Analyze A/B Test Results

This project will assure you have mastered the subjects covered in the statistics lessons. The hope is to have this project be as comprehensive of these topics as possible. Good luck!

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Introduction

A/B tests are very commonly performed by data analysts and data scientists. It is important that you get some practice working with the difficulties of these

For this project, I will find the results of an A/B test run by an e-commerce website. My goal is to work through this notebook to help the company understand if they should implement the new page, keep the old page, or perhaps run the experiment longer to make their decision.

Part I - Probability

To get started, let's import our libraries.

In [1]:

```
import pandas as pd
import numpy as np
import random
import matplotlib.pyplot as plt
%matplotlib inline
#We are setting the seed to assure you get the same answers on quizzes as we set up
random.seed(42)
```

In [2]:

```
df=pd.read_csv('ab_data.csv')
df.head()
```

Out[2]:

	user_id	timestamp	group	landing_page	converted
0	851104	2017-01-21 22:11:48.556739	control	old_page	0
1	804228	2017-01-12 08:01:45.159739	control	old_page	0
2	661590	2017-01-11 16:55:06.154213	treatment	new_page	0
3	853541	2017-01-08 18:28:03.143765	treatment	new_page	0
4	864975	2017-01-21 01:52:26.210827	control	old_page	1

In [3]:

```
df.shape[0]
```

Out[3]:

294478

There are 294478 rows in the dataset

In [4]:

```
df.nunique()
```

Out[4]:

```
user_id         290584
timestamp       294478
group                2
landing_page         2
converted            2
dtype: int64
```

There are 290584 unique users out of the 294478

In [5]:

```
sum(df["converted"])/df.shape[0]
```

Out[5]:

```
0.11965919355605512
```

The percentage of users who converted is around 12%

In [6]:

```
df.query("group == 'control' and landing_page == 'new_page'").shape[0] + df.query("group == 'treatment' and landi
ng_page == 'old_page'").shape[0]
```

Out[6]:

```
3893
```

3893 times the new page and treatment didn't line up

In [7]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 294478 entries, 0 to 294477
Data columns (total 5 columns):
 #   Column        Non-Null Count   Dtype 
---  ------        --------------   ----- 
 0   user_id       294478 non-null  int64 
 1   timestamp     294478 non-null  object
 2   group         294478 non-null  object
 3   landing_page  294478 non-null  object
 4   converted     294478 non-null  int64 
dtypes: int64(2), object(3)
memory usage: 11.2+ MB
```

There are no missing values

In [8]:

```
df2=df[((df['group'] == 'treatment') == (df['landing_page'] == 'new_page')) == True]
```

A new data frame is created by removing all the rows where treatment is not aligned with new_page or control is not aligned with old_page.

In [9]:

```
# Double Check all of the correct rows were removed - this should be 0
df2[((df2['group'] == 'treatment') == (df2['landing_page'] == 'new_page')) == False].shape[0]
```

Out[9]:

```
0
```

In [10]:

```
df2.nunique()
```

Out[10]:

```
user_id         290584
timestamp       290585
group                2
landing_page         2
converted            2
dtype: int64
```

There is one duplicated user

In [11]:

```
df2[df2['user_id'].duplicated()]
```

Out[11]:

	user_id	timestamp	group	landing_page	converted
2893	773192	2017-01-14 02:55:59.590927	treatment	new_page	0

The duplicated user has a user_id of 773192

In [12]:

```
df2[df2['user_id']==773192]
```

Out[12]:

	user_id	timestamp	group	landing_page	converted
1899	773192	2017-01-09 05:37:58.781806	treatment	new_page	0
2893	773192	2017-01-14 02:55:59.590927	treatment	new_page	0

The duplicated users are found on rows 1899 & 2893

In [13]:

```
df2.drop(index=2893,inplace=True)
```

```
/Users/abdullah/opt/anaconda3/lib/python3.7/site-packages/pandas/core/frame.py:3997: SettingWithCopy
Warning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexi
ng.html#returning-a-view-versus-a-copy
  errors=errors,
```

The duplicated user on row 2893 is removed from the dataframe

In [14]:

```
sum(df2["converted"])/df2.shape[0]
```

Out[14]:

```
0.11959708724499628
```

The probability of an individual converting is 0.119

In [15]:

```
sum(df2.query("group =='control'")["converted"])/df2.query("group =='control'").shape[0]
```

Out[15]:

```
0.1203863045004612
```

The probability of an individual from the control group converting is 0.12

In [16]:

```
sum(df2.query("group =='treatment'")["converted"])/df2.query("group =='treatment'").shape[0]
```

Out[16]:

```
0.11880806551510564
```

The probability of an individual from the treatment group converting is 0.118

d. What is the probability that an individual received the new page?

In [17]:

```
df2.query("landing_page =='new_page'").shape[0]/df2.shape[0]
```

Out[17]:

```
0.5000619442226688
```

half of the individuals received the new page

Since half of the individuals received the new page and the other half received the old one thus half of them are in the control group and the other half are in the treatment group and where the control group had a slightly higher conversion probability than the treatment group, we can say that the old page leads to slightly more conversions than the new page

Part II - A/B Test

Null Hypothesis : The old page is better than the new page or equally good to it.

Alternative Hypothesis : The new page is better than the old page.

$ \alpha = 0.05 $

In [18]:

```
df2['converted'].mean()
```

Out[18]:

```
0.11959708724499628
```

assuming that Pnew = to the converted rate in ab_data.csv regardless of the page then Pnew = 0.119

In [19]:

```
df2['converted'].mean()
```

Out[19]:

```
0.11959708724499628
```

assuming that Pold = to the converted rate in ab_data.csv regardless of the page then Pold = 0.119

In [20]:

```
df2[df2['landing_page']=='new_page'].shape[0]
```

Out[20]:

```
145310
```

n new = 145310

In [21]:

```
df2[df2['landing_page']=='old_page'].shape[0]
```

Out[21]:

```
145274
```

n old = 145274

In [22]:

```
new_page_converted = []
for _ in range(145310):
    sample = np.random.choice(2, p=[0.881, 0.119], replace=True)
    new_page_converted.append(sample)
```

In [23]:

```
old_page_converted = []
for _ in range(145274):
    sample = np.random.choice(2, p=[0.881, 0.119], replace=True)
    old_page_converted.append(sample)
```

In [24]:

```
sum(old_page_converted)/len(old_page_converted)
```

Out[24]:

```
0.11888569186502747
```

In [25]:

```
sum(new_page_converted)/len(new_page_converted)
```

Out[25]:

```
0.11940678549308376
```

In [26]:

```
sum(new_page_converted)/len(new_page_converted) - sum(old_page_converted)/len(old_page_converted)
```

Out[26]:

```
0.0005210936280562878
```

In [27]:

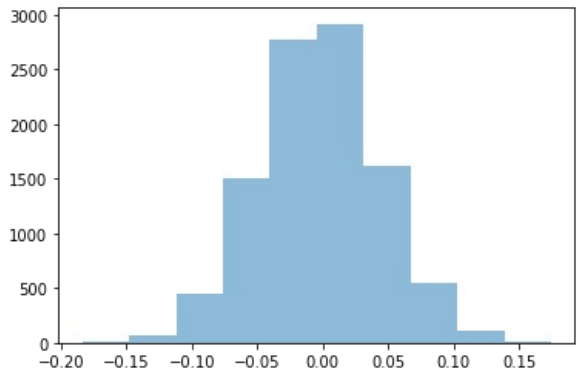
```
p_new, p_old, p_diffs = [], [], []

for _ in range(10000):
    bootsamp = df2.sample(200, replace = True)
    p_new_samp = bootsamp[bootsamp['landing_page']=='new_page']['converted'].mean()
    p_old_samp = bootsamp[bootsamp['landing_page']=='old_page']['converted'].mean()

    p_new.append(p_new_samp)
    p_old.append(p_old_samp)
    p_diffs.append(p_new_samp - p_old_samp)
```

In [28]:

```
plt.hist(p_diffs, alpha = 0.5);
```



The plot looks just as expercted according to the central limit theorem in addition for it being centered at 0.

In [29]:

```
np.std(p_diffs)
```

Out[29]:

```
0.04556027338487988
```

In [30]:

```
null_vals = np.random.normal(0, np.std(p_diffs), 10000)
```

In [31]:

```
sample_mean = sum(new_page_converted)/len(new_page_converted) - sum(old_page_converted)/len(old_page_converted)
```

In [32]:

```
(null_vals>sample_mean).mean()
```

Out[32]:

```
0.5035
```

0.5035 of the p_diffs are greater than the actual difference observed in ab_data.csv

the number found in j is the p value which is the probability of observing your statistic if the null value is true thus here we have a p value of 0.5035 which suggest that we should stick to the null hypothesis and reject the new page.

In [33]:

```
import statsmodels.api as sm

convert_old = sum(df2[df2['landing_page']=='old_page']['converted'])
convert_new = sum(df2[df2['landing_page']=='new_page']['converted'])
n_old = df2[df2['landing_page']=='old_page'].shape[0]
n_new = df2[df2['landing_page']=='new_page'].shape[0]
```

In [34]:

```
sm.stats.proportions_ztest(count=convert_old,nobs=n_old,value=0.5)
```

Out[34]:

```
(-444.63258480571153, 0.0)
```

The z-score is -444 and the p-value is 0 thus we should stick to the null hypothesis.

Part III - A regression approach

Since its is categorical and not quantitative, Multiple linear regression should be performed in this case.

In [35]:

```
df2.head()
```

Out[35]:

	user_id	timestamp	group	landing_page	converted
0	851104	2017-01-21 22:11:48.556739	control	old_page	0
1	804228	2017-01-12 08:01:45.159739	control	old_page	0
2	661590	2017-01-11 16:55:06.154213	treatment	new_page	0
3	853541	2017-01-08 18:28:03.143765	treatment	new_page	0
4	864975	2017-01-21 01:52:26.210827	control	old_page	1

In [36]:

```
landing_page_dummies = pd.get_dummies(df2['landing_page'])
group_dummies = pd.get_dummies(df2['group'])
df3 = df2.join(landing_page_dummies).join(group_dummies)
df3.head()
```

Out[36]:

	user_id	timestamp	group	landing_page	converted	new_page	old_page	control	treatment
0	851104	2017-01-21 22:11:48.556739	control	old_page	0	0	1	1	0
1	804228	2017-01-12 08:01:45.159739	control	old_page	0	0	1	1	0
2	661590	2017-01-11 16:55:06.154213	treatment	new_page	0	1	0	0	1
3	853541	2017-01-08 18:28:03.143765	treatment	new_page	0	1	0	0	1
4	864975	2017-01-21 01:52:26.210827	control	old_page	1	0	1	1	0

In [37]:

```
df3.drop(columns=['old_page','control'], inplace=True)
df3.head()
```

Out[37]:

	user_id	timestamp	group	landing_page	converted	new_page	treatment
0	851104	2017-01-21 22:11:48.556739	control	old_page	0	0	0
1	804228	2017-01-12 08:01:45.159739	control	old_page	0	0	0
2	661590	2017-01-11 16:55:06.154213	treatment	new_page	0	1	1
3	853541	2017-01-08 18:28:03.143765	treatment	new_page	0	1	1
4	864975	2017-01-21 01:52:26.210827	control	old_page	1	0	0

In [38]:

```
df3.rename(columns={'treatment':'ab_page'},inplace=True)
```

In [39]:

```
df3['intercept'] = 1
```

In [40]:

```
lm = sm.OLS(df3['converted'], df3[['intercept', 'new_page', 'ab_page']])
results = lm.fit()
```

In [41]:

```
results.summary()
```

Out[41]:

OLS Regression Results

Dep. Variable:	converted	**R-squared:**	0.000
Model:	OLS	**Adj. R-squared:**	0.000
Method:	Least Squares	**F-statistic:**	1.719
Date:	Fri, 26 Jun 2020	**Prob (F-statistic):**	0.190
Time:	17:38:58	**Log-Likelihood:**	-85267.
No. Observations:	290584	**AIC:**	1.705e+05
Df Residuals:	290582	**BIC:**	1.706e+05
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
intercept	0.1204	0.001	141.407	0.000	0.119	0.122
new_page	-0.0008	0.001	-1.311	0.190	-0.002	0.000
ab_page	-0.0008	0.001	-1.311	0.190	-0.002	0.000

Omnibus:	125553.456	**Durbin-Watson:**	1.995
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	414313.355
Skew:	2.345	**Prob(JB):**	0.00
Kurtosis:	6.497	**Cond. No.**	1.50e+16

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
[2] The smallest eigenvalue is 2.2e-27. This might indicate that there are
strong multicollinearity problems or that the design matrix is singular.

the p-value = 0.19 while in part II the p-value was 0.5279 thus this show that we should choose the alternative hypothesis

Adding other factors to the regression model is a good idea for example studying the time might give us a better understanding of wether the new page is better than the old one or not.

In [42]:

```
countries_df = pd.read_csv('./countries.csv')
df_new = countries_df.set_index('user_id').join(df3.set_index('user_id'), how='inner')
```

In [43]:

```
df_new.sample(10)
```

Out[43]:

user_id	country	timestamp	group	landing_page	converted	new_page	ab_page	intercept
922487	UK	2017-01-07 19:11:14.797797	treatment	new_page	0	1	1	1
819229	US	2017-01-07 19:56:52.334880	control	old_page	0	0	0	1
682387	US	2017-01-11 00:37:47.911251	control	old_page	0	0	0	1
648525	US	2017-01-19 20:24:56.524049	treatment	new_page	0	1	1	1
879044	US	2017-01-13 09:07:12.557091	treatment	new_page	0	1	1	1
633810	CA	2017-01-19 02:57:04.767724	control	old_page	0	0	0	1
796403	US	2017-01-12 17:32:21.993063	treatment	new_page	0	1	1	1
655614	UK	2017-01-06 10:02:07.549099	control	old_page	0	0	0	1
903180	US	2017-01-20 08:27:28.685935	treatment	new_page	0	1	1	1
941829	US	2017-01-09 03:49:28.060958	treatment	new_page	0	1	1	1

In [44]:

```
country_dummies = pd.get_dummies(df_new['country'])
df_new2 = df_new.join(country_dummies)
df_new2.head()
```

Out[44]:

user_id	country	timestamp	group	landing_page	converted	new_page	ab_page	intercept	CA	UK	US
834778	UK	2017-01-14 23:08:43.304998	control	old_page	0	0	0	1	0	1	0
928468	US	2017-01-23 14:44:16.387854	treatment	new_page	0	1	1	1	0	0	1
822059	UK	2017-01-16 14:04:14.719771	treatment	new_page	1	1	1	1	0	1	0
711597	UK	2017-01-22 03:14:24.763511	control	old_page	0	0	0	1	0	1	0
710616	UK	2017-01-16 13:14:44.000513	treatment	new_page	0	1	1	1	0	1	0

In [45]:

```
df_new2['intercept'] = 1
lm = sm.OLS(df_new2['converted'], df_new2[['intercept', 'new_page', 'ab_page','CA','UK']])
results = lm.fit()
results.summary()
```

Out[45]:

OLS Regression Results

Dep. Variable:	converted	**R-squared:**	0.000
Model:	OLS	**Adj. R-squared:**	0.000
Method:	Least Squares	**F-statistic:**	1.640
Date:	Fri, 26 Jun 2020	**Prob (F-statistic):**	0.178
Time:	17:39:01	**Log-Likelihood:**	-85266.
No. Observations:	290584	**AIC:**	1.705e+05
Df Residuals:	290580	**BIC:**	1.706e+05
Df Model:	3		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
intercept	0.1203	0.001	128.267	0.000	0.118	0.122
new_page	-0.0008	0.001	-1.307	0.191	-0.002	0.000
ab_page	-0.0008	0.001	-1.307	0.191	-0.002	0.000
CA	-0.0042	0.003	-1.514	0.130	-0.010	0.001
UK	0.0010	0.001	0.744	0.457	-0.002	0.004

Omnibus:	125551.169	**Durbin-Watson:**	1.996
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	414297.780
Skew:	2.345	**Prob(JB):**	0.00
Kurtosis:	6.497	**Cond. No.**	4.45e+16

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
[2] The smallest eigenvalue is 2.59e-28. This might indicate that there are
strong multicollinearity problems or that the design matrix is singular.

As the summary shows, CA rate of conversion is 0.0042 less than the US while that of the UK is 0.001 more than that of the US. Moreover, the rate of conversion for the new page is a little less than that of the old page. Thus it would be best to stick to the old page

In [ ]:

```
```