In [46]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import random
from numpy.random import seed
from scipy.stats import ttest_ind
from scipy.stats import t
```

In [47]:

```
#reading in users csv file - parsing dates to ensure they have a datetime format
users = pd.read_csv('/home/amybirdee/hobby_projects/click_d/users.csv', delimiter = ','
, parse_dates = ['PROFILE_REGISTERED'])
```

In [48]:

```
users.head()
```

Out[48]:

	UID	PROFILE_GENDER	PROFILE_REGISTERED	AGE
0	7904	M	2018-11-11 14:51:45	27
1	4456	M	2018-11-10 20:32:04	28
2	5801	M	2018-11-10 23:56:36	34
3	2724	M	2018-11-11 12:08:59	23
4	6532	M	2018-11-11 02:35:24	24

In [49]:

```
#reading in events data - parsing dates to ensure they have a datetime format
events = pd.read_csv('/home/amybirdee/hobby_projects/click_d/events.csv', delimiter =
',', parse_dates = ['ACTION_TS'])
```

In [50]:

```
events.head()
```

Out[50]:

	ACTIVE_UID	ACTION_TS	DEV_NAME	EVENT
0	138	2018-11-11 17:56:27	device_type_1	action_2
1	138	2018-11-11 17:56:28	device_type_1	action_1
2	138	2018-11-11 18:13:03	device_type_1	action_1
3	138	2018-11-11 18:18:36	device_type_1	action_2
4	138	2018-11-11 18:19:39	device_type_1	action_2

Cohort analysis

In [51]:

```
#dropping gender, age and ab_group columns as not needed in analysis
users_cohort = users.drop(['PROFILE_GENDER', 'AGE'], axis = 1)
```

In [52]:

```
#changing column names in users table
users_cohort = users_cohort.rename(columns = {'UID': 'user_id', 'PROFILE_REGISTERED': 'registration_date'})
users_cohort.head()
```

Out[52]:

	user_id	registration_date
0	7904	2018-11-11 14:51:45
1	4456	2018-11-10 20:32:04
2	5801	2018-11-10 23:56:36
3	2724	2018-11-11 12:08:59
4	6532	2018-11-11 02:35:24

In [53]:

```
#dropping device column as not needed in analysis
events_cohort = events.drop('DEV_NAME', axis = 1)
```

In [54]:

```
#changing column names in events table
events_cohort = events_cohort.rename(columns = {'ACTIVE_UID': 'user_id', 'ACTION_TS': 'active_date', 'EVENT': 'event'})
events_cohort.head()
```

Out[54]:

	user_id	active_date	event
0	138	2018-11-11 17:56:27	action_2
1	138	2018-11-11 17:56:28	action_1
2	138	2018-11-11 18:13:03	action_1
3	138	2018-11-11 18:18:36	action_2
4	138	2018-11-11 18:19:39	action_2

In [55]:

```
#removing rows with app start as the event as only want to include an actual event (left or right swipe) in the analysis
events_cohort = events_cohort.drop(events_cohort[events_cohort['event'] == 'app_start'].index)
```

In [56]:

```
#renaming the remaining events to left or right swipe
events_cohort['event'] = events_cohort['event'].map({'action_1': 'left or right swipe', 'action_2':'left or right swipe'})
events_cohort.head()
```

Out[56]:

	user_id	active_date	event
0	138	2018-11-11 17:56:27	left or right swipe
1	138	2018-11-11 17:56:28	left or right swipe
2	138	2018-11-11 18:13:03	left or right swipe
3	138	2018-11-11 18:18:36	left or right swipe
4	138	2018-11-11 18:19:39	left or right swipe

In [57]:

```
#merging two tables
merged_cohort = users_cohort.merge(events_cohort, left_on = 'user_id', right_on = 'user_id')
merged_cohort.head()
```

Out[57]:

	user_id	registration_date	active_date	event
0	7904	2018-11-11 14:51:45	2018-11-14 20:18:54	left or right swipe
1	7904	2018-11-11 14:51:45	2018-11-11 15:05:40	left or right swipe
2	7904	2018-11-11 14:51:45	2018-11-11 15:05:35	left or right swipe
3	7904	2018-11-11 14:51:45	2018-11-11 15:21:47	left or right swipe
4	7904	2018-11-11 14:51:45	2018-11-11 15:21:48	left or right swipe

In [58]:

```
merged_cohort = merged_cohort.sort_values(by = ['user_id', 'registration_date', 'active_date']).reset_index(drop = True)
```

In [59]:

```
#checking datatypes - need to change dates from object to date
merged_cohort.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 129984 entries, 0 to 129983
Data columns (total 4 columns):
 #   Column             Non-Null Count   Dtype         
---  ------             --------------   -----         
 0   user_id            129984 non-null  int64         
 1   registration_date  129984 non-null  datetime64[ns]
 2   active_date        129984 non-null  datetime64[ns]
 3   event              129984 non-null  object        
dtypes: datetime64[ns](2), int64(1), object(1)
memory usage: 4.0+ MB
```

In [60]:

```
#splitting date from datetime
merged_cohort['registration_date'] = merged_cohort['registration_date'].dt.date
merged_cohort['active_date'] = merged_cohort['active_date'].dt.date
merged_cohort.head()
```

Out[60]:

	user_id	registration_date	active_date	event
0	46	2018-11-10	2018-11-10	left or right swipe
1	46	2018-11-10	2018-11-10	left or right swipe
2	46	2018-11-10	2018-11-10	left or right swipe
3	46	2018-11-10	2018-11-10	left or right swipe
4	46	2018-11-10	2018-11-10	left or right swipe

In [61]:

```
#adding column to show number of days passed between registration date and active date
merged_cohort['days_passed_since_registration'] = merged_cohort['active_date'] - merged
_cohort['registration_date']
merged_cohort.head()
```

Out[61]:

	user_id	registration_date	active_date	event	days_passed_since_registration
0	46	2018-11-10	2018-11-10	left or right swipe	0 days
1	46	2018-11-10	2018-11-10	left or right swipe	0 days
2	46	2018-11-10	2018-11-10	left or right swipe	0 days
3	46	2018-11-10	2018-11-10	left or right swipe	0 days
4	46	2018-11-10	2018-11-10	left or right swipe	0 days

In [62]:

```
#grouping the data by active date and days passed and unique user ids - nunique counts
 number of unique values
cohort = merged_cohort.groupby(['registration_date', 'days_passed_since_registration'])
.user_id.nunique().reset_index()
cohort
```

Out[62]:

	registration_date	days_passed_since_registration	user_id
0	2018-11-10	0 days	39
1	2018-11-10	1 days	34
2	2018-11-10	2 days	26
3	2018-11-10	3 days	26
4	2018-11-10	4 days	16
5	2018-11-11	0 days	50
6	2018-11-11	1 days	43
7	2018-11-11	2 days	38
8	2018-11-11	3 days	37
9	2018-11-11	4 days	22

In [63]:

```
#pivoting the date to group by active date and days passed
cohort_pivot = cohort.pivot_table(columns = 'days_passed_since_registration',
                                  index = 'registration_date',
                                  values = 'user_id')
cohort_pivot
```

Out[63]:

days_passed_since_registration	0 days	1 days	2 days	3 days	4 days
registration_date					
2018-11-10	39	34	26	26	16
2018-11-11	50	43	38	37	22

In [64]:

```
#converting to dataframe
cohort_pivot_df = cohort_pivot.reset_index()
cohort_pivot_df
```

Out[64]:

days_passed_since_registration	registration_date	0 days 00:00:00	1 days 00:00:00	2 days 00:00:00	3 days 00:00:00	4 00:0
0	2018-11-10	39	34	26	26	
1	2018-11-11	50	43	38	37	

In [65]:

```
#converting all columns to string as chart isn't accepting the non-string columns
cohort_pivot_df.columns = cohort_pivot_df.columns.astype(str)
```

In [66]:

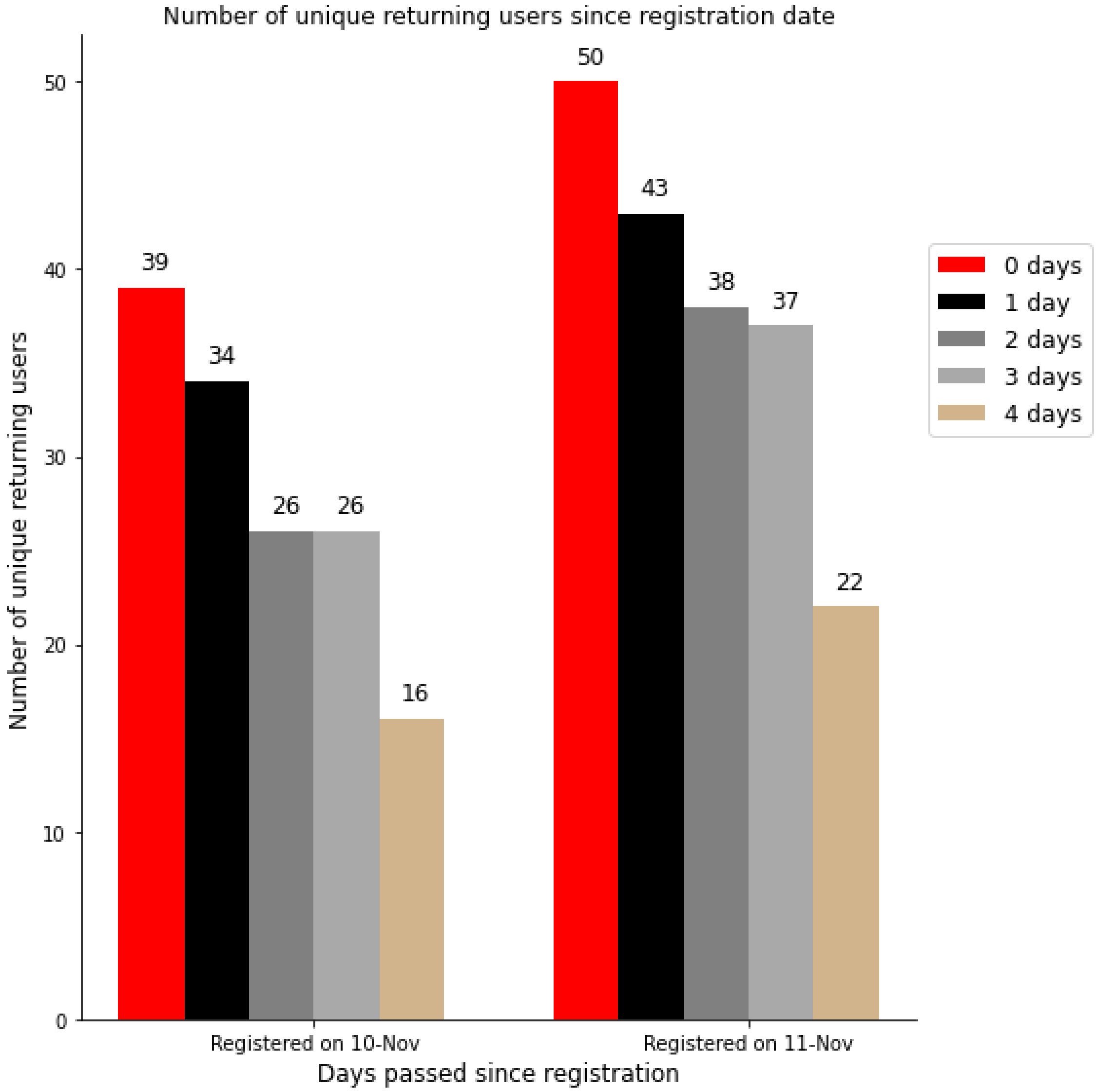
```
#renaming the columns
cohort_pivot_df = cohort_pivot_df.rename(columns = {'0 days 00:00:00': '0 days', '1 days 00:00:00': '1 day', '2 days 00:00:00': \
                                                              '2 days', '3 days 00:00:00': '3 days', '4 days 00:00:00': '4 days'})
cohort_pivot_df
```

Out[66]:

days_passed_since_registration	registration_date	0 days	1 day	2 days	3 days	4 days
0	2018-11-10	39	34	26	26	16
1	2018-11-11	50	43	38	37	22

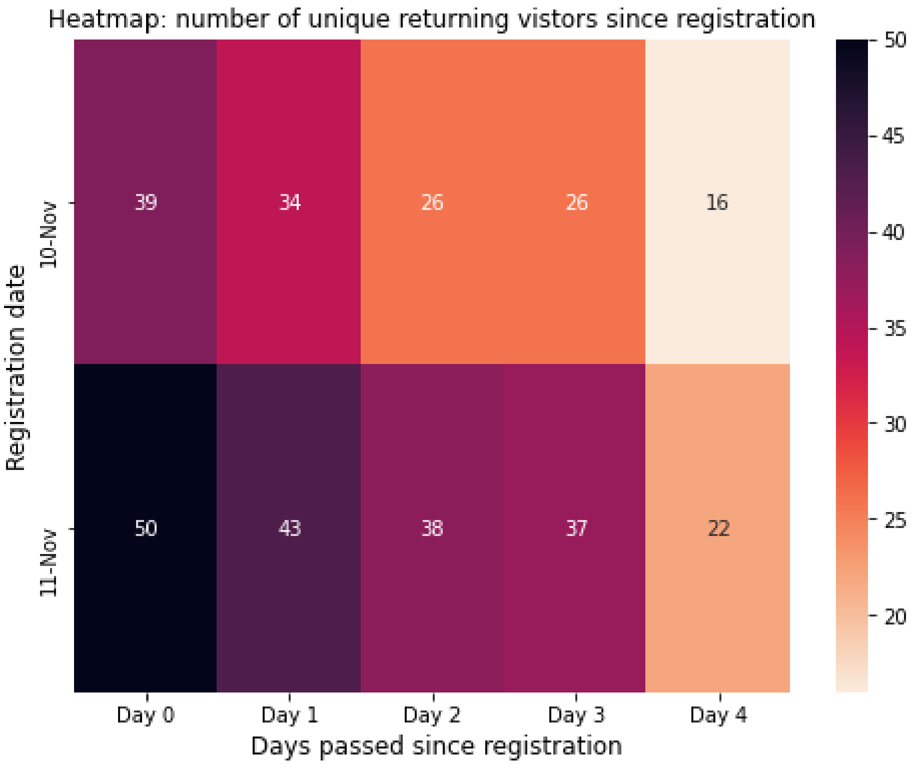
In [67]:

```
num_bars = 2
width = 0.15

cohort_bars = np.arange(num_bars)
labels = ['Registered on 10-Nov', 'Registered on 11-Nov']

fig = plt.figure(figsize = (8, 8))
ax = fig.add_subplot()

bar_1 = ax.bar(cohort_bars, cohort_pivot_df['0 days'], width, color = 'red', label = '0')
bar_2 = ax.bar(cohort_bars + 0.15, cohort_pivot_df['1 day'], width, color = 'black', label = '1')
bar_3 = ax.bar(cohort_bars + 0.3, cohort_pivot_df['2 days'], width, color = 'grey', label = '2')
bar_4 = ax.bar(cohort_bars + 0.45, cohort_pivot_df['3 days'], width, color = 'darkgrey', label = '3')
bar_5 = ax.bar(cohort_bars + 0.6, cohort_pivot_df['4 days'], width, color = 'tan', label = '4')

#removing chart borders
ax.spines['top'].set_visible(False)
ax.spines['right'].set_visible(False)

#adding data labels
for bar in bar_1:
    yval = bar.get_height()
    ax.text(bar.get_x() + 0.05, yval + 1, yval, fontsize = 12)

for bar in bar_2:
    yval = bar.get_height()
    ax.text(bar.get_x() + 0.05, yval + 1, yval, fontsize = 12)

for bar in bar_3:
    yval = bar.get_height()
    ax.text(bar.get_x() + 0.05, yval + 1, yval, fontsize = 12)

for bar in bar_4:
    yval = bar.get_height()
    ax.text(bar.get_x() + 0.05, yval + 1, yval, fontsize = 12)

for bar in bar_5:
    yval = bar.get_height()
    ax.text(bar.get_x() + 0.05, yval + 1, yval, fontsize = 12)


ax.set_ylabel('Number of unique returning users', fontsize = 12)
ax.set_xlabel('Days passed since registration', fontsize = 12)
ax.set_xticks(cohort_bars + (width * 5) / 2)
ax.set_xticklabels(labels)
ax.legend((bar_1, bar_2, bar_3, bar_4, bar_5), ('0 days', '1 day', '2 days', '3 days', '4 days'), bbox_to_anchor = \
          (1.0, 0.8), fontsize = 12)
ax.set_title('Number of unique returning users since registration date', fontsize = 12)
plt.tight_layout()
plt.savefig('cohort')
```


Number of unique returning users since registration date
Number of unique returning users
0
10
20
30
40
50
39
34
26
26
16
50
43
38
37
22
Registered on 10-Nov
Registered on 11-Nov
Days passed since registration
0 days
1 day
2 days
3 days
4 days

In [68]:

```
#creating heatmap. The default color scheme is sns.cm.rocket - the code cmap = sns.cm.rocket_r reverses this so
#higher numbers are darker and lower numbers are ligher
xticks = ['Day 0', 'Day 1', 'Day 2', 'Day 3', 'Day 4']
yticks = ['10-Nov', '11-Nov']
cmap = sns.cm.rocket_r

plt.figure(figsize = (8, 6))
sns.heatmap(cohort_pivot, xticklabels = xticks, yticklabels = yticks, annot = True, cmap = cmap)
plt.title('Heatmap: number of unique returning vistors since registration', fontsize = 12)
plt.xlabel(' Days passed since registration', fontsize = 12)
plt.ylabel('Registration date', fontsize = 12)
plt.savefig('heatmap')
```



Assigning random A/B test groups

In [69]:

```
#setting the seed in order to replicate results
seed(26)
```

In [70]:

```
#adding a random number to each user to assign them into A and B test groups
users['random_number'] = np.random.randint(1, 3, users.shape[0])
users.head()
```

Out[70]:

	UID	PROFILE_GENDER	PROFILE_REGISTERED	AGE	random_number
0	7904	M	2018-11-11 14:51:45	27	2
1	4456	M	2018-11-10 20:32:04	28	1
2	5801	M	2018-11-10 23:56:36	34	1
3	2724	M	2018-11-11 12:08:59	23	1
4	6532	M	2018-11-11 02:35:24	24	2

In [71]:

```
#assiging A and B groups
users['group'] = users['random_number'].apply(lambda row: 'A' if row == 1 else 'B')
users.head()
```

Out[71]:

	UID	PROFILE_GENDER	PROFILE_REGISTERED	AGE	random_number	group
0	7904	M	2018-11-11 14:51:45	27	2	B
1	4456	M	2018-11-10 20:32:04	28	1	A
2	5801	M	2018-11-10 23:56:36	34	1	A
3	2724	M	2018-11-11 12:08:59	23	1	A
4	6532	M	2018-11-11 02:35:24	24	2	B

In [72]:

```
#dropping the random number and profile registered columns as no longer needed
users_ab = users.drop(['random_number', 'PROFILE_REGISTERED'], axis = 1).reset_index(dr
op = True)
users_ab.head()
```

Out[72]:

	UID	PROFILE_GENDER	AGE	group
0	7904	M	27	B
1	4456	M	28	A
2	5801	M	34	A
3	2724	M	23	A
4	6532	M	24	B

In [73]:

```
#renaming columns
users_ab = users_ab.rename(columns = {'UID': 'user_id', 'PROFILE_GENDER': 'gender', 'AGE': 'age'})
users_ab.head()
```

Out[73]:

	user_id	gender	age	group
0	7904	M	27	B
1	4456	M	28	A
2	5801	M	34	A
3	2724	M	23	A
4	6532	M	24	B

In [74]:

```
#dropping date and device name columns as not needed in analysis
events_ab = events.drop(['ACTION_TS', 'DEV_NAME'], axis = 1).reset_index(drop = True)
events_ab.head()
```

Out[74]:

	ACTIVE_UID	EVENT
0	138	action_2
1	138	action_1
2	138	action_1
3	138	action_2
4	138	action_2

In [75]:

```
#renaming columns
events_ab = events_ab.rename(columns = {'ACTIVE_UID': 'user_id', 'EVENT': 'event'})
events_ab.head()
```

Out[75]:

	user_id	event
0	138	action_2
1	138	action_1
2	138	action_1
3	138	action_2
4	138	action_2

In [76]:

```
#merging tables
merged_ab = users_ab.merge(events_ab, left_on = 'user_id', right_on = 'user_id')
merged_ab.head()
```

Out[76]:

	user_id	gender	age	group	event
0	7904	M	27	B	action_1
1	7904	M	27	B	action_2
2	7904	M	27	B	action_1
3	7904	M	27	B	action_1
4	7904	M	27	B	action_1

In [77]:

```
#removing rows with app start as the event as only want to include an actual event in t
he analysis
merged_ab = merged_ab.drop(merged_ab[merged_ab['event'] == 'app_start'].index)
```

In [78]:

```
#assigning events for A/B test groups - group A: left swipe = no, right swipe = yes. Gr
oup B: down swipe = no,
#up swipe = yes

def swipe(row):
    if row['group'] == 'A' and row['event'] == 'action_1':
        value = 'right swipe'
    elif row['group'] == 'A' and row['event'] == 'action_2':
        value = 'left swipe'
    elif row['group'] == 'B' and row['event'] == 'action_1':
        value = 'up swipe'
    else:
        value = 'down swipe'
    return value
```

In [79]:

```
#applying the function to the merged dataframe and viewing a sample of the results. The
frac = 0.0001 tells Python what
#fraction of the data you want to see
merged_ab['swipe_direction'] = merged_ab.apply(swipe, axis = 1)
merged_ab.sample(frac = 0.0001)
```

Out[79]:

	user_id	gender	age	group	event	swipe_direction
22631	9163	M	29	B	action_2	down swipe
32833	12331	F	41	B	action_2	down swipe
41778	12331	F	41	B	action_2	down swipe
55846	12121	M	32	A	action_2	left swipe
118790	12182	M	32	B	action_1	up swipe
68992	4685	M	31	B	action_1	up swipe
79017	2360	M	32	B	action_2	down swipe
55012	5795	F	35	B	action_2	down swipe
135198	5454	M	36	B	action_1	up swipe
30821	4307	F	29	A	action_2	left swipe
25798	2178	M	28	B	action_1	up swipe
99841	9190	F	35	A	action_2	left swipe
135587	5454	M	36	B	action_1	up swipe

Analysing A/B test results with a t-test

In [80]:

```
ab_group_data = merged_ab.groupby(['user_id', 'group']).size().to_frame().sort_values(
'user_id').\
reset_index().rename(columns = {0: 'swipe_count'})
ab_group_data.head()
```

Out[80]:

	user_id	group	swipe_count
0	46	B	1524
1	84	B	358
2	138	B	886
3	353	A	77
4	500	B	2217

In [81]:

```
#counting users in A and B test groups
count_users = ab_group_data.groupby('group').count()
count_users
```

Out[81]:

	user_id	swipe_count
group		
A	49	49
B	43	43

In [82]:

```
#testing for 95% convidence level
#null hypothesis: the average number of swipes is no different between left/right swipe and up/down swipe
#alternative hypothesis: the average number of swipes is higher for up/down swipes than left/right swipes
```

In [83]:

```
#calculating average number of swipes for each group - average is higher for Group B (up/down swipe)
average_swipes = ab_group_data.groupby('group').swipe_count.mean()
average_swipes
```

Out[83]:

```
group
A    1072.714286
B    1800.488372
Name: swipe_count, dtype: float64
```

In [84]:

```
#creating pivot for t-test to see if results are statistically significant
ab_pivot = ab_group_data.pivot_table(columns = 'group',
                                     index = 'user_id',
                                     values = 'swipe_count')
ab_pivot
```

Out[84]:

group	**A**	**B**
user_id		
46	NaN	1524.0
84	NaN	358.0
138	NaN	886.0
353	77.0	NaN
500	NaN	2217.0
...	...	...
12339	NaN	4357.0
12632	NaN	26.0
12847	NaN	176.0
13247	4607.0	NaN
13259	NaN	55.0

92 rows × 2 columns

In [85]:

```
#creating dataframe from pivot to feed into t-test
ab_ttest = ab_pivot.reset_index()
ab_ttest.head()
```

Out[85]:

group	**user_id**	**A**	**B**
0	46	NaN	1524.0
1	84	NaN	358.0
2	138	NaN	886.0
3	353	77.0	NaN
4	500	NaN	2217.0

In [86]:

```
#performing t-test and getting the t statistic and p value. The nan_policy code tells Python to omit nans
#this p-value is for a two-tailed test. To get the p-value for a one-tailed test, we divide the p-value by 2
t_stat, p = ttest_ind(ab_ttest['A'], ab_ttest['B'], nan_policy = 'omit')
print(f't stat = {t_stat}, p value = {p}')
```

```
t stat = -1.5443911282502167, p value = 0.12600272040577903
```

In [87]:

```
#calculating p-value for one-tailed test. P-value is greater than 0.05 and therefore the results are not significant and
#likely happened by change. We therefore cannot reject the null hypothesis and would not implement version B in this case
p_value_one_tailed = 0.12600272040577903 / 2
p_value_one_tailed
```

Out[87]:

```
0.063001360202888952
```

In [ ]:

```
```