User Total Active Time as Metric

In [629]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from scipy import stats
```

In [630]:
```
# reading the data sets
t1_user_active_min     = pd.read_csv("t1_user_active_min.csv")
t2_user_variant        = pd.read_csv("t2_user_variant.csv")
t3_user_active_min_pre = pd.read_csv("t3_user_active_min_pre.csv")
t4_user_attributes     = pd.read_csv("t4_user_attributes.csv")
```

Use table 1 and 2

In [631]:
```
t1_user_active_min.head()
```

Out[631]:

	uid	dt	active_mins
0	0	2019-02-22	5.0
1	0	2019-03-11	5.0
2	0	2019-03-18	3.0
3	0	2019-03-22	4.0
4	0	2019-04-03	9.0

In [632]:
```
t2_user_variant.head()
```

Out[632]:

	uid	variant_number	dt	signup_date
0	0	0	2019-02-06	2018-09-24
1	1	0	2019-02-06	2016-11-07
2	2	0	2019-02-06	2018-09-17
3	3	0	2019-02-06	2018-03-04
4	4	0	2019-02-06	2017-03-09

In [633]:
```
# Drop data with active_mins more than (24 hrs * 60 mins) on a single da
te.
t1_user_active_min = t1_user_active_min[t1_user_active_min.active_mins <
= 24*60]
```

In [634]:
```
# Total minutes per user
t1_user_active_min_total = t1_user_active_min.groupby(by=['uid'], as_ind
ex=False).sum()
```

In [635]:
```
# merge t1 and t2 by uid
t12 = pd.merge(t2_user_variant, t1_user_active_min_total, on='uid')
```

In [636]:
```
t12.head()
```

Out[636]:

	uid	variant_number	dt	signup_date	active_mins
0	0	0	2019-02-06	2018-09-24	43.0
1	1	0	2019-02-06	2016-11-07	15205.0
2	2	0	2019-02-06	2018-09-17	17.0
3	3	0	2019-02-06	2018-03-04	77.0
4	4	0	2019-02-06	2017-03-09	39.0

In [637]:
```
t12.variant_number.value_counts()
```

Out[637]:
```
0    37425
1     9208
Name: variant_number, dtype: int64
```

Compute confidence interval on difference of means.

In [638]:
```
stats12 = t12.groupby(['variant_number'])['active_mins'].agg(['mean', 'c
ount', 'std','var'])
stats12
```

Out[638]:

variant_number	mean	count	std	var
0	458.221162	37425	1653.447132	2.733887e+06
1	458.402476	9208	1680.571091	2.824319e+06

In [639]:
```
sigma_diff = np.sqrt(stats12.loc[0]['var'] / stats12.loc[0]['count'] +
                     stats12.loc[1]['var'] / stats12.loc[1]['count'])
upper = (stats12.loc[1]['mean'] - stats12.loc[0]['mean']) + (1.96 * sigm
a_diff)
lower = (stats12.loc[1]['mean'] - stats12.loc[0]['mean']) - (1.96 * sigm
a_diff)
print([lower, upper])
```

```
[-38.01476992103114, 38.37739748719736]
```

Perform a t-test:

In [640]:
```
stats.ttest_ind(t12.active_mins[t12.variant_number==1], t12.active_mins[
t12.variant_number==0], equal_var =False)
```

Out[640]:
```
Ttest_indResult(statistic=0.009303964709989936, pvalue=0.99257675062736
44)
```

The high p-value suggests INSUFFICIENT evidence for the new UI design to make a positive impact on total active time per user.

Add Table 3

In [641]:
```
t3_user_active_min_pre.head()
```

Out[641]:

	uid	dt	active_mins
0	0	2018-09-24	3.0
1	0	2018-11-08	4.0
2	0	2018-11-24	3.0
3	0	2018-11-28	6.0
4	0	2018-12-02	6.0

In [642]:
```
# Drop data with active_mins more than (24 hrs * 60 mins) on a single da
te.
t3_user_active_min_pre = t3_user_active_min_pre[t3_user_active_min_pre.a
ctive_mins <= 24*60]
```

In [643]:
```
# Total minutes per user
t3_user_active_min_pre_total = t3_user_active_min_pre.groupby(by=['uid'
], as_index=False).sum()
```

In [644]:
```
t123 = pd.merge(t12, t3_user_active_min_pre_total, on='uid', suffixes=(
'_post', '_pre'))
```

In [645]:
```
t123.head()
```

Out[645]:

	uid	variant_number	dt	signup_date	active_mins_post	active_mins_pre
0	0	0	2019-02-06	2018-09-24	43.0	70.0
1	1	0	2019-02-06	2016-11-07	15205.0	19158.0
2	2	0	2019-02-06	2018-09-17	17.0	37.0
3	3	0	2019-02-06	2018-03-04	77.0	108.0
4	4	0	2019-02-06	2017-03-09	39.0	66.0

In [646]:
```
t123['active_mins_diff'] = t123['active_mins_post'] - t123['active_mins_pre']
```

In [648]:
```
stats123 = t123.groupby(['variant_number'])['active_mins_post', 'active_mins_pre', 'active_mins_diff'].agg(['mean', 'count', 'std','var'])
stats123
```

Out[648]:

	active_mins_post				active_mins_pre			
	mean	count	std	var	mean	count	std	v
variant_number								
0	459.544824	37313	1655.747990	2.741501e+06	506.84027	37313	1874.763969	3
1	460.465139	9165	1684.238222	2.836658e+06	295.81102	9165	1118.898491	1

Difference in difference

For each user, first obtain difference in post-test total time and pre-test total time: $\Delta x_1 \equiv x_{1,post} - x_{1,pre}$ and $\Delta x_2 \equiv x_{0,post} - x_{0,pre}$

Then obtain the difference in mean: $\overline{\Delta x_1} - \overline{\Delta x_2}$

Standard Error: $\sqrt{\frac{s^2_{\Delta x_1}}{n_1} + \frac{s^2_{\Delta x_2}}{n_1}}$

In [649]:
```
mean_did = stats123.loc[1,'active_mins_diff']['mean'] - stats123.loc[0,
'active_mins_diff']['mean']

sigma_did = np.sqrt(stats123.loc[1,'active_mins_diff']['var'] / stats123
.loc[1,'active_mins_diff']['count'] +
                    stats123.loc[0,'active_mins_diff']['var'] / stats123
.loc[0,'active_mins_diff']['count'])

upper = mean_did + (1.96 * sigma_did)
lower = mean_did - (1.96 * sigma_did)
print([lower, upper])
```

```
[188.86398661059266, 235.03514450519842]
```

Perform a t-test:

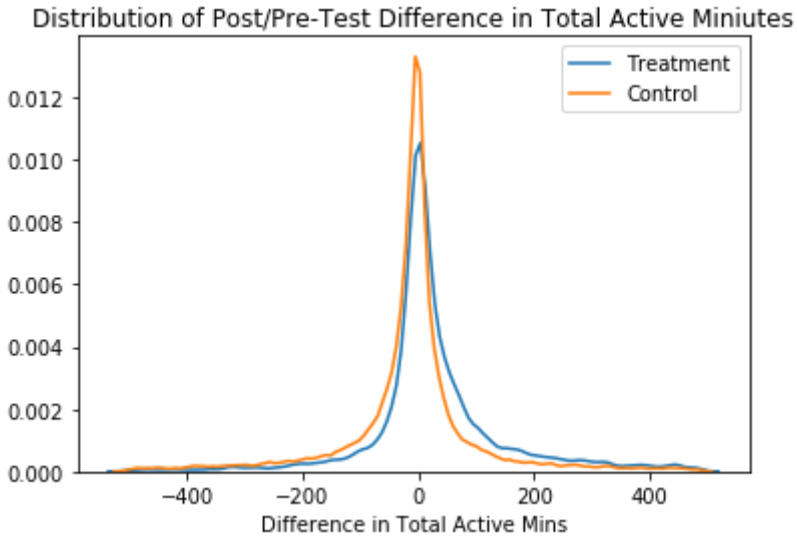
In [650]:
```
stats.ttest_ind(t123.active_mins_diff[t123.variant_number==1], t123.acti
ve_mins_diff[t123.variant_number==0], equal_var =False)
```

Out[650]:
```
Ttest_indResult(statistic=17.994833460393252, pvalue=1.462502346186859e
-71)
```

The low p-value suggests high evidence for the new UI design to make a positive impact on total active time per user.

In [651]:
```
def build_dist(df1, df2, col1, col2, xlabel, legend1, legend2, title):
    sns.distplot(df1[col1], hist=False, label = legend1, axlabel = xlabe
l)
    sns.distplot(df2[col2], hist=False, label = legend2, axlabel = xlabe
l)
    plt.title(title)
    #plt.xlim([-1000,1000])
    plt.show()
```

In [652]:
```
build_dist(t123[(t123.variant_number==1) &
                (t123.active_mins_diff < t123.active_mins_diff.quantile(
0.95)) &
                (t123.active_mins_diff > t123.active_mins_diff.quantile(
0.05))],
           t123[(t123.variant_number==0) &
                (t123.active_mins_diff < t123.active_mins_diff.quantile(
0.95)) &
                (t123.active_mins_diff > t123.active_mins_diff.quantile(
0.05))],
           "active_mins_diff","active_mins_diff","Difference in Total Ac
tive Mins", "Treatment","Control",
           title='Distribution of Post/Pre-Test Difference in Total Acti
ve Miniutes')
```



Add Table 4

In [654]:
```
t4_user_attributes.head()
```

Out[654]:

	uid	gender	user_type
0	0	male	non_reader
1	1	male	reader
2	2	male	non_reader
3	3	male	non_reader
4	4	male	non_reader

In [655]:
```
t1234 = pd.merge(t4_user_attributes, t123, on='uid')
```

In [656]:
```
t1234.head()
```

Out[656]:

	uid	gender	user_type	variant_number	dt	signup_date	active_mins_post	active_mins_pr
0	0	male	non_reader	0	2019-02-06	2018-09-24	43.0	70.
1	1	male	reader	0	2019-02-06	2016-11-07	15205.0	19158.
2	2	male	non_reader	0	2019-02-06	2018-09-17	17.0	37.
3	3	male	non_reader	0	2019-02-06	2018-03-04	77.0	108.
4	4	male	non_reader	0	2019-02-06	2017-03-09	39.0	66.

In [657]:
```
pd.crosstab(t1234['variant_number'],t1234['gender']).apply(lambda r: r/r.sum(), axis=1)
```

Out[657]:

gender	female	male	unknown
variant_number			
0	0.286737	0.561493	0.151770
1	0.282815	0.559083	0.158101

In [658]:
```
pd.crosstab(t1234['variant_number'],t1234['user_type']).apply(lambda r: r/r.sum(), axis=1)
```

Out[658]:

user_type	contributor	new_user	non_reader	reader
variant_number				
0	0.024415	0.061185	0.735240	0.17916
1	0.013857	0.084015	0.764648	0.13748

In [659]:
```
pd.crosstab(t1234['gender'],t1234['user_type']).apply(lambda r: r/r.sum(), axis=1)
```

Out[659]:

user_type	contributor	new_user	non_reader	reader
gender				
female	0.018734	0.074637	0.745166	0.161463
male	0.025849	0.055801	0.732579	0.185772
unknown	0.016170	0.085208	0.764342	0.134280

Gender

In [660]:
```
stats1234_gender = t1234.groupby(['variant_number','gender'])['active_mi
ns_post', 'active_mins_pre', 'active_mins_diff'].agg(['mean', 'count',
'var'])
stats1234_gender
```

Out[660]:

		active_mins_post			active_mins_pre			ac
		mean	count	var	mean	count	var	me
variant_number	gender							
0	female	347.295635	10699	1.775838e+06	388.001309	10699	2.291656e+06	-4
	male	555.593957	20951	3.547350e+06	602.397213	20951	4.430440e+06	-4
	unknown	316.268939	5663	1.506830e+06	377.835246	5663	2.361617e+06	-6
1	female	355.527778	2592	1.705491e+06	224.615741	2592	6.196977e+05	13
	male	534.548009	5124	3.581443e+06	341.800546	5124	1.663136e+06	19
	unknown	386.204969	1449	2.184961e+06	260.536922	1449	9.123354e+05	12

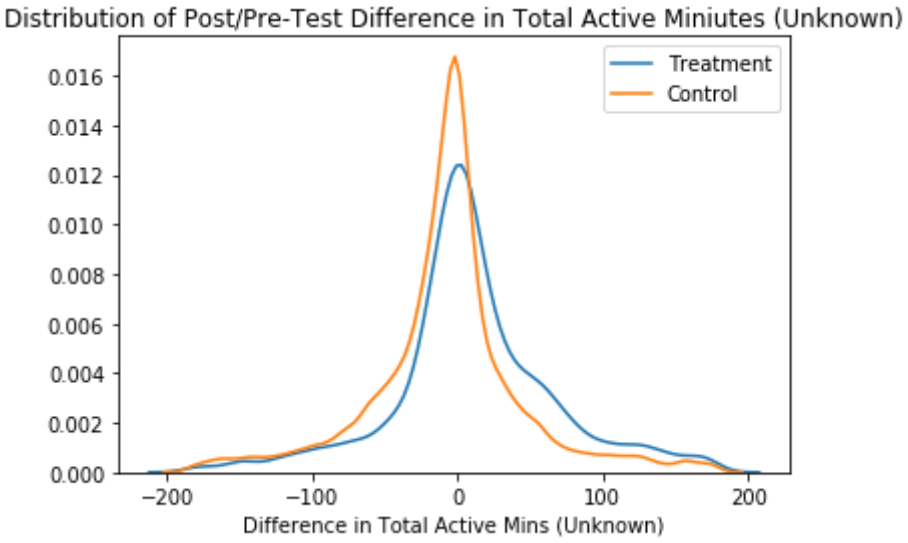
In [714]:
```
def ConfidenceInterval(stats, attribute):
    mean_did = stats.loc[1, attribute]['active_mins_diff', 'mean'] - sta
ts.loc[0,attribute]['active_mins_diff', 'mean']
    SE_did = np.sqrt(stats.loc[1, attribute]['active_mins_diff','var'] /
stats.loc[1, attribute]['active_mins_diff','count'] +
                     stats.loc[0, attribute]['active_mins_diff','var'] /
stats.loc[0, attribute]['active_mins_diff','count'])

    upper = mean_did + (1.96 * SE_did)
    lower = mean_did - (1.96 * SE_did)
    return [lower, upper]
```

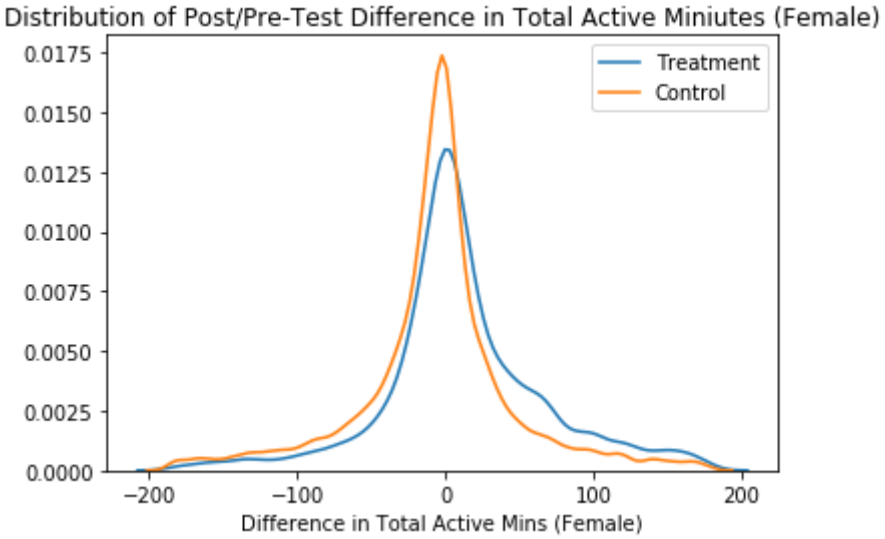
In [715]:
```
intervals = {}
for g in set(t4_user_attributes['gender']):
    intervals[g] = ConfidenceInterval(stats1234_gender, g)
    print(g, ':', ConfidenceInterval(stats1234_gender, g))
```

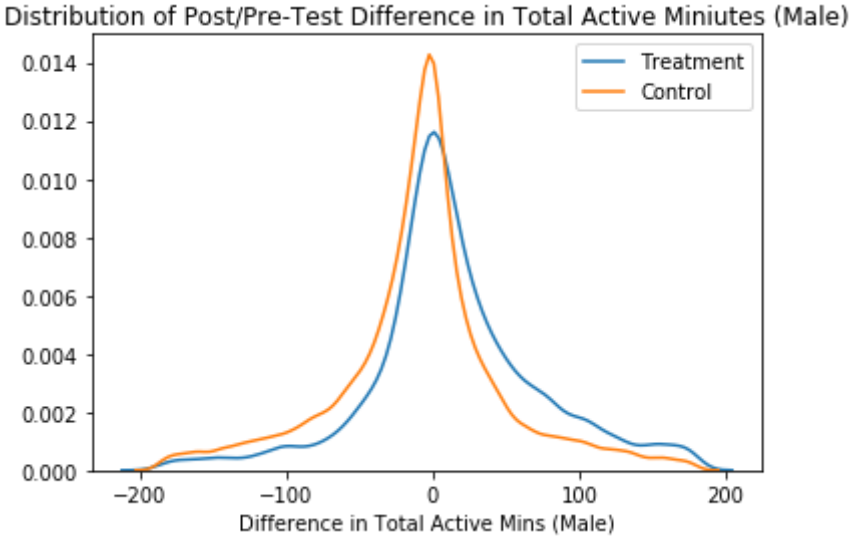
```
unknown : [136.26857431526759, 238.20013476417938]
female : [134.88598802514008, 208.34943290378027]
male : [205.61842607578922, 273.4830101924954]
```

In [767]:

```
for g in set(t4_user_attributes['gender']):
    build_dist(t1234[(t1234.variant_number==1) & (t1234.gender==g) &
                 (t1234.active_mins_diff < t1234.active_mins_diff.quantil
e(0.90)) &
                 (t1234.active_mins_diff > t1234.active_mins_diff.quantil
e(0.10))],
            t1234[(t1234.variant_number==0) & (t1234.gender==g) &
                 (t1234.active_mins_diff < t1234.active_mins_diff.quantil
e(0.9)) &
                 (t1234.active_mins_diff > t1234.active_mins_diff.quantil
e(0.1))],
            "active_mins_diff","active_mins_diff","Difference in Total Ac
tive Mins " + '(' + g.title() + ')', "Treatment","Control",
            title='Distribution of Post/Pre-Test Difference in Total Acti
ve Miniutes ' + '(' + g.title() + ')')
```


Distribution of Post/Pre-Test Difference in Total Active Miniutes (Unknown)
Treatment
Control
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
−200
−100
0
100
200
Difference in Total Active Mins (Unknown)


Distribution of Post/Pre-Test Difference in Total Active Miniutes (Female)
Treatment
Control
0.0175
0.0150
0.0125
0.0100
0.0075
0.0050
0.0025
0.0000
−200
−100
0
100
200
Difference in Total Active Mins (Female)


Distribution of Post/Pre-Test Difference in Total Active Miniutes (Male)
Treatment
Control
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
−200
−100
0
100
200
Difference in Total Active Mins (Male)

User Type

In [664]:
```
stats1234_user_type = t1234.groupby(['variant_number','user_type'])['active_mins_post', 'active_mins_pre', 'active_mins_diff'].agg(['mean', 'count', 'var'])
stats1234_user_type
```

Out[664]:

		active_mins_post			active_mins_pre		
		mean	count	var	mean	count	var
variant_number	user_type						
0	contributor	4309.835346	911	3.489298e+07	4967.092206	911	4.838156e+07
	new_user	29.132720	2283	2.346789e+04	6.105563	2283	8.846519e+01
	non_reader	104.923671	27434	1.121262e+05	108.010352	27434	9.982839e+04
	reader	1537.135378	6685	6.323741e+06	1706.748691	6685	7.733619e+06
1	contributor	4708.031496	127	5.280503e+07	3231.299213	127	2.824765e+07
	new_user	54.623377	770	4.513559e+04	6.487013	770	7.679892e+01
	non_reader	164.454623	7008	1.961370e+05	99.442066	7008	3.998564e+04
	reader	1926.734127	1260	9.683510e+06	1268.926984	1260	3.980188e+06

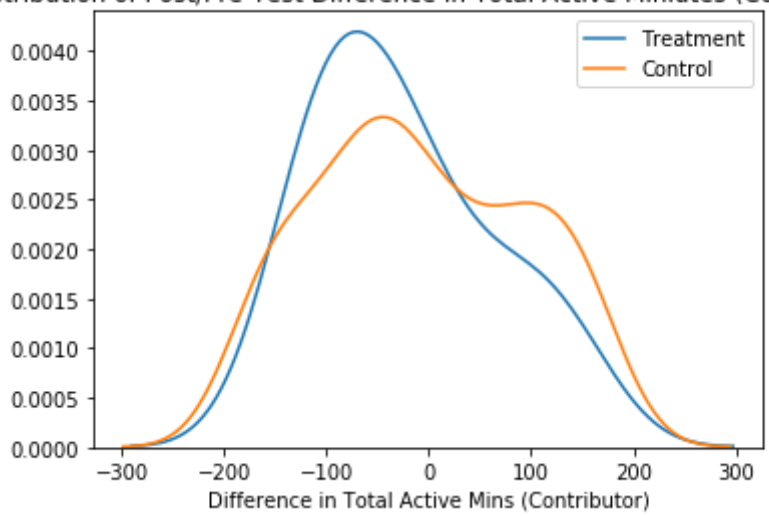
In [716]:
```
for g in set(t4_user_attributes['user_type']):
    intervals[g] = ConfidenceInterval(stats1234_user_type, g)
    print(g, ':', ConfidenceInterval(stats1234_user_type, g))
```

```
contributor : [1284.297301979685, 2983.680986134959]
non_reader : [58.15701884268577, 78.04145683476409]
reader : [710.25891739744, 944.5819950932107]
new_user : [8.967288343457433, 41.2511244308029]
```

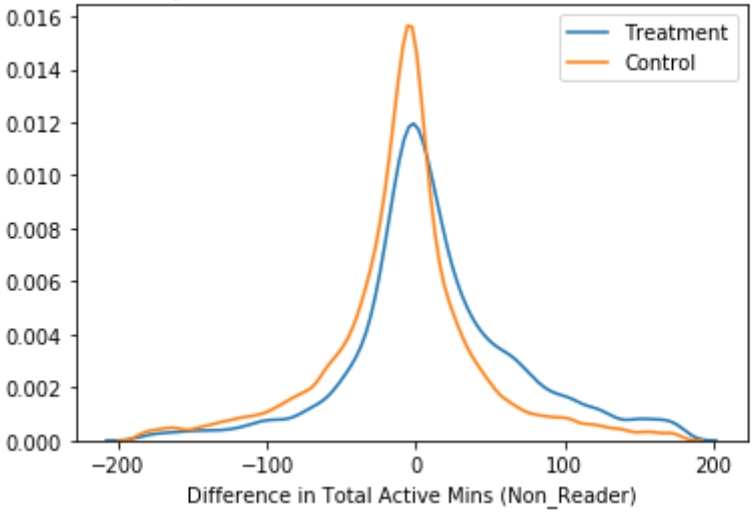
In [666]:

```
for g in set(t4_user_attributes['user_type']):
    build_dist(t1234[(t1234.variant_number==1) & (t1234.user_type==g) &
                (t1234.active_mins_diff < t1234.active_mins_diff.quantil
e(0.9)) &
                (t1234.active_mins_diff > t1234.active_mins_diff.quantil
e(0.10))],
            t1234[(t1234.variant_number==0) & (t1234.user_type==g) &
                (t1234.active_mins_diff < t1234.active_mins_diff.quantil
e(0.9)) &
                (t1234.active_mins_diff > t1234.active_mins_diff.quantil
e(0.1))],
            "active_mins_diff","active_mins_diff","Difference in Total Ac
tive Mins " + '(' + g.title() + ')', "Treatment","Control",
            title='Distribution of Post/Pre-Test Difference in Total Acti
ve Miniutes ' + '(' + g.title() + ')')
```

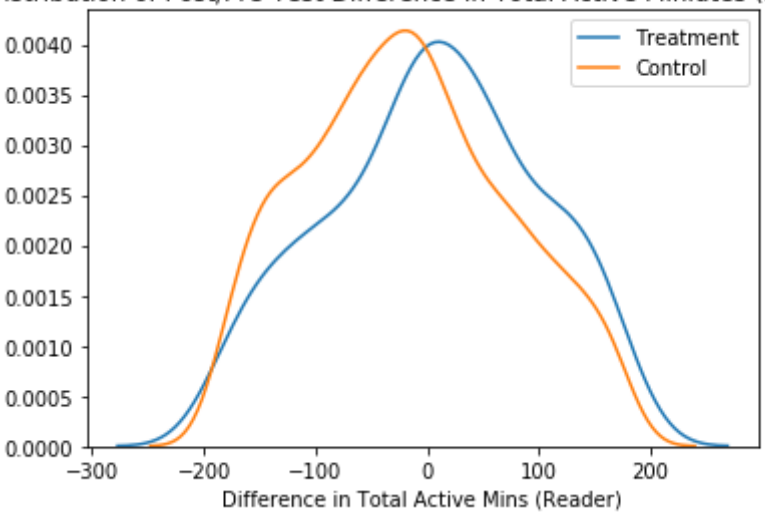
Distribution of Post/Pre-Test Difference in Total Active Miniutes (Contributor)

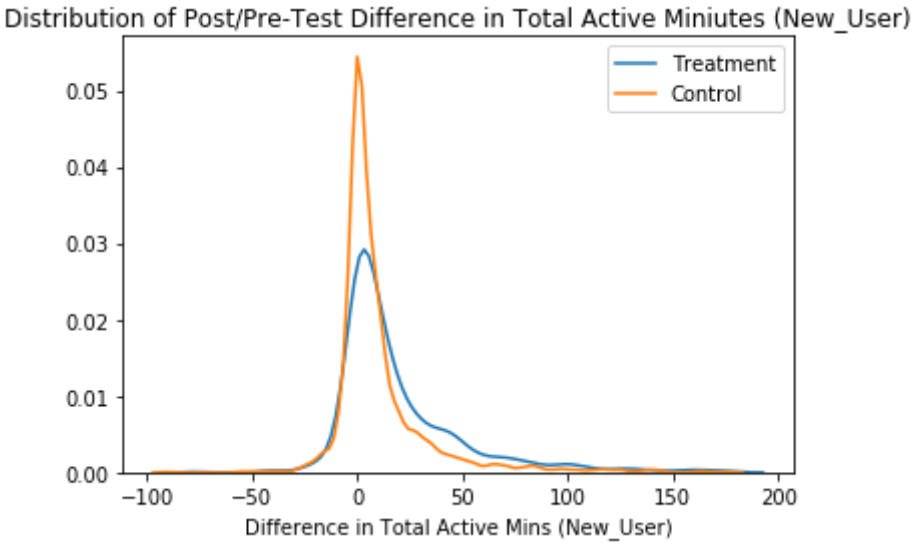


Distribution of Post/Pre-Test Difference in Total Active Miniutes (Non_Reader)



Distribution of Post/Pre-Test Difference in Total Active Miniutes (Reader)





Gender and User Type

In [706]:
```
stats1234 = t1234.groupby(['variant_number','user_type','gender'])['active_mins_post', 'active_mins_pre', 'active_mins_diff'].agg(['mean', 'count', 'var'])
stats1234
```

Out[706]:

			active_mins_post			active_mins_pre		
			mean	count	var	mean	count	var
variant_number	user_type	gender						
0	contributor	female	2891.901345	223	1.919445e+07	3680.219731	223	2.7
		male	4959.790541	592	4.056130e+07	5466.097973	592	5.5
		unknown	3595.520833	96	2.918201e+07	4879.187500	96	4.7
	new_user	female	28.274590	732	2.253973e+04	5.845628	732	5.3
		male	30.543119	1090	2.800025e+04	6.227523	1090	8.6
		unknown	27.160521	461	1.430522e+04	6.229935	461	1.4
	non_reader	female	91.746596	7932	1.876154e+05	97.312532	7932	2.0
		male	115.496277	15175	9.035496e+04	116.640461	15175	5.7
		unknown	92.000462	4327	4.926881e+04	97.354749	4327	5.4
	reader	female	1281.672737	1812	5.308603e+06	1409.699227	1812	6.4
		male	1689.815584	4094	7.074096e+06	1858.350513	4094	8.4
		unknown	1328.952503	779	4.437375e+06	1600.966624	779	6.6
1	contributor	female	3514.038462	26	2.606714e+07	2304.115385	26	5.3
		male	5354.695122	82	6.312565e+07	3830.280488	82	3.9
		unknown	3551.052632	19	4.398827e+07	1915.000000	19	7.1
	new_user	female	50.650000	260	1.585127e+04	6.334615	260	6.6
		male	58.923288	365	6.926217e+04	6.487671	365	8.0
		unknown	50.924138	145	3.735781e+04	6.758621	145	8.6
	non_reader	female	137.462475	1972	1.131500e+05	80.724645	1972	2.4
		male	184.613955	3927	2.676727e+05	108.973262	3927	4.0
		unknown	141.066727	1109	8.735659e+04	98.974752	1109	6.7
	reader	female	1634.485030	334	7.857262e+06	1082.218563	334	3.0
		male	2071.270667	750	1.057237e+07	1342.662667	750	4.2
		unknown	1865.420455	176	9.208636e+06	1309.034091	176	4.7

In [711]:
```
covariates = [[a,b] for a in set(t4_user_attributes['user_type']) for b in set(t4_user_attributes['gender'])]
len(covariates)
```

Out[711]: 12

In [712]:
```
def ConfidenceInterval_covariate(stats, covariate):
    mean_did = stats.loc[1, covariate[0], covariate[1]]['active_mins_dif
f', 'mean'] - stats.loc[0, covariate[0], covariate[1]]['active_mins_dif
f', 'mean']
    SE_did = np.sqrt(stats.loc[1, covariate[0], covariate[1]]['active_mi
ns_diff','var'] / stats.loc[1, covariate[0], covariate[1]]['active_mins_
diff','count'] +
                     stats.loc[0, covariate[0], covariate[1]]['active_mi
ns_diff','var'] / stats.loc[0, covariate[0], covariate[1]]['active_mins_
diff','count'])

    upper = mean_did + (1.96 * SE_did)
    lower = mean_did - (1.96 * SE_did)
    return [lower, upper]
```

In [717]:
```
for c in covariates:
    intervals['_'.join(c)] = ConfidenceInterval_covariate(stats1234, c)
    print(c, ':', ConfidenceInterval_covariate(stats1234, c))
```

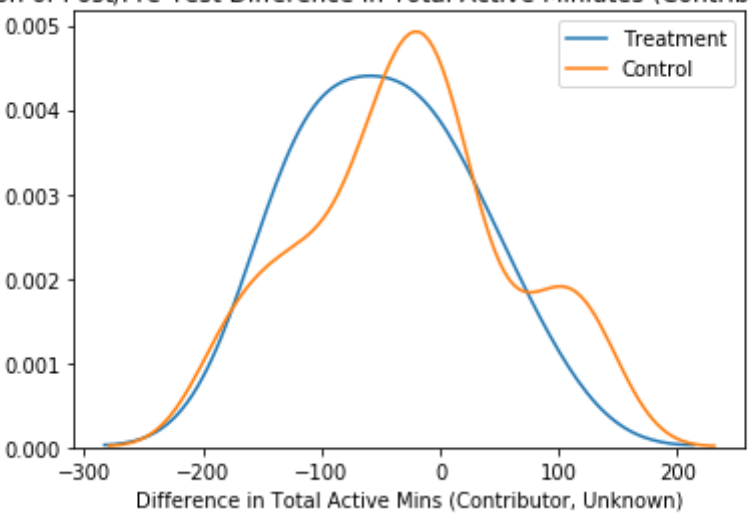
```
['contributor', 'unknown'] : [653.6048080357796, 5185.8337884554485]
['contributor', 'female'] : [343.4674981069095, 3653.0154270396924]
['contributor', 'male'] : [925.4251510097495, 3136.018982147799]
['non_reader', 'unknown'] : [28.39717566566377, 66.49534790818825]
['non_reader', 'female'] : [49.22753265482336, 75.3799974770583]
['non_reader', 'male'] : [61.20339354405016, 92.36636076534171]
['reader', 'unknown'] : [545.8458322158888, 1110.9551363918833]
['reader', 'female'] : [460.6913673558314, 899.8945469083554]
['reader', 'male'] : [739.678278996958, 1054.607579332304]
['new_user', 'unknown'] : [-9.935825860614052, 56.405688976778315]
['new_user', 'female'] : [3.262515103845068, 40.5103306296564]
['new_user', 'male'] : [-0.4068322301028964, 56.646872446264766]
```

In [718]:
```
df_intervals = pd.DataFrame(intervals)
```

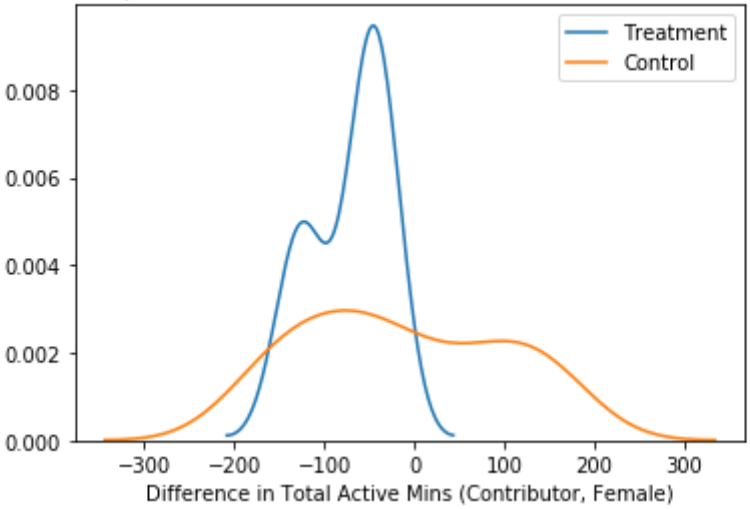
In [769]:

```
for c in covariates:
    build_dist(t1234[(t1234.variant_number==1) & (t1234.user_type==c[0]) & (t1234.gender==c[1]) &
                (t1234.active_mins_diff < t1234.active_mins_diff.quantile(0.90)) &
                (t1234.active_mins_diff > t1234.active_mins_diff.quantile(0.10))],
            t1234[(t1234.variant_number==0) & (t1234.user_type==c[0]) & (t1234.gender==c[1]) &
                (t1234.active_mins_diff < t1234.active_mins_diff.quantile(0.90)) &
                (t1234.active_mins_diff > t1234.active_mins_diff.quantile(0.1))],
            "active_mins_diff","active_mins_diff","Difference in Total Active Mins " + '(' + c[0].title() + ', ' + c[1].title() + ')', "Treatment","Control",
            title='Distribution of Post/Pre-Test Difference in Total Active Miniutes ' + '(' + c[0].title() + ', ' + c[1].title() + ')')
```

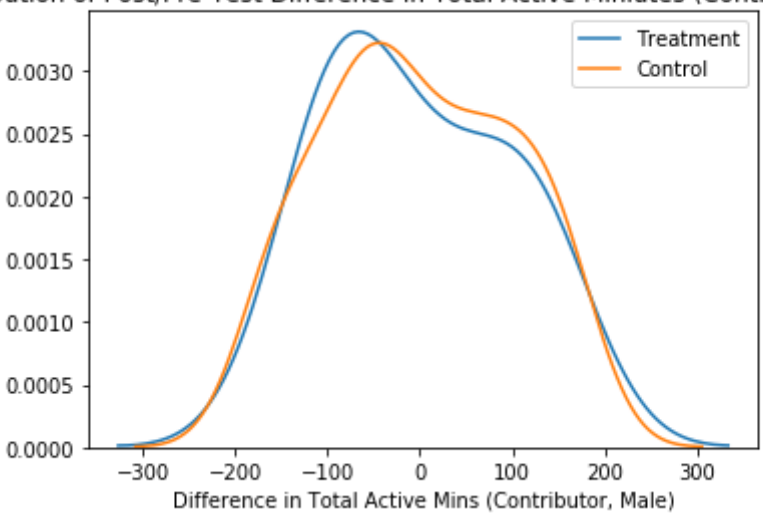
Distribution of Post/Pre-Test Difference in Total Active Miniutes (Contributor, Unknown)



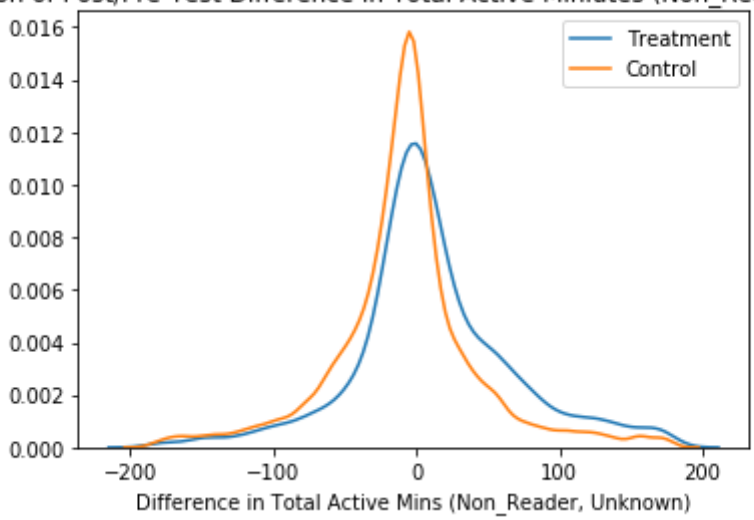
Distribution of Post/Pre-Test Difference in Total Active Miniutes (Contributor, Female)



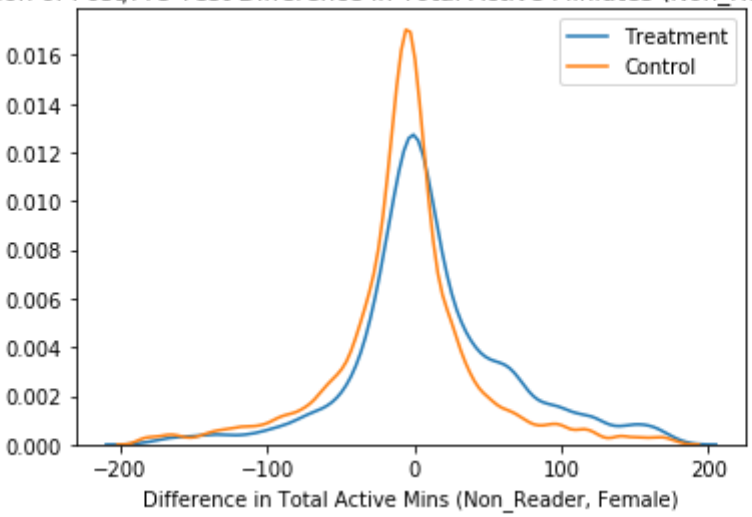
Distribution of Post/Pre-Test Difference in Total Active Miniutes (Contributor, Male)



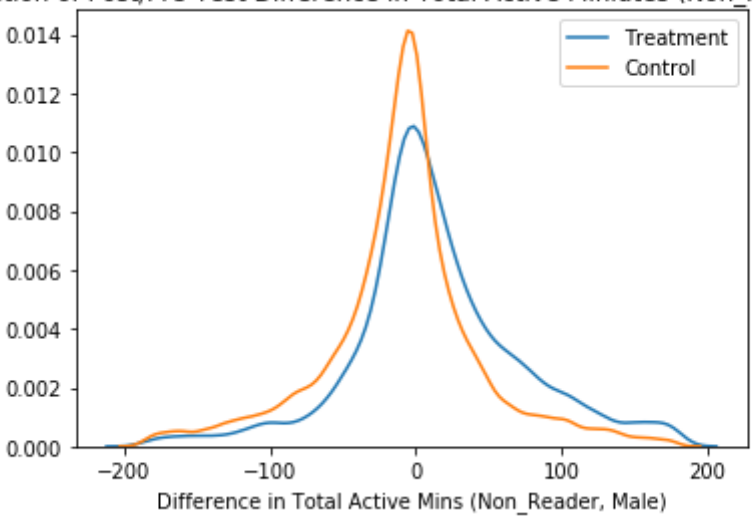
Distribution of Post/Pre-Test Difference in Total Active Miniutes (Non_Reader, Unknown)



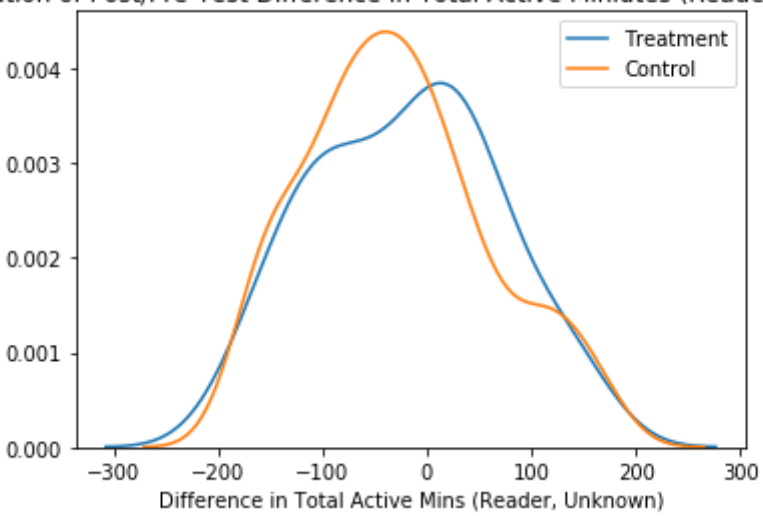
Distribution of Post/Pre-Test Difference in Total Active Miniutes (Non_Reader, Female)



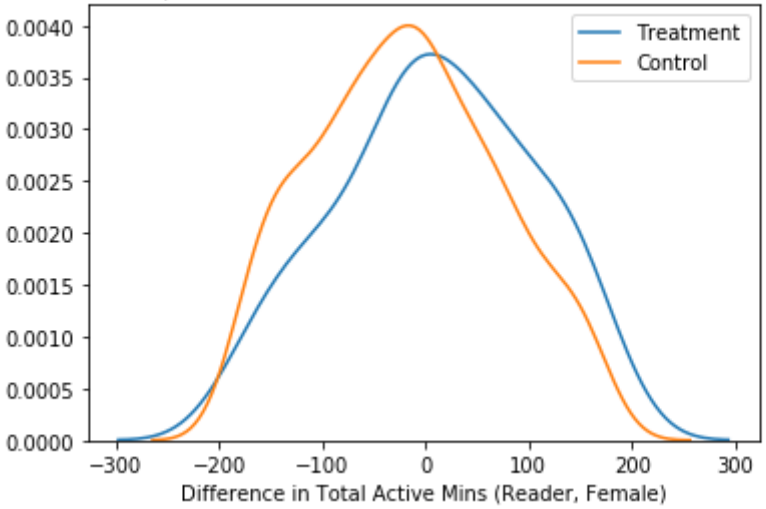
Distribution of Post/Pre-Test Difference in Total Active Miniutes (Non_Reader, Male)



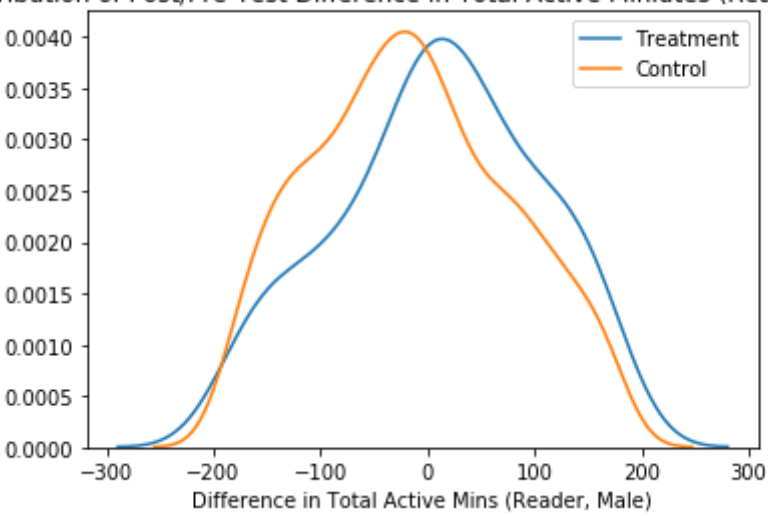
Distribution of Post/Pre-Test Difference in Total Active Miniutes (Reader, Unknown)



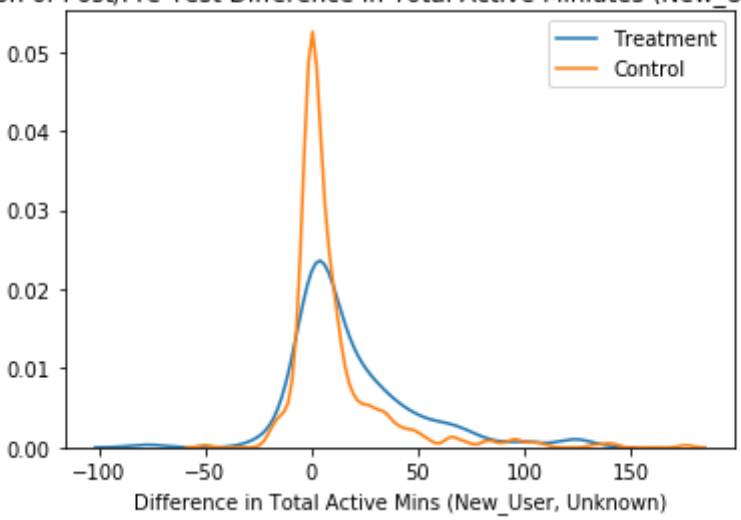
Distribution of Post/Pre-Test Difference in Total Active Miniutes (Reader, Female)



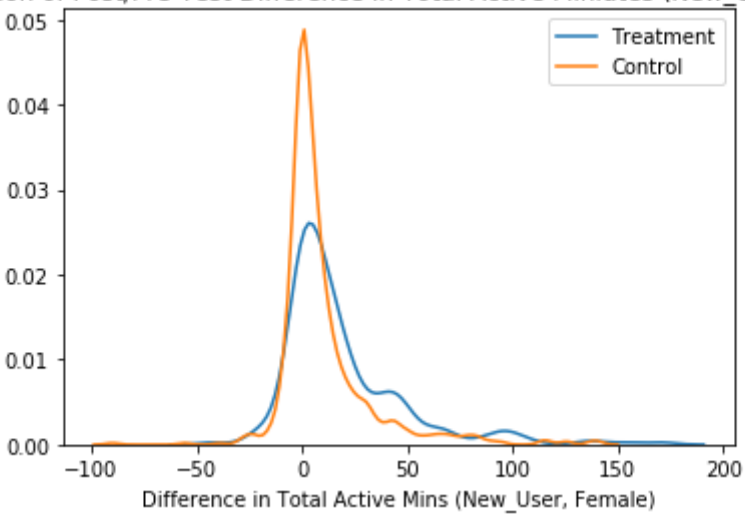
Distribution of Post/Pre-Test Difference in Total Active Miniutes (Reader, Male)



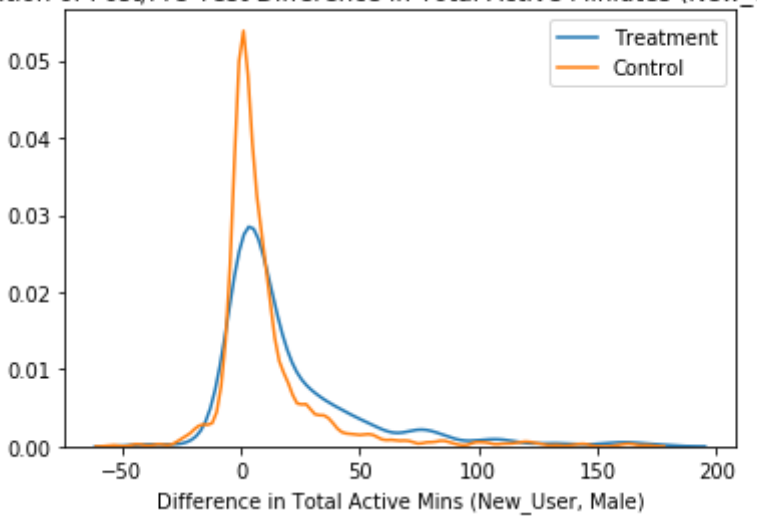
Distribution of Post/Pre-Test Difference in Total Active Miniutes (New_User, Unknown)



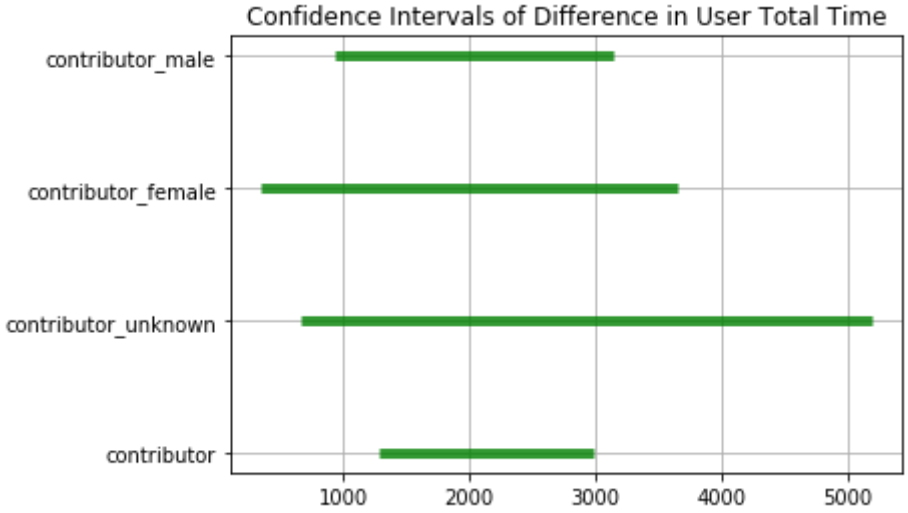
Distribution of Post/Pre-Test Difference in Total Active Miniutes (New_User, Female)

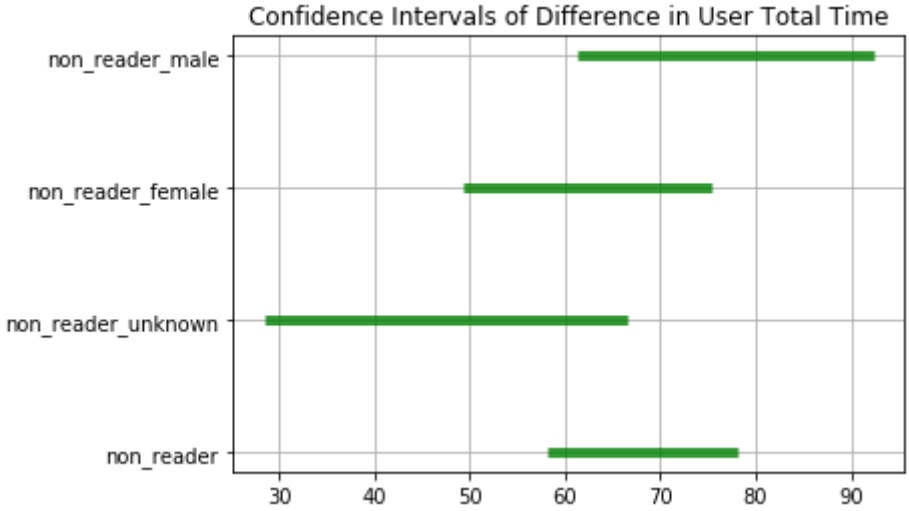


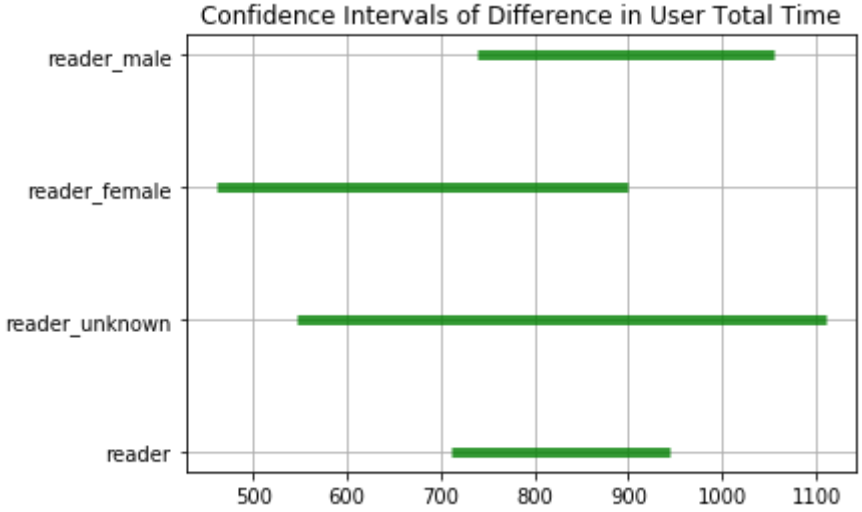
Distribution of Post/Pre-Test Difference in Total Active Miniutes (New_User, Male)

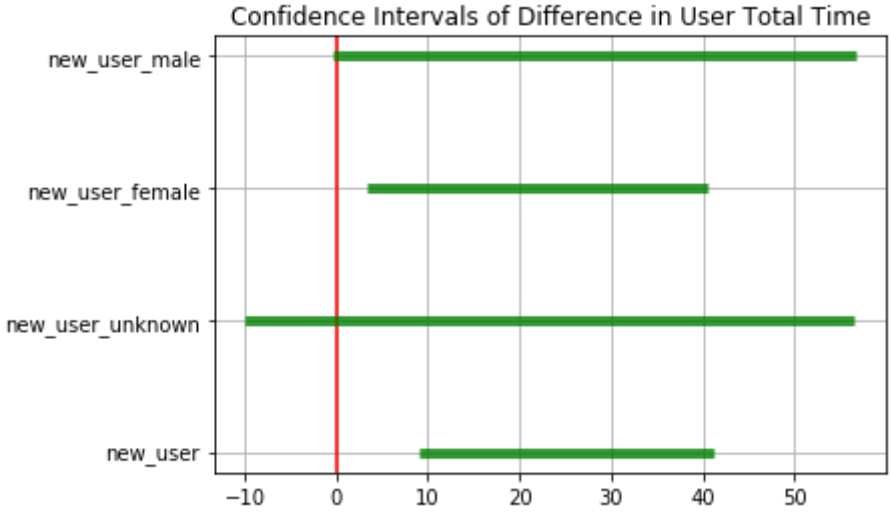


In [771]:
```
for u in set(t4_user_attributes.user_type):
    plt.figure()
    plt.title('Confidence Intervals of Difference in User Total Time')
    plt.grid()
    plt.vlines(0, -1, 4, colors='r')
    for i in df_intervals.columns[df_intervals.columns.str.startswith(u
)]:
        plt.hlines(i, df_intervals[i][0], df_intervals[i][1], colors='g'
, alpha=0.8, linestyles='solid', label=i, linewidth=5.0)
```


Confidence Intervals of Difference in User Total Time
contributor_male
contributor_female
contributor_unknown
contributor
1000
2000
3000
4000
5000


Confidence Intervals of Difference in User Total Time
non_reader_male
non_reader_female
non_reader_unknown
non_reader
30
40
50
60
70
80
90


Confidence Intervals of Difference in User Total Time
reader_male
reader_female
reader_unknown
reader
500
600
700
800
900
1000
1100


Confidence Intervals of Difference in User Total Time
new_user_male
new_user_female
new_user_unknown
new_user
−10
0
10
20
30
40
50