In [95]:
```
import pandas as pd
import numpy as np
import scipy.stats as sstats
import statsmodels as sm
import warnings
import matplotlib.pyplot as plt
warnings.filterwarnings("ignore")

df = pd.read_csv('ab_test.csv')
print(df.shape)
```

```
(320415, 10)
```

In [96]:
```
df.columns
```

Out[96]:
```
Index(['AB_TEST', 'USER_ID', 'TOPNEWS_IMPRESSION_COUNT',
       'TOPNEWS_CLICKED_COUNT', 'ADS_IMPRESSION_TOPNEWS_COUNT',
       'ADS_CLICKED_TOPNEWS_COUNT', 'MYNEWS_COUNT',
       'ARTICLE_MYNEWS_CLICKED_COUNT', 'ADS_IMPRESSION_MYNEWS_COUNT',
       'ADS_CLICKED_MYNEWS_COUNT'],
      dtype='object')
```

Checking for missing values & dropping if any

In [97]:
```
df.isna().sum()
```

Out[97]:
```
AB_TEST                         0
USER_ID                         2
TOPNEWS_IMPRESSION_COUNT        0
TOPNEWS_CLICKED_COUNT           0
ADS_IMPRESSION_TOPNEWS_COUNT    0
ADS_CLICKED_TOPNEWS_COUNT       0
MYNEWS_COUNT                    0
ARTICLE_MYNEWS_CLICKED_COUNT    0
ADS_IMPRESSION_MYNEWS_COUNT     0
ADS_CLICKED_MYNEWS_COUNT        0
dtype: int64
```

In [98]:
```
df.dropna(inplace=True)
df.shape
```

Out[98]:
```
(320413, 10)
```

In [99]:
```
## Ensuring that the data contains only unique users.
df['USER_ID'].nunique()
```

Out[99]:
```
320118
```

The data contains mostly unique users. There are less than 0.09% of duplicates. Hence removing the duplicates.

In [100…
```
df_new = df.drop_duplicates(subset=['USER_ID'])
df_new.shape
```

Out[100…
```
(320118, 10)
```

Checking the split of control & experiment groups

In [101…
```
df_new['AB_TEST'].value_counts()
```

Out[101…
```
Test       168532
Control    151586
Name: AB_TEST, dtype: int64
```

Aggregating Impressions & Clicks

In [102…
```
## Define New Variables
df_new['Total_Ads_Imp']=df_new['ADS_IMPRESSION_TOPNEWS_COUNT']+df_new['ADS_IMPRESSIO
df_new['Total_News_Imp']=df_new['TOPNEWS_IMPRESSION_COUNT']+df_new['MYNEWS_COUNT']
df_new['Total_Ads_Clicked']=df_new['ADS_CLICKED_TOPNEWS_COUNT']+df_new['ADS_CLICKED_
df_new['Total_News_Clicked']=df_new['TOPNEWS_CLICKED_COUNT']+df_new['ARTICLE_MYNEWS_
```

In [103…
```
pd.DataFrame(df_new.describe()).T
```

Out[103…

	count	mean	std	min	25%	50%	75%	max
TOPNEWS_IMPRESSION_COUNT	320118.0	24.777638	64.568742	0.0	0.0	5.0	21.0	6307.0
TOPNEWS_CLICKED_COUNT	320118.0	2.204340	5.991379	0.0	0.0	0.0	2.0	293.0
ADS_IMPRESSION_TOPNEWS_COUNT	320118.0	4.094649	12.468467	0.0	0.0	0.0	3.0	371.0
ADS_CLICKED_TOPNEWS_COUNT	320118.0	0.043368	0.358782	0.0	0.0	0.0	0.0	22.0
MYNEWS_COUNT	320118.0	25.691470	215.441378	0.0	0.0	0.0	1.0	22126.0
ARTICLE_MYNEWS_CLICKED_COUNT	320118.0	1.308102	7.934788	0.0	0.0	0.0	0.0	535.0
ADS_IMPRESSION_MYNEWS_COUNT	320118.0	3.056298	25.896082	0.0	0.0	0.0	0.0	2027.0
ADS_CLICKED_MYNEWS_COUNT	320118.0	0.019371	0.334934	0.0	0.0	0.0	0.0	106.0
Total_Ads_Imp	320118.0	7.150947	33.828390	0.0	0.0	0.0	3.0	2028.0
Total_News_Imp	320118.0	50.469108	249.185918	0.0	0.0	5.0	26.0	23003.0
Total_Ads_Clicked	320118.0	0.062739	0.540312	0.0	0.0	0.0	0.0	108.0
Total_News_Clicked	320118.0	3.512442	11.683594	0.0	0.0	0.0	3.0	729.0

The 25th percentile of all columns are 0.

This suggests that the sample population that were a part of the experiment were not active users of the app itself.

Since the hypothesis is to identify change in UI experience, we can ignore people who have not opened the app at all.

Including a sample population which have not opened the app will lead to a bias when we are analyzing UI experience.

Removing outliers & samples with 0 impressions will provide an unbiased sample for analysis.

In [247…
```
### Identifying sample size with zero overall impressions.
zero_impressions = len(df_new[(df_new['Total_News_Imp']==0)&(df_new['Total_Ads_Imp']
total_data_size = len(df_new)
print("Users With Zero Impressions:", zero_impressions, "\nPercentage Of Total Data:
```

```
Users With Zero Impressions: 85124
Percentage Of Total Data: 26.59 %
```

Removing All Zero Impression Users

In [248...
```
df_valid = df_new[~((df_new['Total_News_Imp']==0)&(df_new['Total_Ads_Imp']==0))]
df_valid.shape
```

Out[248...
```
(234994, 14)
```

In [251...
```
### Evaluating the size of Zero Total_Ads_Impressions
df_valid[df_valid['Total_Ads_Imp']==0].shape
```

Out[251...
```
(96828, 14)
```

In [252...
```
df_test = df_valid[df_valid['AB_TEST']=='Test']
df_control = df_valid[df_valid['AB_TEST']=='Control']
```

In [253...
```
df_test.shape
```

Out[253...
```
(120800, 14)
```

Test Group

In [254...
```
pd.DataFrame(df_test.describe()).T
```

Out[254...

	count	mean	std	min	25%	50%	75%	max
TOPNEWS_IMPRESSION_COUNT	120800.0	32.742334	72.739398	0.0	3.0	11.0	30.0	6307.0
TOPNEWS_CLICKED_COUNT	120800.0	3.036904	7.203524	0.0	0.0	1.0	3.0	249.0
ADS_IMPRESSION_TOPNEWS_COUNT	120800.0	5.052161	13.642765	0.0	0.0	1.0	4.0	368.0
ADS_CLICKED_TOPNEWS_COUNT	120800.0	0.050224	0.380511	0.0	0.0	0.0	0.0	22.0
MYNEWS_COUNT	120800.0	28.321498	229.315858	0.0	0.0	0.0	2.0	18792.0
ARTICLE_MYNEWS_CLICKED_COUNT	120800.0	1.404180	8.504191	0.0	0.0	0.0	0.0	535.0
ADS_IMPRESSION_MYNEWS_COUNT	120800.0	2.534371	25.779682	0.0	0.0	0.0	0.0	2027.0
ADS_CLICKED_MYNEWS_COUNT	120800.0	0.011937	0.245031	0.0	0.0	0.0	0.0	40.0
Total_Ads_Imp	120800.0	7.586531	33.426998	0.0	0.0	1.0	5.0	2028.0
Total_News_Imp	120800.0	61.063833	263.674918	0.0	4.0	13.0	39.0	18890.0
Total_Ads_Clicked	120800.0	0.062161	0.488379	0.0	0.0	0.0	0.0	50.0
Total_News_Clicked	120800.0	4.441084	12.899031	0.0	0.0	1.0	4.0	618.0

Control Group

In [255...
```
pd.DataFrame(df_control.describe()).T
```

Out[255...

	count	mean	std	min	25%	50%	75%	max
TOPNEWS_IMPRESSION_COUNT	114194.0	34.822267	73.922519	0.0	3.0	11.0	32.0	1940.0
TOPNEWS_CLICKED_COUNT	114194.0	2.930495	6.379948	0.0	0.0	1.0	3.0	293.0
ADS_IMPRESSION_TOPNEWS_COUNT	114194.0	6.134035	14.875777	0.0	0.0	1.0	5.0	371.0
ADS_CLICKED_TOPNEWS_COUNT	114194.0	0.068445	0.453441	0.0	0.0	0.0	0.0	22.0
MYNEWS_COUNT	114194.0	42.060572	271.514131	0.0	0.0	0.0	8.0	22126.0
ARTICLE_MYNEWS_CLICKED_COUNT	114194.0	2.181542	9.896710	0.0	0.0	0.0	1.0	500.0
ADS_IMPRESSION_MYNEWS_COUNT	114194.0	5.886684	34.082411	0.0	0.0	0.0	1.0	1747.0
ADS_CLICKED_MYNEWS_COUNT	114194.0	0.041675	0.500126	0.0	0.0	0.0	0.0	106.0
Total_Ads_Imp	114194.0	12.020719	44.316414	0.0	0.0	1.0	7.0	1854.0
Total_News_Imp	114194.0	76.882840	312.738454	0.0	4.0	12.0	46.0	23003.0
Total_Ads_Clicked	114194.0	0.110120	0.748929	0.0	0.0	0.0	0.0	108.0
Total_News_Clicked	114194.0	5.112037	13.926066	0.0	0.0	1.0	4.0	729.0

A significant diffference in mean, median, max values suggests, there are outliers in the data.

Outlier Boundary = Q3 + 1.5 IQR

We will cap all upward outliers at value of the outlier boundary.

In [201...

```
def treat_outliers(df_sub:pd.DataFrame):
    df_final=pd.DataFrame()
    cols= ['TOPNEWS_IMPRESSION_COUNT', 'Total_Ads_Imp', 'Total_News_Imp', 'Total_Ads
    for col in cols:
        q1 = np.percentile(df_sub[col],25)
        q3 = np.percentile(df_sub[col],75)
        iqr = q3-q1
        outlier_cap = q3 + (1.5*iqr)
        df_final[col] = np.where(df_sub[col]>outlier_cap, outlier_cap, df_sub[col])
    return df_final
```

In [202...

```
clean_test = treat_outliers(df_test)
clean_control = treat_outliers(df_control)
```

In [198...

```
### Adding a Success-Metric
clean_test['Ads_Yes']=(clean_test['Total_Ads_Imp']>0).astype(int)
clean_control['Ads_Yes']=(clean_control['Total_Ads_Imp']>0).astype(int)
# clean_test.at[:,"Group"]="Test"
# clean_control.at[:,"Group"]="Control"
# df_clean = pd.concat([clean_test,clean_control])
# df_clean.head(5)
df_clean.to_csv('df_clean.csv', index=False)
```

In [203...

```
pd.DataFrame(clean_test.describe()).T
```

Out[203...

	count	mean	std	min	25%	50%	75%	max
TOPNEWS_IMPRESSION_COUNT	120800.0	20.866043	23.144631	0.0	3.0	11.0	30.0	70.5
Total_Ads_Imp	120800.0	3.117695	4.317144	0.0	0.0	1.0	5.0	12.5
Total_News_Imp	120800.0	26.988464	30.801633	0.0	4.0	13.0	39.0	91.5
Total_Ads_Clicked	120800.0	0.000000	0.000000	0.0	0.0	0.0	0.0	0.0
Total_News_Clicked	120800.0	2.570050	3.300685	0.0	0.0	1.0	4.0	10.0

In [204...

```
pd.DataFrame(clean_control.describe()).T
```

Out[204...

	count	mean	std	min	25%	50%	75%	max
TOPNEWS_IMPRESSION_COUNT	114194.0	22.053015	25.060955	0.0	3.0	11.0	32.0	75.5
Total_Ads_Imp	114194.0	4.642656	6.270731	0.0	0.0	1.0	7.0	17.5
Total_News_Imp	114194.0	31.216649	37.692420	0.0	4.0	12.0	46.0	109.0
Total_Ads_Clicked	114194.0	0.000000	0.000000	0.0	0.0	0.0	0.0	0.0
Total_News_Clicked	114194.0	2.794043	3.467166	0.0	0.0	1.0	4.0	10.0

The outliers have been removed and yet, mean is more than double the value of the median. This suggests that data is highly right-skewed.

Also mean of control-group appear to be higher than that of the test group.

The clicks are almost negligent, hence will proceed with analysing impressions alone.

H0: The new UI did not make any significant improvement in the impressions.

H1: The new UI improved the impression count

In [379...

```
## Checking the mean & standard-deviation of control & test population after clean-u
print("Top-News Impressions")
print("\nMean\nControl\t\tTest\n",format(clean_control['TOPNEWS_IMPRESSION_COUNT'].m
print("\nStandard Deviation\nControl\t\tTest\n",format(clean_control['TOPNEWS_IMPRES

print("\nTotal-News Impressions")
print("\nMean\nControl\t\tTest\n",format(clean_control['Total_News_Imp'].mean(),".3f
print("\nStandard Deviation\nControl\t\tTest\n",format(clean_control['Total_News_Imp

print("\nTotal Ad Impressions")
print("\nMean\nControl\t\tTest\n",format(clean_control['Total_Ads_Imp'].mean(),".3f"
print("\nStandard Deviation\nControl\t\tTest\n",format(clean_control['Total_Ads_Imp'
```

```
Top-News Impressions

Mean
Control         Test
 22.053          20.866

Standard Deviation
Control         Test
 25.061          23.145
```

```
Total-News Impressions

Mean
Control         Test
 31.217          26.988

Standard Deviation
Control         Test
 37.692          30.802

Total Ad Impressions

Mean
Control         Test
 4.643           3.118

Standard Deviation
Control         Test
 6.271           4.317
```

In [163…

```
from scipy.stats import shapiro
import scipy.stats as stats
from scipy.stats import mannwhitneyu
```

In [413…

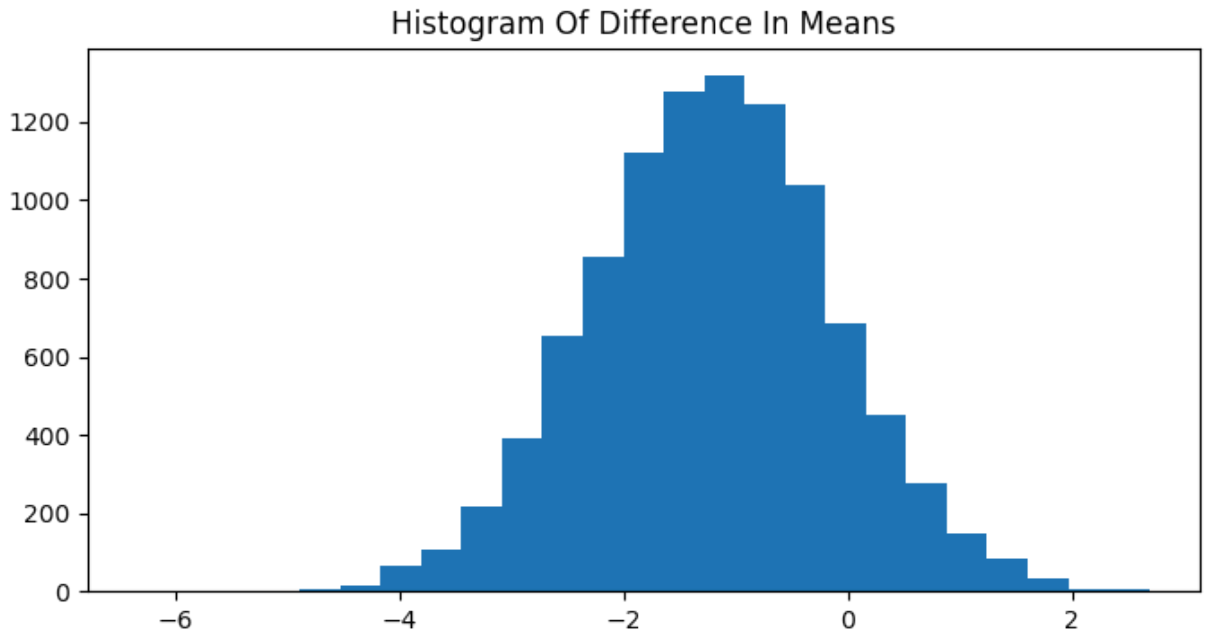
```
# Creating the sampling distribution of difference in means

def stat_test(control,test,metric):
    means_diff = []
    wstats=[]
    size = df.shape[0]
    for _ in range(10000):
        test_sample = test.sample(1000, replace=False)
        control_sample = control.sample(1000, replace=False)
        control_mean = control_sample[metric].mean()
        test_mean = test_sample[metric].mean()
        w, p = sstats.ttest_ind(test_sample[metric],control_sample[metric], equal_va
        wstats.append(w)
        means_diff.append(test_mean - control_mean)

    print("Mean Of Test Group Better Than Control:\n",format((sum(np.array(means_dif
    print("W-Stats Indicating Test Group Is Better Than Control:\n",(sum(np.array(ws
    plt.figure(figsize = (8,4), dpi = 100)
    plt.hist(means_diff, bins = 25)
    plt.title("Histogram Of Difference In Means")
    plt.show()
```

Probability Of Test Group Being Better Than Control Group

In [414…

```
stat_test(clean_control,clean_test,'TOPNEWS_IMPRESSION_COUNT')
```

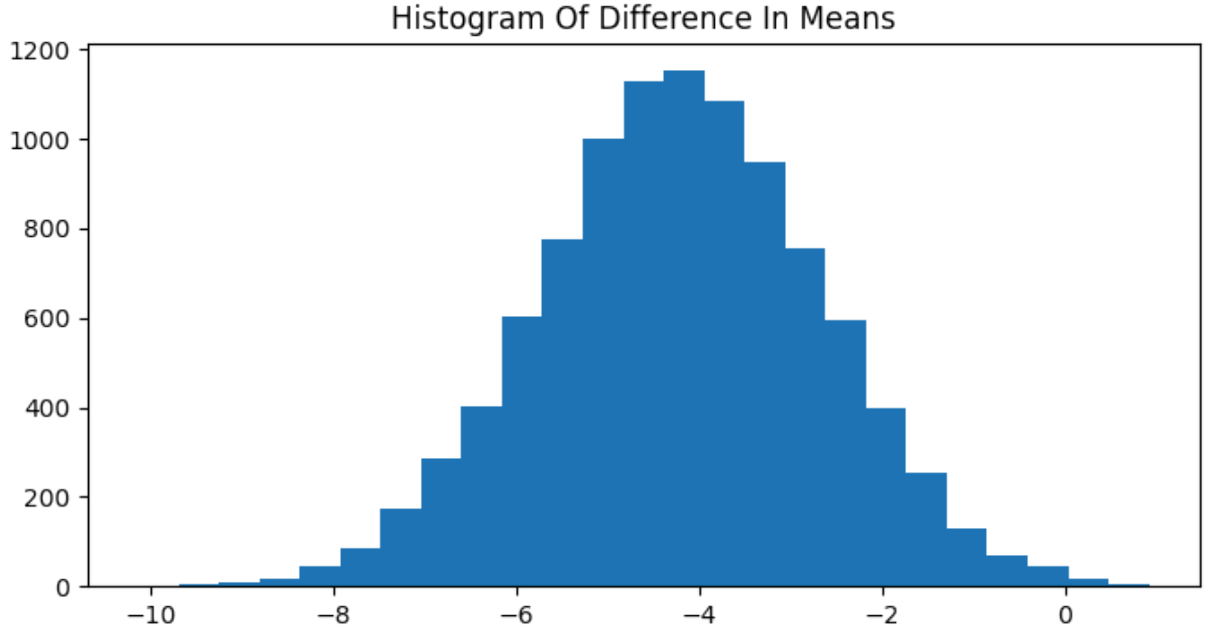
```
Mean Of Test Group Better Than Control:
 12.91 %
W-Stats Indicating Test Group Is Better Than Control:
 0.25 %
```



In [415…

```
stat_test(clean_control,clean_test,'Total_News_Imp')
```

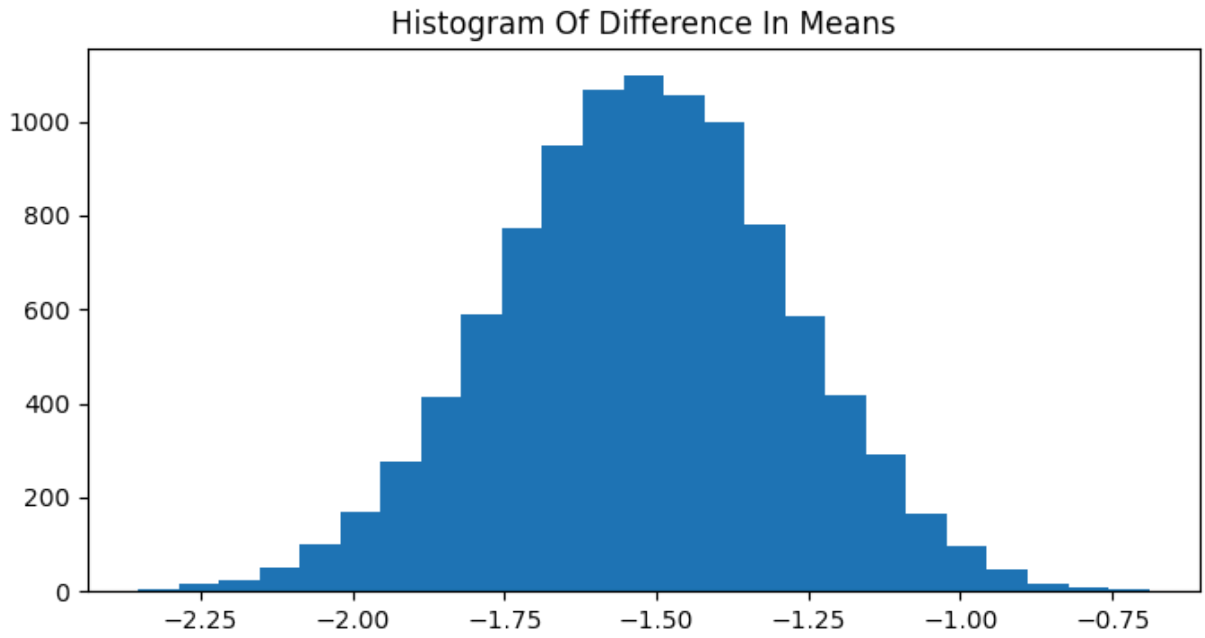
```
Mean Of Test Group Better Than Control:
 0.23 %
W-Stats Indicating Test Group Is Better Than Control:
 0.0 %
```



In [416…

```
stat_test(clean_control,clean_test,'Total_Ads_Imp')
```

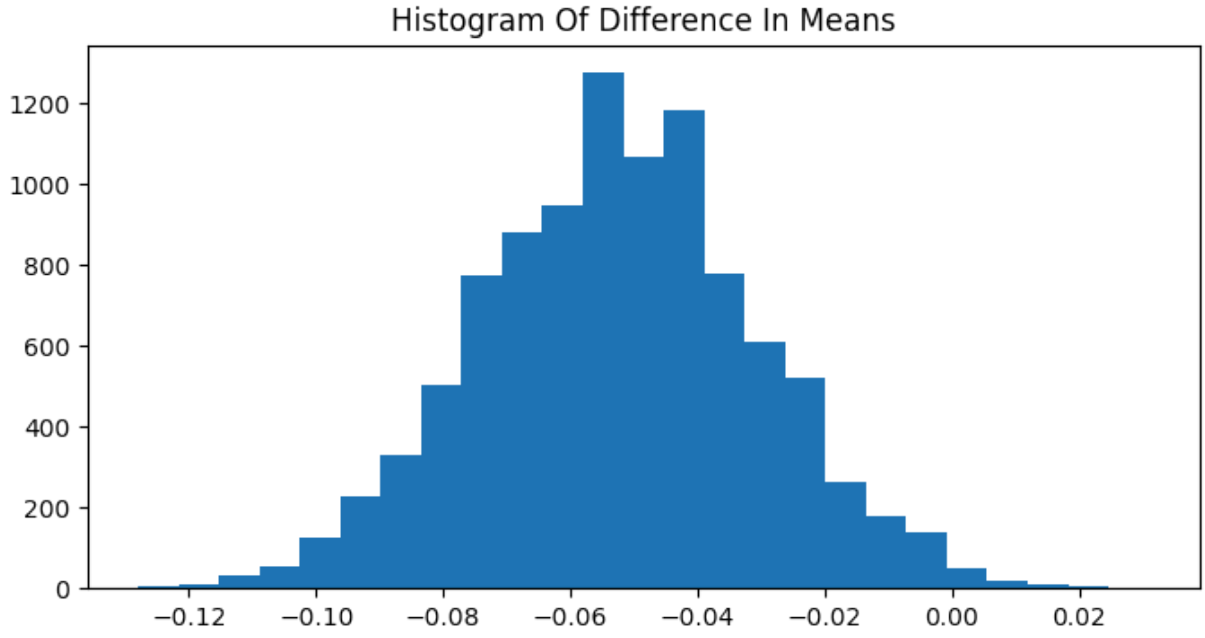
```
Mean Of Test Group Better Than Control:
 0.00 %
W-Stats Indicating Test Group Is Better Than Control:
 0.0 %
```



In [417…

```
### Adding a Success-Metric
clean_test['Ads_Yes']=(clean_test['Total_Ads_Imp']>0).astype(int)
clean_control['Ads_Yes']=(clean_control['Total_Ads_Imp']>0).astype(int)

stat_test(clean_control,clean_test,'Ads_Yes')
```

```
Mean Of Test Group Better Than Control:
 0.80 %
W-Stats Indicating Test Group Is Better Than Control:
 0.0 %
```



A/B Testing Of Success Metric

In [373…

```
## The median Ad-Impression in both control & test group is 0.
## If a person has got atleast 1 Ad impression, it means he has browsed through news
## We need more users who have viewed an ad, than the same user viewing multiple ads
## So we take user-id count of people who have had atleast an Ad impression.

clean_test.loc[:,"Group"]="Test"
clean_control.loc[:,"Group"]="Control"
```

```
ab_test = pd.concat([clean_test,clean_control])
ab_test = ab_test.reset_index(drop=True)
ab_test.head(2)
```

Out[373...

	TOPNEWS_IMPRESSION_COUNT	Total_Ads_Imp	Total_News_Imp	Total_Ads_Clicked	Total_News_Clic
0	4.0	0.0	4.0	0.0	
1	70.5	0.0	91.5	0.0	

In [374...

```
conversion_rates = ab_test.groupby('Group')['Ads_Yes']

std_p = lambda x: np.std(x, ddof=0)              # Std. deviation of the proportion
se_p = lambda x: stats.sem(x, ddof=0)            # Std. error of the proportion (std

conversion_rates = conversion_rates.agg([np.mean, std_p, se_p])
conversion_rates.columns = ['success_rate', 'std_deviation', 'std_error']
conversion_rates.style.format('{:.3f}')
```

Out[374...

Group	success_rate	std_deviation	std_error
Control	0.615	0.487	0.001
Test	0.562	0.496	0.001

In [375...

```
from statsmodels.stats.proportion import proportions_ztest, proportion_confint
controls = clean_control['Ads_Yes']
treatments = clean_test['Ads_Yes']
num_ctrl = controls.count()
num_treat = treatments.count()
successes = [controls.sum(), treatments.sum()]
tots = [num_ctrl, num_treat]

z_stat, pval = proportions_ztest(successes, nobs=tots)
(lower_con, lower_treat), (upper_con, upper_treat) = proportion_confint(successes, n

print(f'z statistic: {z_stat:.2f}')
print(f'p-value: {pval:.3f}')
print(f'ci 95% for control group: [{lower_con:.3f}, {upper_con:.3f}]')
print(f'ci 95% for treatment group: [{lower_treat:.3f}, {upper_treat:.3f}]')
```

```
z statistic: 25.93
p-value: 0.000
ci 95% for control group: [0.612, 0.618]
ci 95% for treatment group: [0.560, 0.565]
```

In [376...

```
## Random Sample
test_sample = clean_test.sample(1000, replace=False)
control_sample = clean_control.sample(1000, replace=False)


controls = control_sample['Ads_Yes']
treatments = test_sample['Ads_Yes']
num_ctrl = controls.count()
num_treat = treatments.count()
successes = [controls.sum(), treatments.sum()]
tots = [num_ctrl, num_treat]
```

```
z_stat, pval = proportions_ztest(successes, nobs=tots)
(lower_con, lower_treat), (upper_con, upper_treat) = proportion_confint(successes, n

print(f'z statistic: {z_stat:.2f}')
print(f'p-value: {pval:.3f}')
print(f'ci 95% for control group: [{lower_con:.3f}, {upper_con:.3f}]')
print(f'ci 95% for treatment group: [{lower_treat:.3f}, {upper_treat:.3f}]')
```

```
z statistic: 2.14
p-value: 0.033
ci 95% for control group: [0.585, 0.645]
ci 95% for treatment group: [0.537, 0.599]
```

Conclusion:

At alpha value of 0.05, the z-critical value is 1.64.

With a p-value < 0.05, the H0 that there is no change in metrics can be rejected.

The z-statistics obtained is consistently higher than the critical value, implying there is strong evidence that control-group is better than treatment group.

In [436…

```
## Random Sample for A/A Testing
test_sample_one = clean_test.sample(1000, replace=False)
remaining_indexes = list(set(clean_test.index).difference(set(test_sample_one.index)
test_sample_two = clean_test.iloc[remaining_indexes,:].sample(1000, replace=False)

controls = test_sample_one['Ads_Yes']
treatments = test_sample_two['Ads_Yes']
num_ctrl = controls.count()
num_treat = treatments.count()
successes = [controls.sum(), treatments.sum()]
tots = [num_ctrl, num_treat]

z_stat, pval = proportions_ztest(successes, nobs=tots)
(lower_con, lower_treat), (upper_con, upper_treat) = proportion_confint(successes, n

print(f'z statistic: {z_stat:.2f}')
print(f'p-value: {pval:.3f}')
print(f'ci 95% for control group: [{lower_con:.3f}, {upper_con:.3f}]')
print(f'ci 95% for treatment group: [{lower_treat:.3f}, {upper_treat:.3f}]')
```

```
z statistic: -0.23
p-value: 0.822
ci 95% for control group: [0.523, 0.585]
ci 95% for treatment group: [0.528, 0.590]
```

NOTE: The A/A testing on 2 samples from the treatment group has a high p-value, implying that there is no significant difference within the treatment group and the user experience is same across.