
        _data2 = data2[data2.order == i].money.values
        sns.distplot(_data1, bins=bins, label="true data", ax=axs[i])
        sns.distplot(_data2, bins=bins, label="sim data", ax=axs[i])
        axs[i].set_title('hist of {}-th'.format(i))
        axs[i].set_xlim([0, xlim])
    axs[0].legend()
    fig.tight_layout()
    plt.savefig(os.path.join(img_dir, "distribution-true-and-sim.png"))
    plt.show()

data_true = pd.read_csv('data_df.csv', index_col=0)
plot_hist_for_players(data_true, data)
```



H_0: Our algorithm of generating money create the same distribution as the one that the experiment data is sampled from.

So we reject H_0 if $p < 1\%$, where p is obtained by calculating Kolmogorov-Smirnov statistic on 2 samples data.

See `kstest.py`

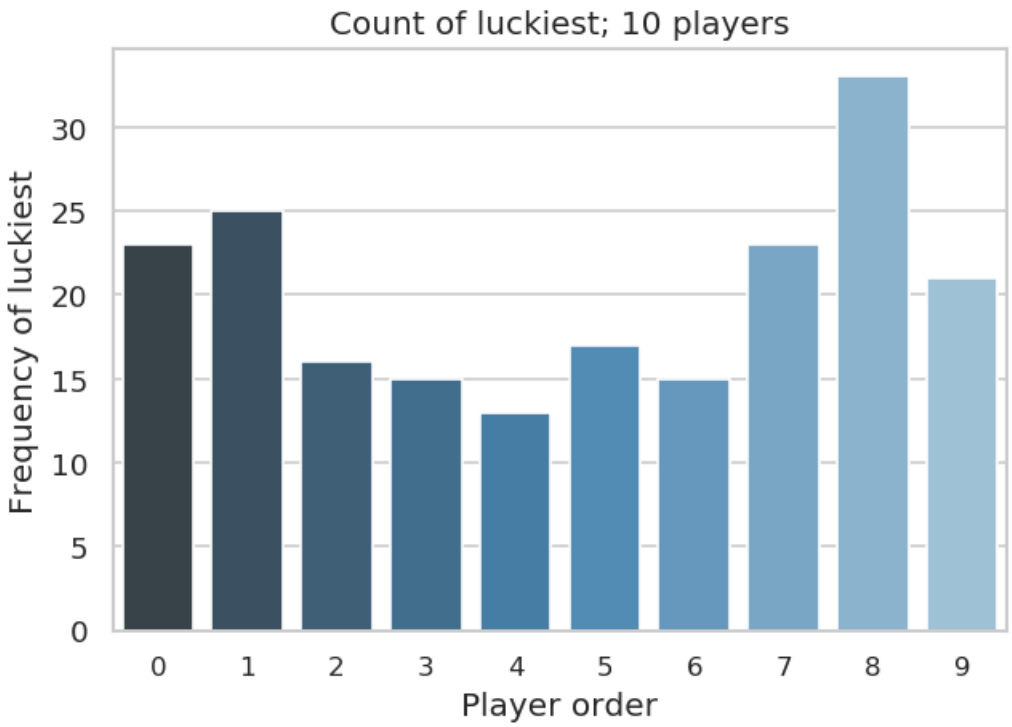
2 Luckiest & Unluckiest Players

[5]:
```
data_df = pd.read_csv('data_df.csv', index_col=0)
data_df.order = data_df.order.astype(int)
data_df.trial = data_df.trial.astype(int)
data_df.describe()
```

[5]:

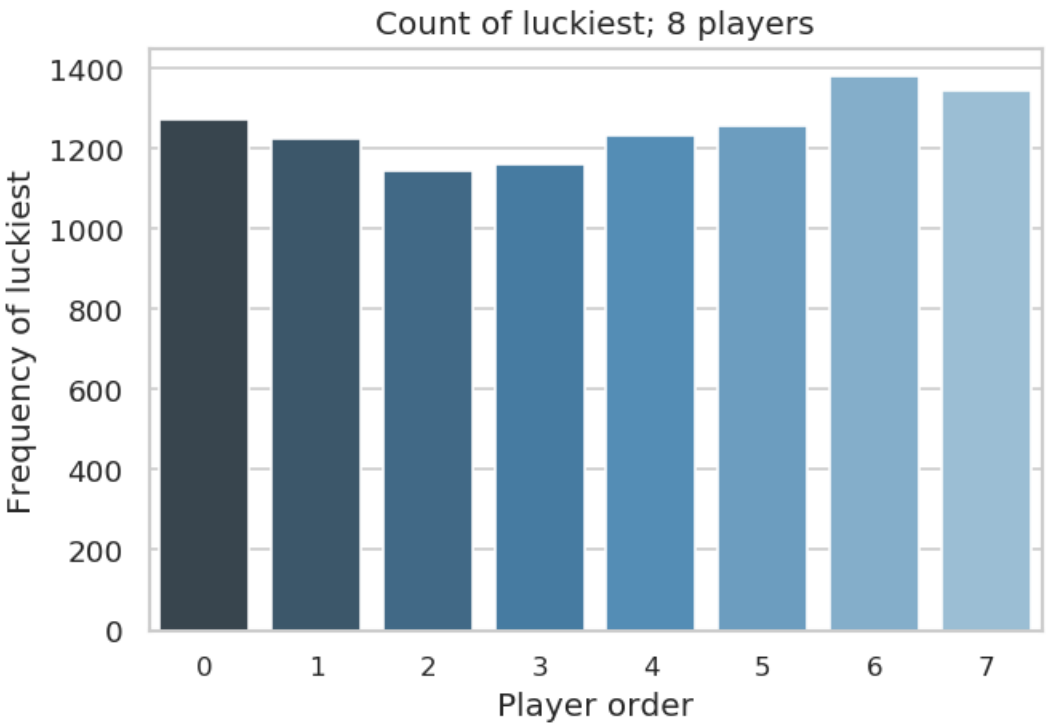
	order	money	trial
count	2000.000	2000.000000	2000.000000
mean	4.500	6.600000	99.500000
std	2.873	4.143568	57.748744
min	0.000	0.050000	0.000000
25%	2.000	3.210000	49.750000
50%	4.500	6.360000	99.500000
75%	7.000	9.550000	149.250000
max	9.000	24.100000	199.000000

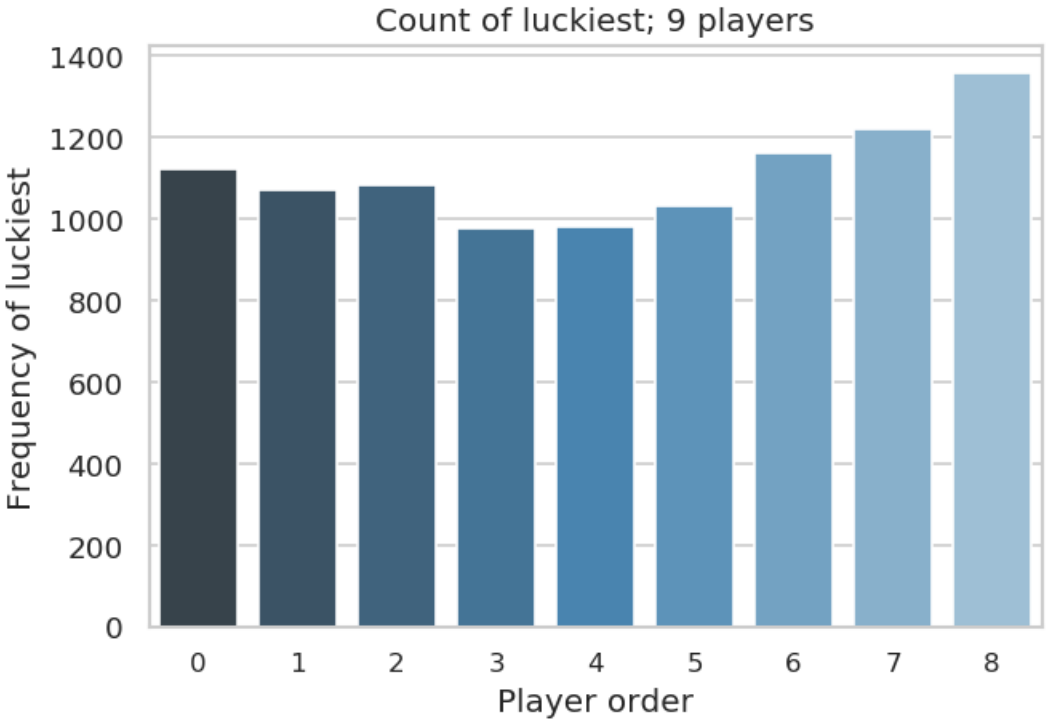
[9]:
```
def plot_lucky(d: pd.DataFrame, plot_prefix=''):
    n_p = len(d.order.unique())
    idx = d.groupby(['trial'])['money'].transform(max)
    idx = idx == d['money']
    lucky = d[idx]
    n_lucky = lucky.groupby(['order']).order.count()
    lucky = pd.DataFrame({'order': n_lucky.index, 'n_lucky': n_lucky.values})

    # display(lucky)
    ratio = lucky.n_lucky.iloc[-1] / lucky.n_lucky.iloc[0]

    fig, ax = plt.subplots()
    sns.barplot(x='order', y='n_lucky', data=lucky,
                label='Lucky', ax=ax, palette="Blues_d")
    ax.set_ylabel('Frequency of luckiest')
    ax.set_xlabel('Player order')
    ax.set_title('Count of luckiest; {} players'.format(n_p))
    # We change the fontsize of ticks label
    ax.tick_params(axis='x', which='major', labelsize=10)
    # ax.legend()
    plt.savefig(os.path.join(img_dir, plot_prefix + 'lucky-{}-players.png'.
 ↪format(n_p)))
    plt.show()
    return ratio

plot_lucky(data_df, 'true-data-')
```

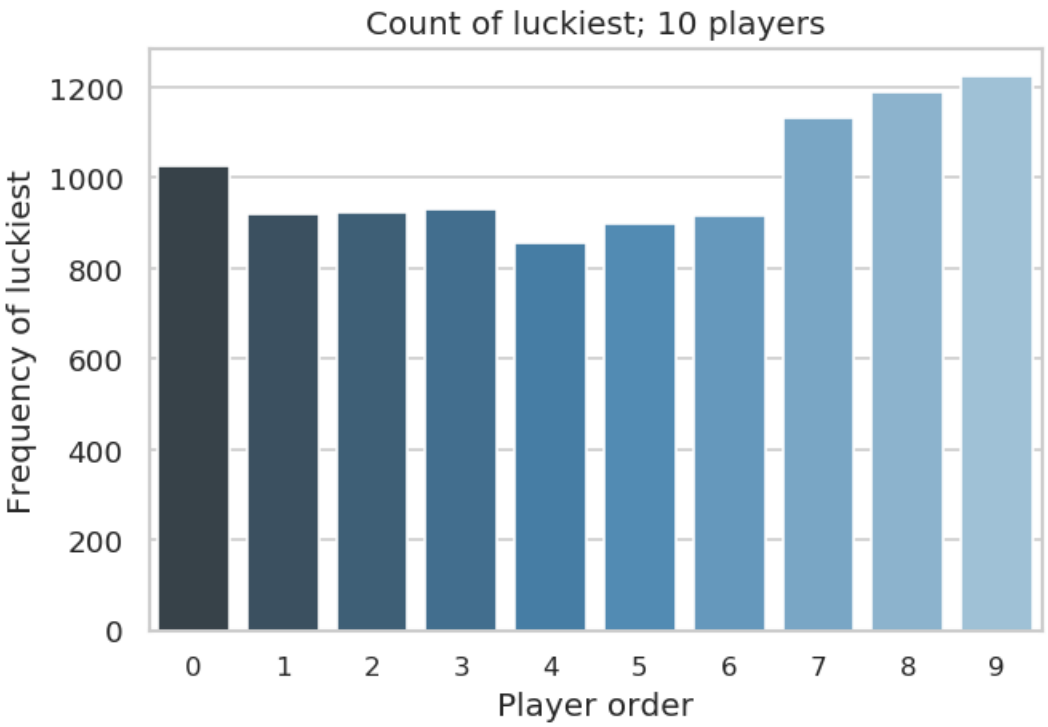


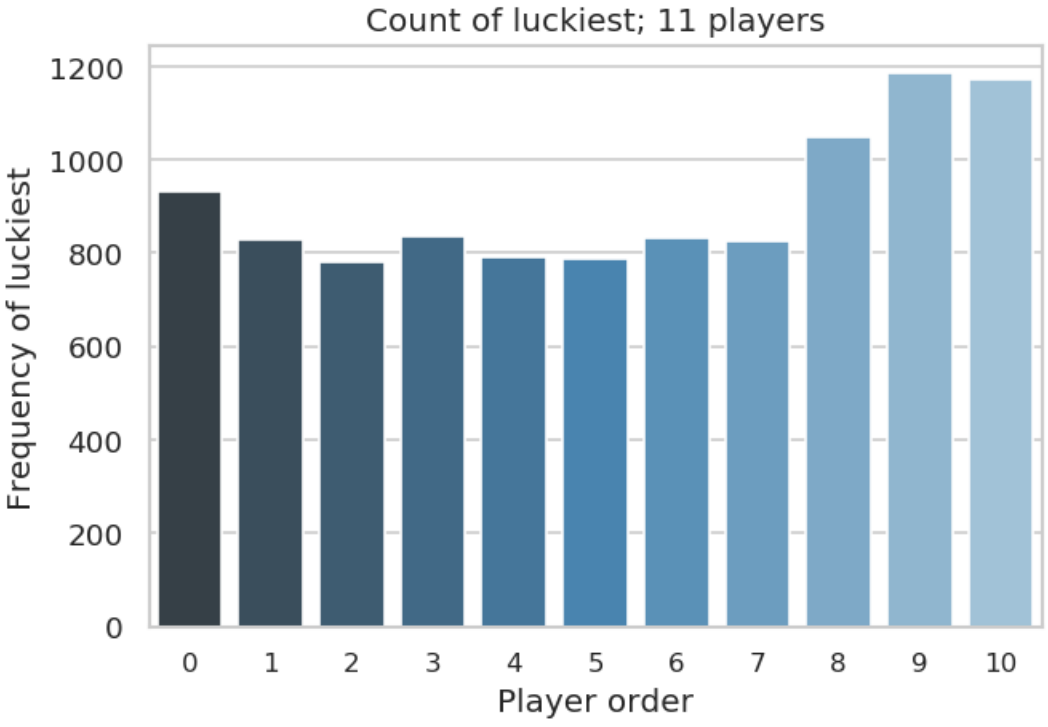
[9]:
```
0.9130434782608695
```

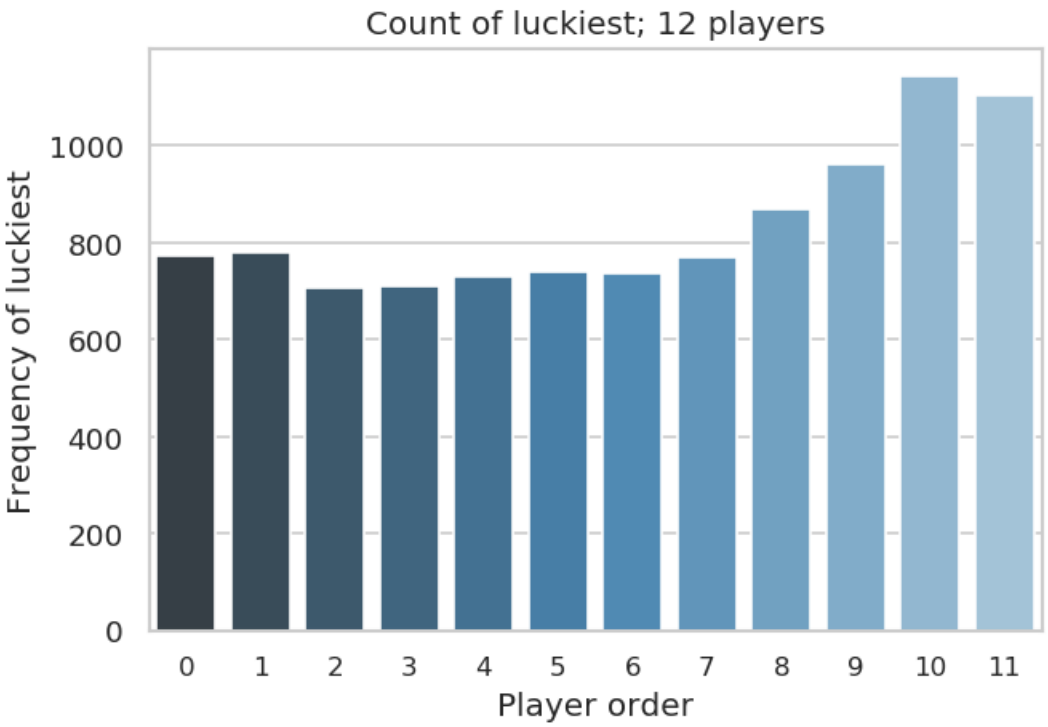
[10]:
```
n_trials = 10000
money = 66.0
ratios = []
for n_players in range(3, 25):
    data = sim_trials(n_trials, n_players, money)
    if n_players >= 8:
        ratios.append(plot_lucky(data))
print(ratios)
```

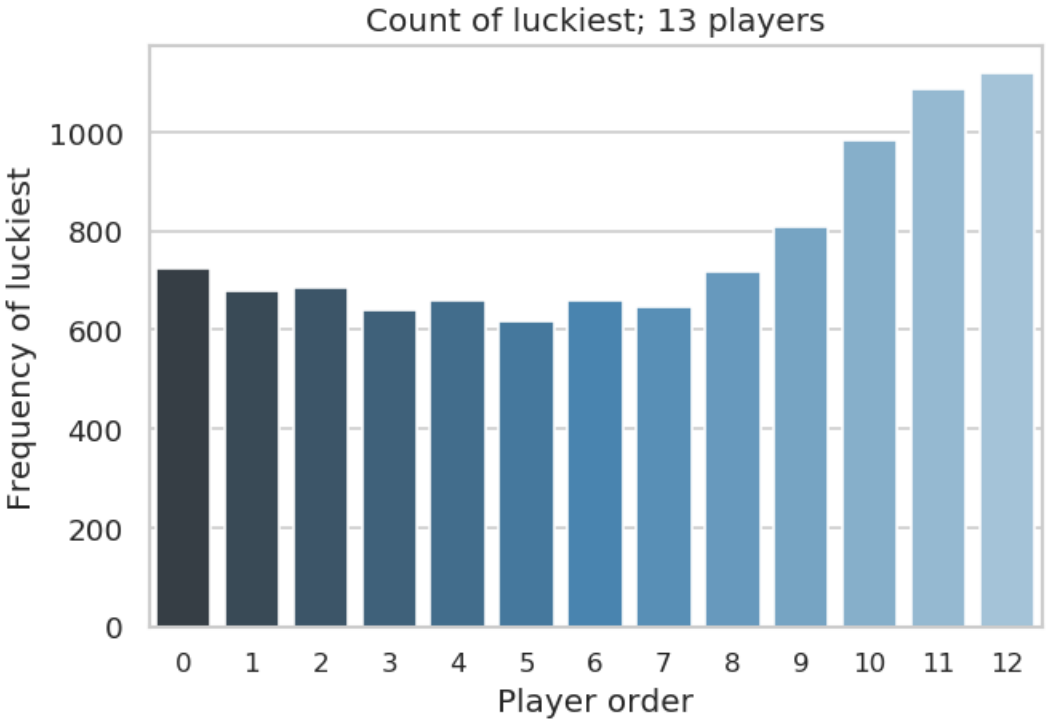

Count of luckiest; 8 players
Frequency of luckiest
1400
1200
1000
800
600
400
200
0
0
1
2
3
4
5
6
7
Player order

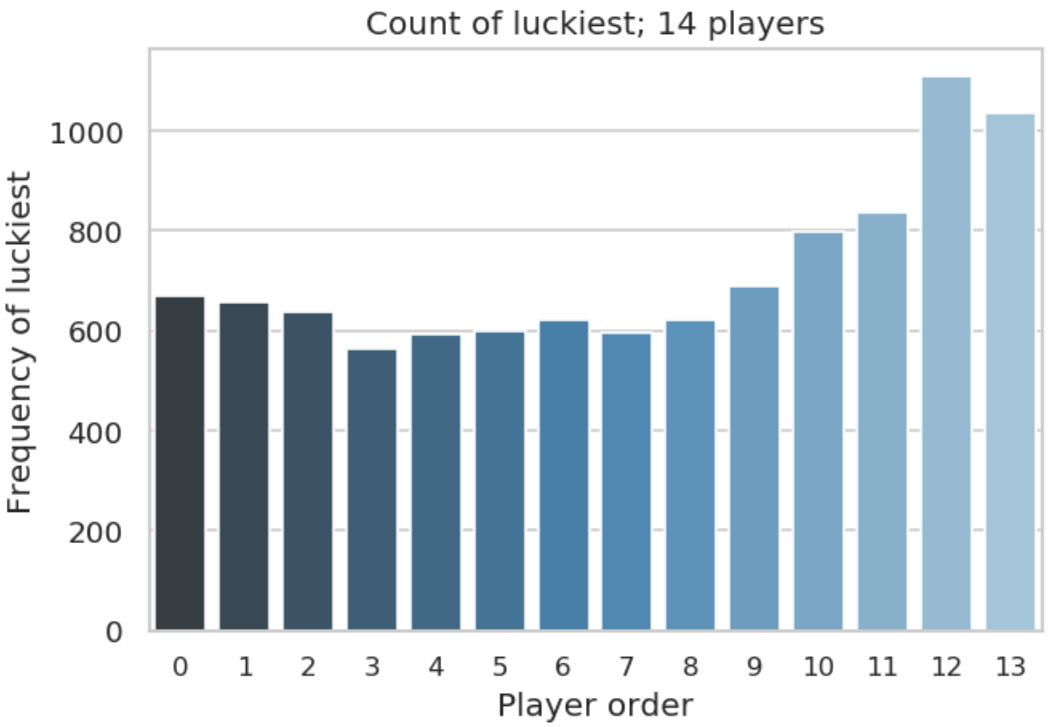

Count of luckiest; 9 players
Frequency of luckiest
1400
1200
1000
800
600
400
200
0
0
1
2
3
4
5
6
7
8
Player order

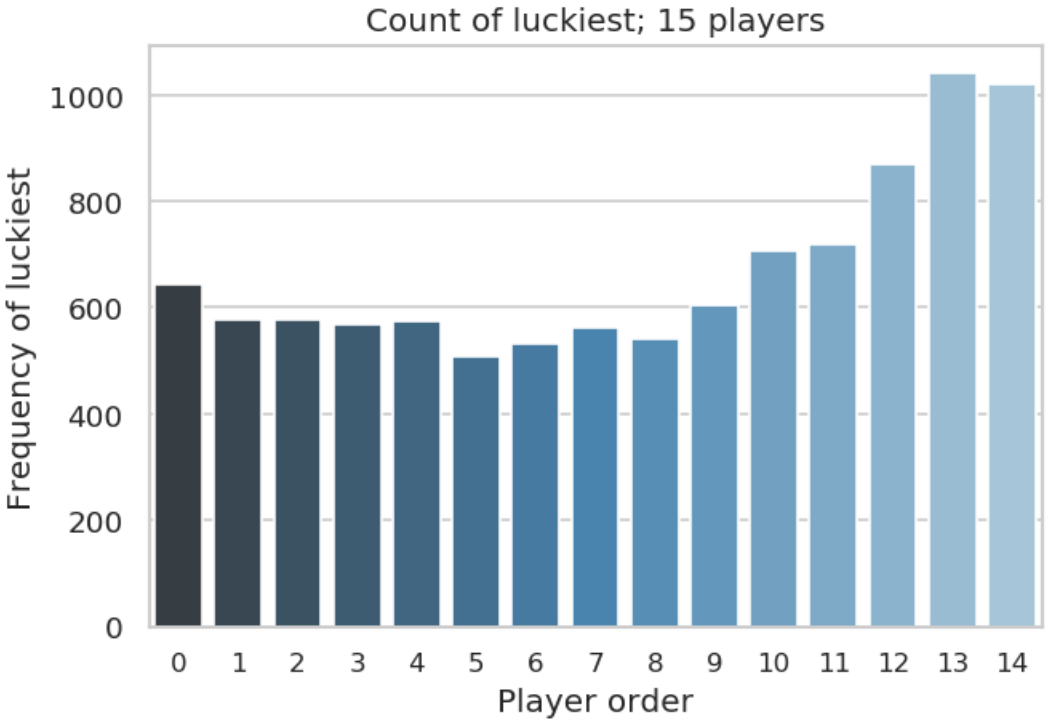

Count of luckiest; 10 players
Frequency of luckiest
0
200
400
600
800
1000
1200
0
1
2
3
4
5
6
7
8
9
Player order

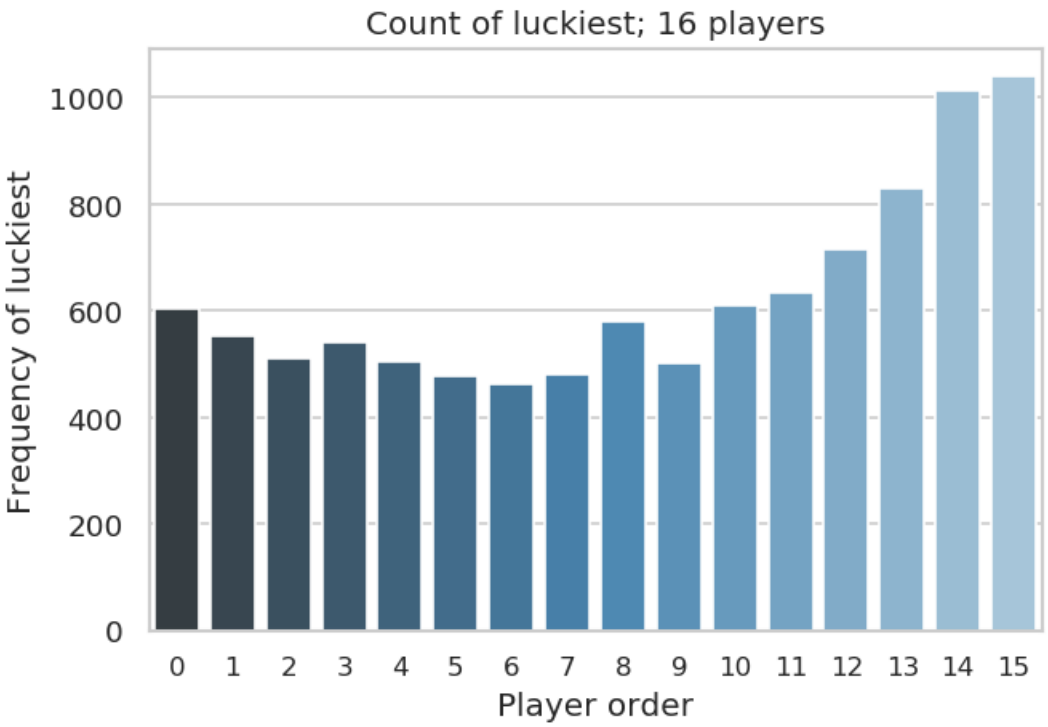

Count of luckiest; 11 players
Frequency of luckiest
0
200
400
600
800
1000
1200
0
1
2
3
4
5
6
7
8
9
10
Player order

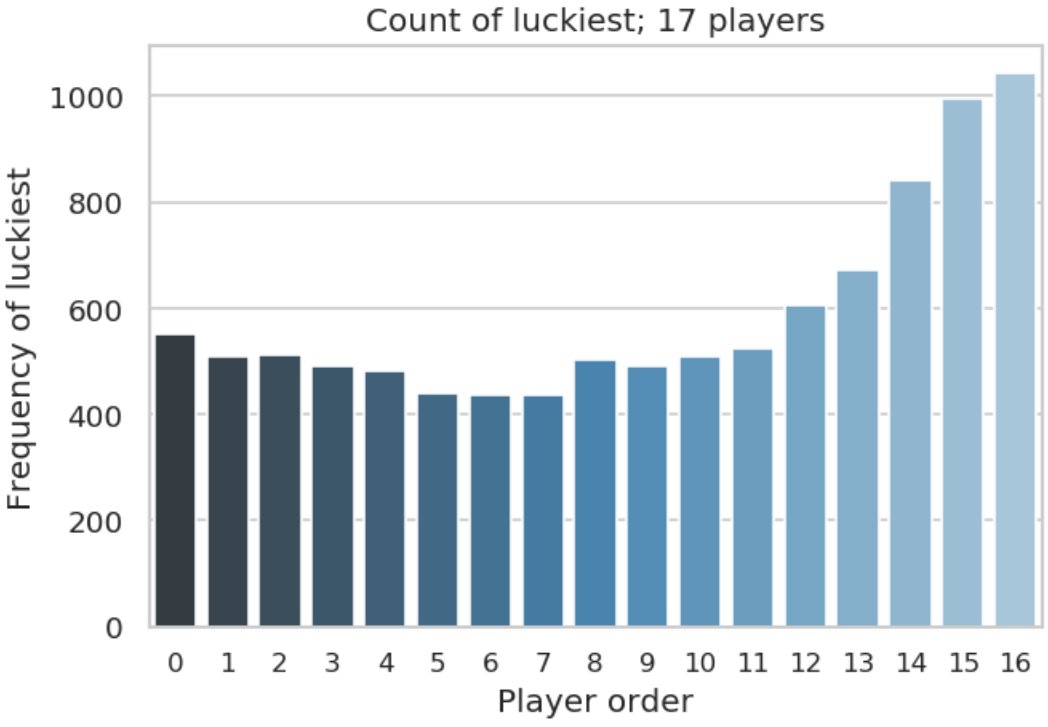

Count of luckiest; 12 players
Frequency of luckiest
0
200
400
600
800
1000
0 1 2 3 4 5 6 7 8 9 10 11
Player order

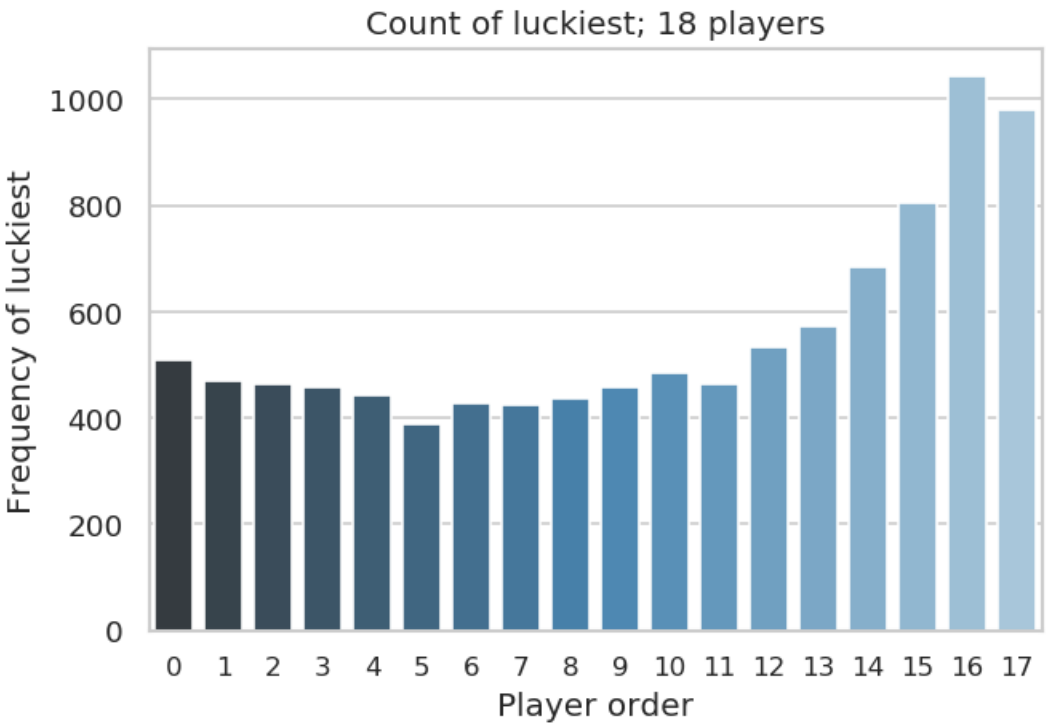

Count of luckiest; 13 players
Frequency of luckiest
0
200
400
600
800
1000
0 1 2 3 4 5 6 7 8 9 10 11 12
Player order

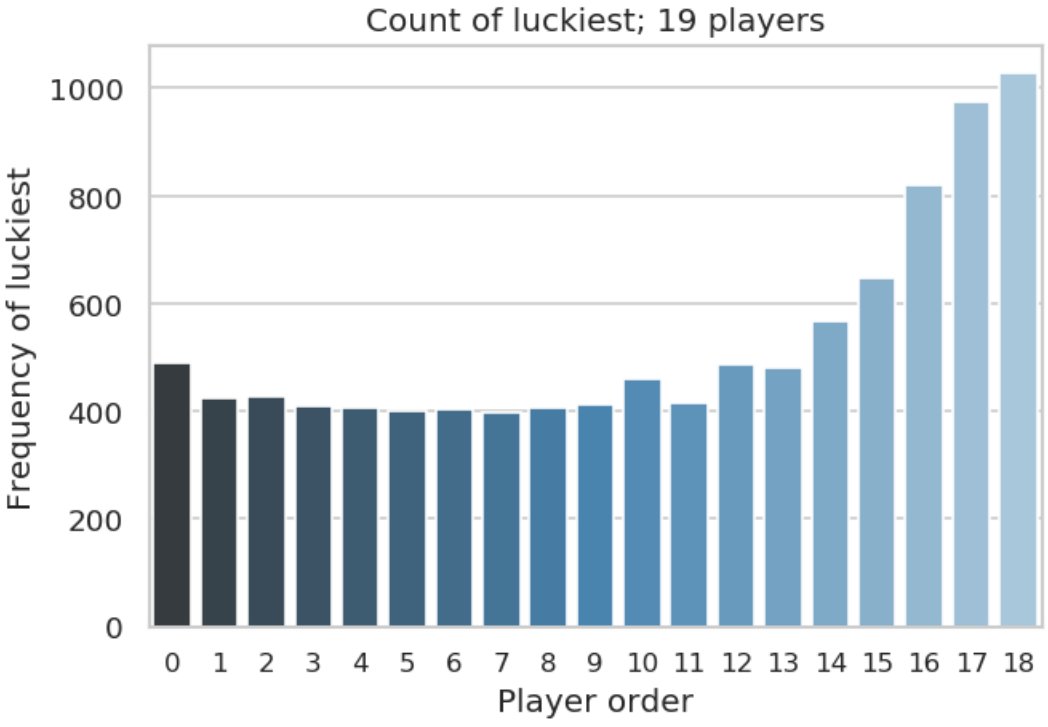

Count of luckiest; 14 players
Frequency of luckiest
0
200
400
600
800
1000
0 1 2 3 4 5 6 7 8 9 10 11 12 13
Player order

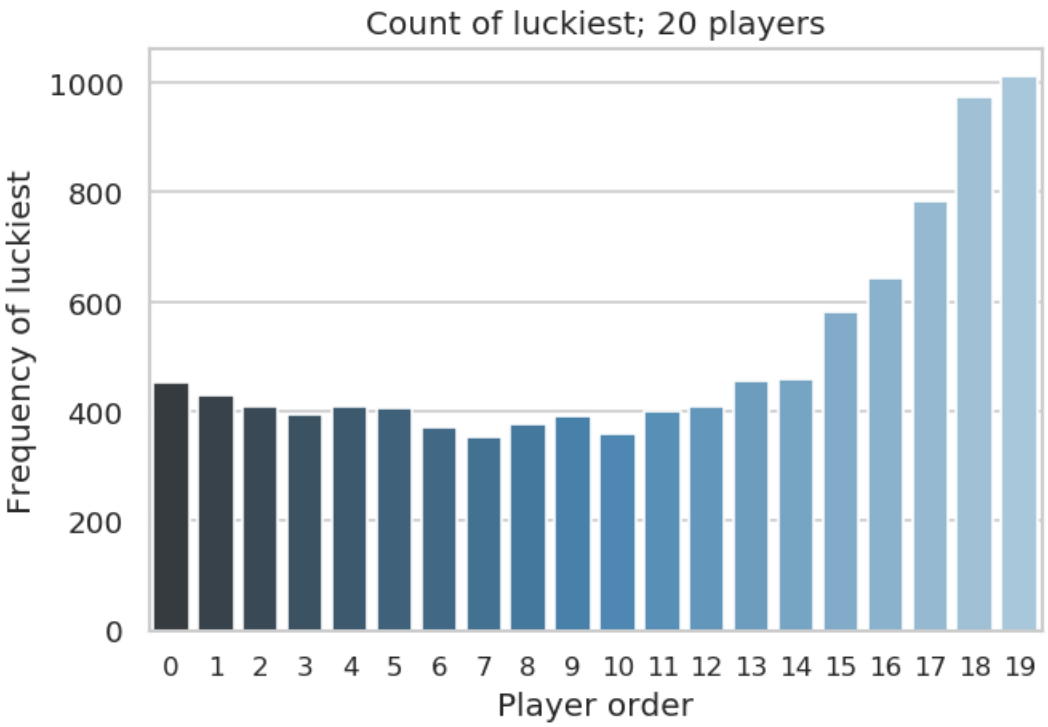

Count of luckiest; 15 players
Frequency of luckiest
0
200
400
600
800
1000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
Player order

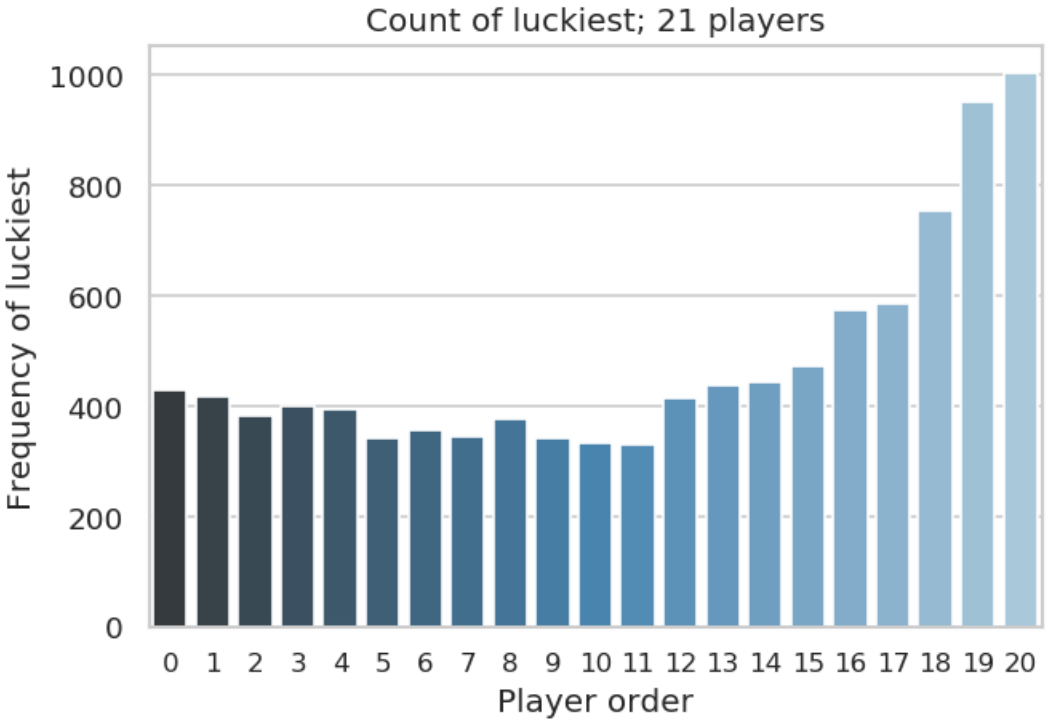

Count of luckiest; 16 players
Frequency of luckiest
0
200
400
600
800
1000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Player order

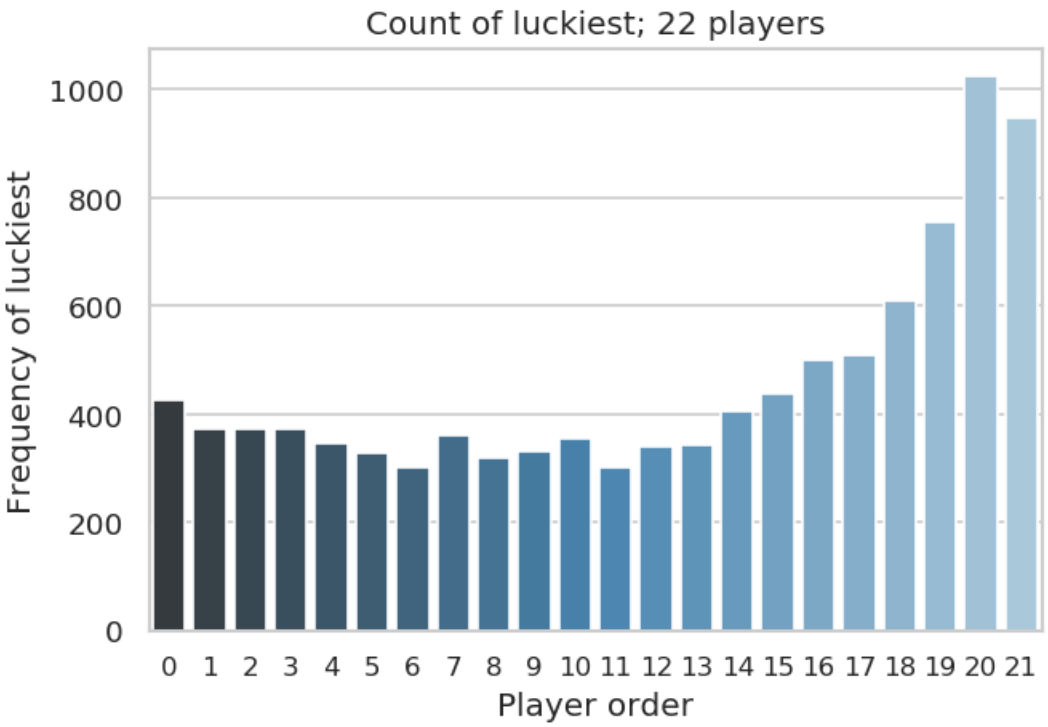

Count of luckiest; 17 players
Frequency of luckiest
0
200
400
600
800
1000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Player order

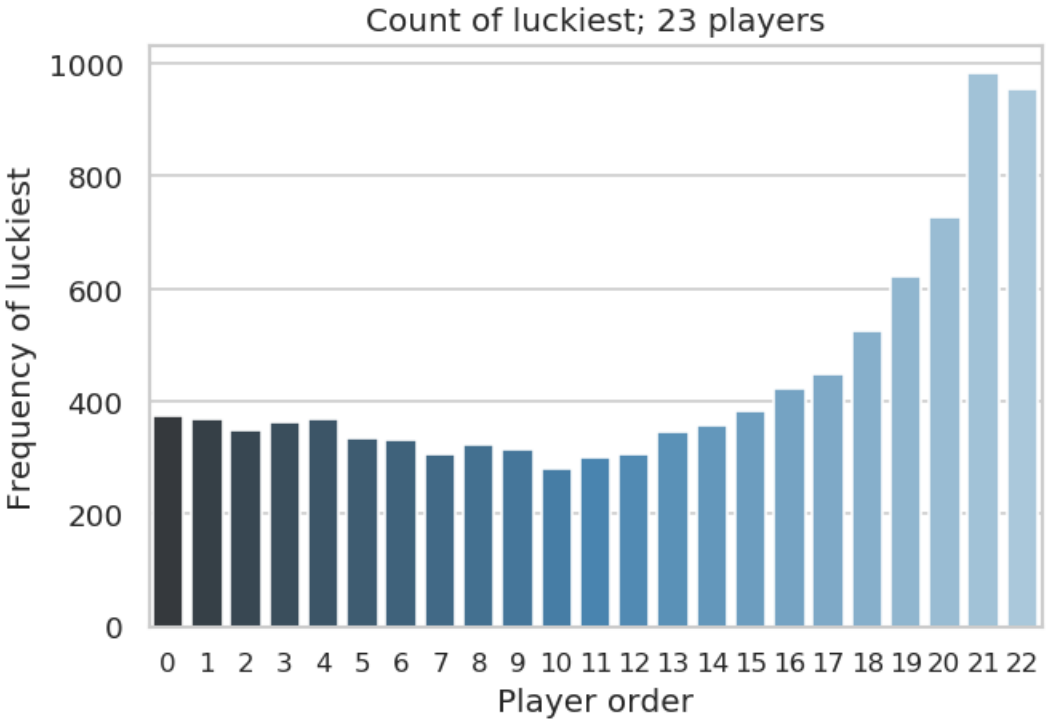

Count of luckiest; 18 players
Frequency of luckiest
0
200
400
600
800
1000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
Player order

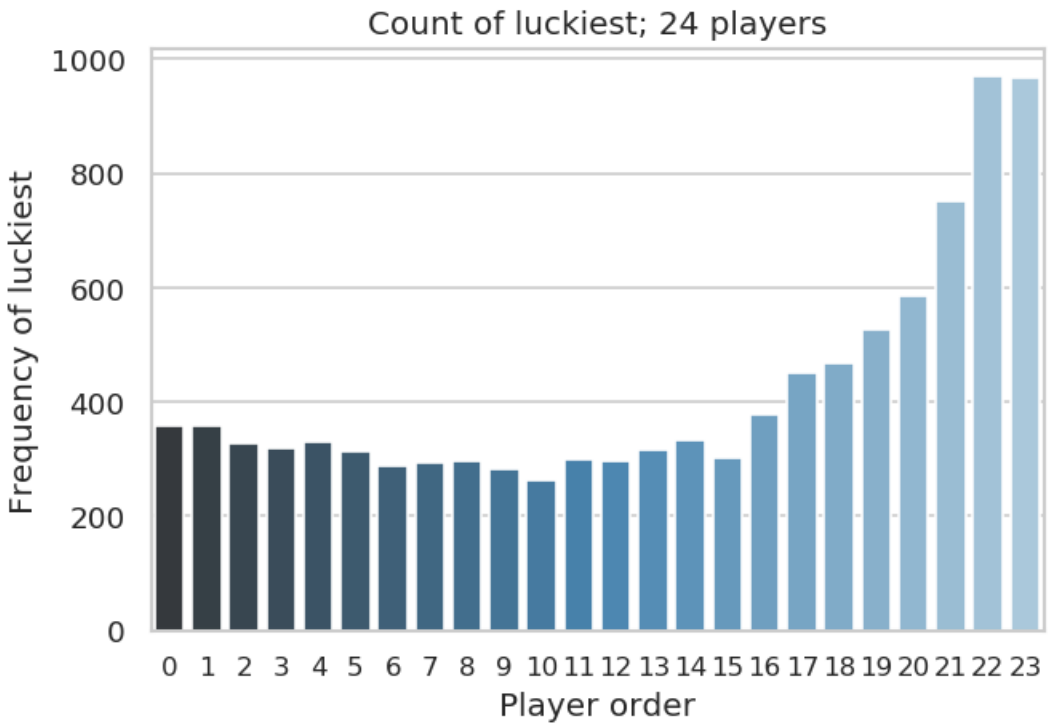

Count of luckiest; 19 players
Frequency of luckiest
0
200
400
600
800
1000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Player order


Count of luckiest; 20 players
Frequency of luckiest
1000
800
600
400
200
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Player order


Count of luckiest; 21 players
Frequency of luckiest
1000
800
600
400
200
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Player order


Count of luckiest; 22 players
Frequency of luckiest
0
200
400
600
800
1000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Player order


Count of luckiest; 23 players
Frequency of luckiest
0
200
400
600
800
1000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
Player order




```
[1.0566037735849056, 1.2083704363312555, 1.192007797270955, 1.261290322580645,
1.426356589147287, 1.5441988950276244, 1.5462686567164179, 1.587869362363919,
1.7201986754966887, 1.8945454545454545, 1.9233791748526523, 2.095918367346939,
2.2268722466960353, 2.3411214953271027, 2.2224824355971897, 2.546666666666667,
2.6963788300835656]
```