Normalized Tasks -- Functional Level Comparision

This notebook computes significance for the Normalized Task (Non-Opus Tasks) score for the following:

1. Electric Hook Type TD
   - vs. all types of Electric Hand
   - vs. Electric single grip hand
   - vs. body-powered TD
   - vs. Electric multi-articulating hand
2. Motion Control ETD
   - vs. electric hooks
3. Multi-articulating hands
   - vs. Electric single grip hand
   - vs. Body-powered TD
4. Check T-tests
   - Anova
   - Tukey
5. Compare scores on normalized tasks among brands and number of respondents

In [1]:

```
import pandas as pd
import numpy as np
from scipy import stats
import matplotlib.pyplot as plt
from driverCleanData import cleanData
%matplotlib inline
[sht,_] = cleanData();
```

```
There are 0 duplicates
```

The tasks we are considering are

In [34]:

```
from vectorSubsets import taskFull
print(taskFull[20:28])
```

```
['GrabObjectsWetEnvironment', 'GrabObjectsDirtyEnvironment', 'UseFingerTips', 'CanYouPa
rticipateArtsCrafts', 'CanYouParticipateInHobbies', 'GoRidingMotorcycleATVetc', 'Partic
ipateOutdoorActivities', 'PerformHomeImprovement']
```

Let's look at the summary stats for all the data on the normalized tasks.

In [35]:

```
print(sht.normalizedTask.dropna().describe())
```

```
count    1212.000000
mean        3.047572
std         0.435905
min         1.571429
25%         2.750000
50%         3.000000
75%         3.250000
max         4.000000
Name: normalizedTask, dtype: float64
```

The normalization process means that the scores on the tasks are only counted if the respondent performs the task with their prosthesis. The maxiumum score is a 4 and implies that the respondent finds the tasks easy with their device.

Electric Hook TD

vs. all types of Electric Hand

In [2]:
```
from vectorSubsets import electricHooks, electricHandMA, electricHandSG
print("Electric hooks are: {0}".format(electricHooks))
print()
print("Electric hands - multi articulating are {0}".format(electricHandMA))
print()
print("Electric hands - single grip are {0}".format(electricHandSG))
```

```
Electric hooks are: ['Motion Control (MC) ETD', 'Otto Bock Axon Hook', 'Otto Bock Greif
er']

Electric hands - multi articulating are ['bebionic Hand', 'i-limb Hand', 'Michelangelo
 Hand']

Electric hands - single grip are ['Motion Control (MC) Hand', 'Otto Bock Hand']
```

In [3]:
```
sht["TaskEHo"] = sht.normalizedTask[sht["PrimaryTerminalDevice"].isin(electricHooks)]
sht["TaskAllEHa"] = sht.normalizedTask[sht["PrimaryTerminalDevice"].isin(electricHandMA
or electricHandSG)]
```

Summary Stats

First up the electric hooks

In [4]:
```
sht.TaskEHo.dropna().describe()
```

Out[4]:
```
count    114.000000
mean       2.946773
std        0.391915
min        2.000000
25%        2.750000
50%        3.000000
75%        3.093750
max        4.000000
Name: TaskEHo, dtype: float64
```

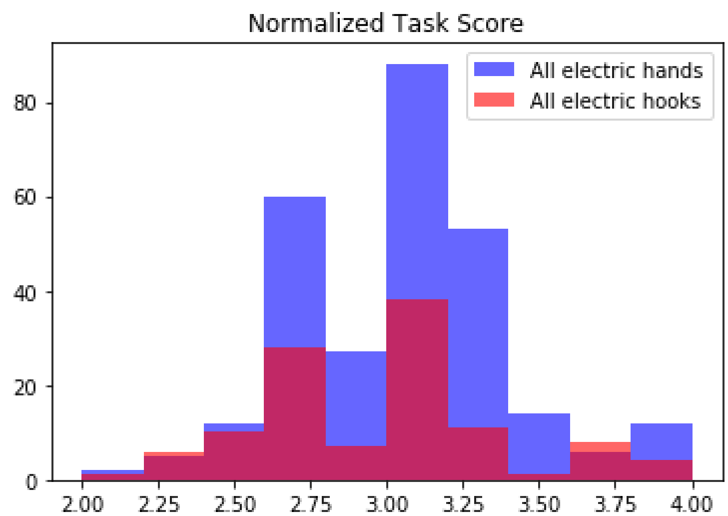
Now for the electric hands

```
In [5]: sht.TaskAllEHa.dropna().describe()
```

```
Out[5]: count    279.000000
        mean       3.028136
        std        0.358486
        min        2.000000
        25%        2.750000
        50%        3.000000
        75%        3.250000
        max        4.000000
        Name: TaskAllEHa, dtype: float64
```

Histogram

```
In [31]: plt.hist(sht.TaskAllEHa.dropna(), alpha=0.6, color='b', label = "All electric hands")
         plt.hist(sht.TaskEHo.dropna(), alpha=0.6, color='r', label = "All electric hooks")
         plt.title("Normalized Task Score")
         plt.legend()
         plt.show()
```




```
In [7]: stats.ttest_ind(sht.TaskAllEHa.dropna(), sht.TaskEHo.dropna())
```

```
Out[7]: Ttest_indResult(statistic=1.9865381765195675, pvalue=0.047671245003818315)
```

The higher mean score on the normalized tasks for the electric hands is significant.

vs. Electric single grip hand

In [8]:
```
sht["TaskElecSG"] =
sht.normalizedTask[sht["PrimaryTerminalDevice"].isin(electricHandSG)]
print("The types of devices we are considering as electric hands are {0}".format(electri
cHandSG))
print()
print("The mean of the electric hooks Task is {0}".format(sht.TaskEHo.dropna().mean()))
print()
print("The summary stats for the single grip are")
print(sht.TaskElecSG.dropna().describe())
```

```
The types of devices we are considering as electric hands are ['Motion Control (MC) Han
d', 'Otto Bock Hand']

The mean of the electric hooks Task is 2.946773182957393

The summary stats for the single grip are
count    604.000000
mean       3.099135
std        0.469637
min        2.000000
25%        2.750000
50%        3.000000
75%        3.333333
max        4.000000
Name: TaskElecSG, dtype: float64
```

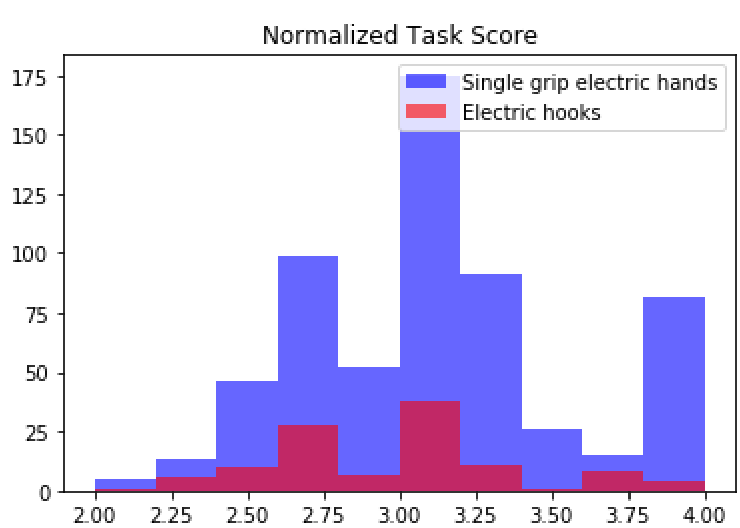
In [9]:
```
stats.ttest_ind(sht.TaskEHo.dropna(), sht.TaskElecSG.dropna())
```

Out[9]:
```
Ttest_indResult(statistic=-3.2559968034549294, pvalue=0.0011831605382561048)
```

The single grips higher score on the normalized tasks is significant.

Histograms

In [37]:
```
plt.hist(sht.TaskElecSG.dropna(), color='b', alpha=0.6, label = "Single grip electric ha
nds")
plt.hist(sht.TaskEHo.dropna(), color='r', alpha=0.6, label = "Electric hooks")
plt.title("Normalized Task Score")
plt.legend()
plt.show()
```



vs. Body Powered Hooks

In [11]:
```
from vectorSubsets import bodyPoweredHooks
sht["TaskBPHook"] = sht.normalizedTask[sht["PrimaryTerminalDevice"].isin(bodyPoweredHook
s)]
sht.TaskBPHook.dropna().describe()
```

Out[11]:
```
count    183.000000
mean       2.969659
std        0.424145
min        2.000000
25%        2.625000
50%        2.875000
75%        3.125000
max        4.000000
Name: TaskBPHook, dtype: float64
```

In [12]:
```
stats.ttest_ind(sht.TaskEHo.dropna(), sht.TaskBPHook.dropna())
```

Out[12]:
```
Ttest_indResult(statistic=-0.46544563120854221, pvalue=0.64195578235207362)
```

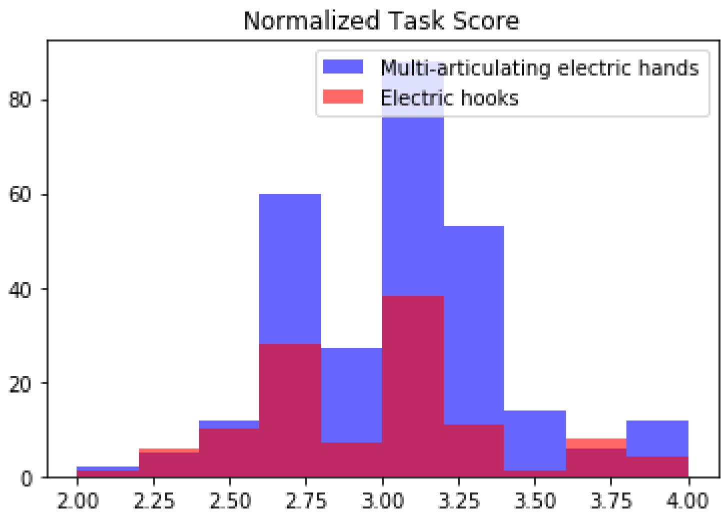
Can't reject the null at alpha=0.05

vs. Multi-articulating Hands

In [13]:
```
from vectorSubsets import electricHandMA
sht["TaskMA"] = sht.normalizedTask[sht["PrimaryTerminalDevice"].isin(electricHandMA)]
print("The mean of the electric hooks Task is {0}".format(sht.TaskEHo.dropna().mean()))
print()
print("The summary stats for multi-articulating are:")
print(sht.TaskMA.dropna().describe())
```

```
The mean of the electric hooks Task is 2.946773182957393

The summary stats for multi-articulating are:
count    279.000000
mean       3.028136
std        0.358486
min        2.000000
25%        2.750000
50%        3.000000
75%        3.250000
max        4.000000
Name: TaskMA, dtype: float64
```

In [36]:
```
plt.hist(sht.TaskMA.dropna(), alpha=0.6, color='b', label = "Multi-articulating electric
 hands")
plt.hist(sht.TaskEHo.dropna(), alpha=0.6, color='r', label = "Electric hooks")
plt.title("Normalized Task Score")
plt.legend()
plt.show()
```



In [15]:
```
stats.ttest_ind(sht.TaskEHo.dropna(),sht.TaskMA.dropna())
```

Out[15]:
```
Ttest_indResult(statistic=-1.9865381765195675, pvalue=0.047671245003818315)
```

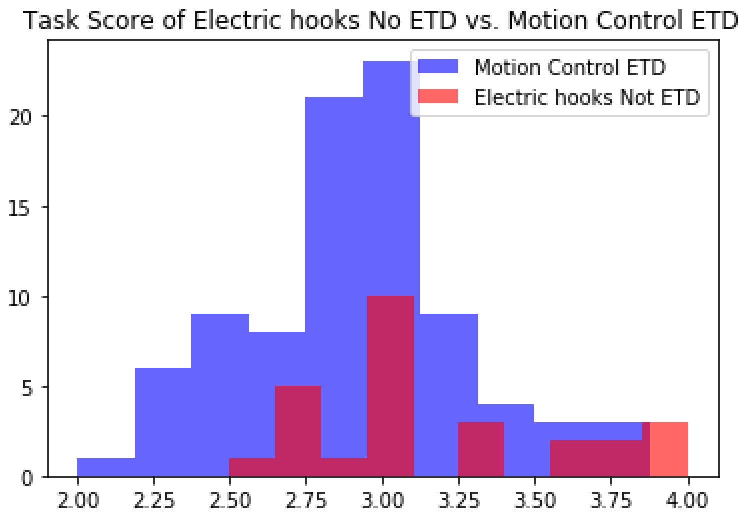
The higher mean score of the multi-articulating is significant compared to electric hooks.

Motion Control ETD vs. All Electric Hooks

In [16]:
```
sht["TaskETD"] = sht.normalizedTask[sht["PrimaryTerminalDevice"]=="Motion Control (MC) E
TD"]
from vectorSubsets import electricHooksNoETD
sht["TaskElecNoETD"] = sht.normalizedTask[sht["PrimaryTerminalDevice"].isin(electricHook
sNoETD)]
print("The electric hooks we are considering are: {0}".format(electricHooksNoETD))
print("The number of participants are {0}".format(sht.TaskElecNoETD.dropna().count()))
print()
print("The average score on Task for the ETD is
{0}".format(sht.TaskETD.dropna().mean()))
print("The average score on Task for the electric hooks is
{0}".format(sht.TaskElecNoETD.dropna().mean()))
print()
print(stats.ttest_ind(sht.TaskETD.dropna(), sht.TaskElecNoETD.dropna()))
```

```
The electric hooks we are considering are: ['Otto Bock Greifer', 'Otto Bock Axon Hook']
The number of participants are 27

The average score on Task for the ETD is 2.8816228790366725
The average score on Task for the electric hooks is 3.1567019400352736

Ttest_indResult(statistic=-3.3247908774966337, pvalue=0.001196618104693462)
```

In [17]:
```
plt.hist(sht.TaskETD.dropna(), alpha=0.6, color='b', label = "Motion Control ETD")
plt.hist(sht.TaskElecNoETD.dropna(), alpha=0.6, color='r', label = "Electric hooks Not E
TD")
plt.title("Task Score of Electric hooks No ETD vs. Motion Control ETD")
plt.legend()
plt.show()
```



The distribution for the not ETD electric hooks looks somewhat normal, however I would hold out for more data before I make a call.

Multi-articulating hands

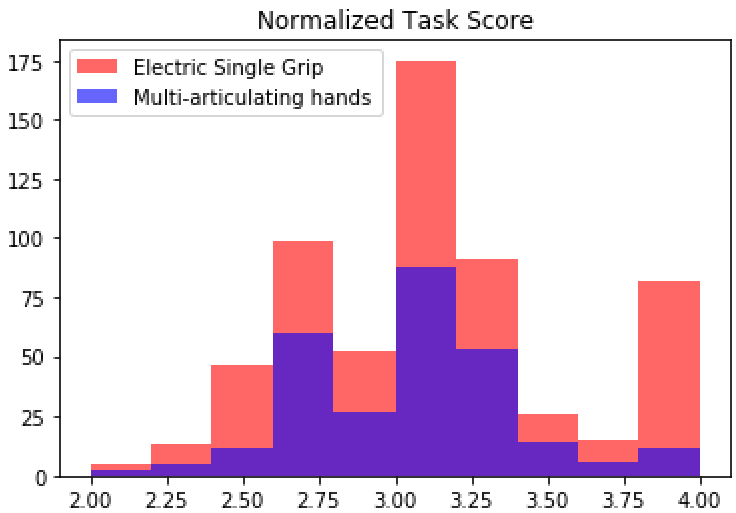
vs. Single Grip hands

In [18]:
```
print("The hands in the multi-articulating group are {0}".format(electricHandMA))
print()
print("The hands in the single grip group are {0}".format(electricHandSG))
print()
print("The average score on Task for the multi-articulating is {0}".format(sht.TaskMA.dr
opna().mean()))
print("The average score on Task for the single grip is {0}".format(sht.TaskElecSG.dropn
a().mean()))
print()
print(stats.ttest_ind(sht.TaskMA.dropna(), sht.TaskElecSG.dropna()))
```

```
The hands in the multi-articulating group are ['bebionic Hand', 'i-limb Hand', 'Michela
ngelo Hand']

The hands in the single grip group are ['Motion Control (MC) Hand', 'Otto Bock Hand']

The average score on Task for the multi-articulating is 3.0281362007168475
The average score on Task for the single grip is 3.099134736676127

Ttest_indResult(statistic=-2.2412490757044687, pvalue=0.025258284124866637)
```

The higher score on the single grip hands is significant. We did not see this result on the normalized opus.

In [38]:
```
plt.hist(sht.TaskElecSG.dropna(), alpha=0.6, color='r', label = "Electric Single Grip")
plt.hist(sht.TaskMA.dropna(), alpha=0.6, color='b', label = "Multi-articulating hands")
plt.title("Normalized Task Score")
plt.legend()
plt.show()
```



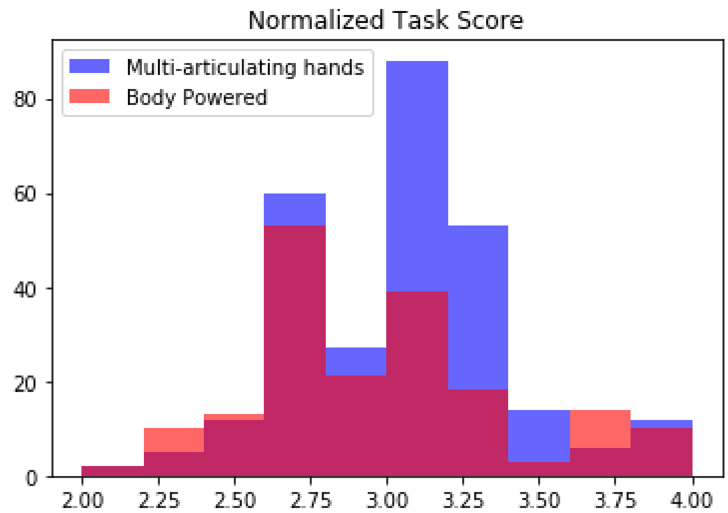
vs. Body Powered

In [20]:
```
print("The hands in the multi-articulating group are {0}".format(electricHandMA))
print()
print("The hands in the body powered group are {0}".format(bodyPoweredHooks))
print()
print("The average score on Task for the multi-articulating is {0}".format(sht.TaskMA.dr
opna().mean()))
print("The average score on Task for body powered is
{0}".format(sht.TaskBPHook.dropna().mean()))
print()
print(stats.ttest_ind(sht.TaskMA.dropna(), sht.TaskBPHook.dropna()))
```

```
The hands in the multi-articulating group are ['bebionic Hand', 'i-limb Hand', 'Michela
ngelo Hand']

The hands in the body powered group are ['TRS Hook', 'Hosmer Hook', 'Body-powered Han
d']

The average score on Task for the multi-articulating is 3.0281362007168475
The average score on Task for body powered is 2.969659120478793

Ttest_indResult(statistic=1.5934105785977839, pvalue=0.1117549718073446)
```

The higher score on the normalized ask by the multi-articulating hands is significant.

In [39]:
```
plt.hist(sht.TaskMA.dropna(), alpha=0.6, color='b', label = "Multi-articulating hands")
plt.hist(sht.TaskBPHook.dropna(), alpha=0.6, color='r', label = "Body Powered")
plt.title("Normalized Task Score")
plt.legend()
plt.show()
```



Check t-test analysis

The results from t-tests can sometimes lead to too many false positives, anova and Tukey's test accomadate for multiple comparisons. So the below should be a validation of what was observed above.

ANOVA

Use anova to make sure there is a difference in the means of at least one of the Task scores between the body powered, multi-articulating, single grip, and electric hooks

In [22]:
```
print("The body powered hooks are {0}".format(bodyPoweredHooks))
print()
print("The multi-articulating hands are {0}".format(electricHandMA))
print()
print("The single grip hands are {0}".format(electricHandSG))
print()
print("The electric hooks are {0}".format(electricHooks))
```

```
The body powered hooks are ['TRS Hook', 'Hosmer Hook', 'Body-powered Hand']

The multi-articulating hands are ['bebionic Hand', 'i-limb Hand', 'Michelangelo Hand']

The single grip hands are ['Motion Control (MC) Hand', 'Otto Bock Hand']

The electric hooks are ['Motion Control (MC) ETD', 'Otto Bock Axon Hook', 'Otto Bock Gr
eifer']
```

Now we'll run anova to check that there is a difference among the mean scores on Task of these 4 groups.

In [23]:
```
stats.f_oneway(sht.TaskBPHook.dropna(), sht.TaskMA.dropna(), sht.TaskElecSG.dropna(), sh
t.TaskEHo.dropna())
```

Out[23]:
```
F_onewayResult(statistic=7.1306028233433931, pvalue=9.5281023784380089e-05)
```

We have have signficance at 0.05.

Tukey

The below will display a graph and a table the table will tell us the mean difference, confidence intervals and if we can reject the null hypothesis at a 95% confidence level

In [24]:
```
TaskDf = pd.concat([sht['PrimaryTerminalDevice'], sht['normalizedTask']], axis=1, keys=
['deviceCategory','normalizedTask'])
TaskDf["deviceCategory"] = TaskDf["deviceCategory"].replace([bodyPoweredHooks],"Body Pow
ered")
TaskDf["deviceCategory"] = TaskDf["deviceCategory"].replace([electricHandMA], "Multi-art
iculating")
TaskDf["deviceCategory"] = TaskDf["deviceCategory"].replace([electricHandSG], "Single Gr
ip")
TaskDf["deviceCategory"] = TaskDf["deviceCategory"].replace([electricHooks], "Electric H
ooks")
TaskDf["deviceCategory"] = TaskDf["deviceCategory"].replace('Otto.*', "Electric Hooks",
regex=True)
TaskDf["deviceCategory"] = TaskDf["deviceCategory"].replace('Other.*', np.nan, regex=Tru
e)
TaskDf["deviceCategory"] = TaskDf["deviceCategory"].replace('Pass.*', np.nan,
regex=True)
#groups = TaskDf.groupby(TaskDf['deviceCategory']).groups
#TaskDf['deviceCategory'] = str(TaskDf['deviceCategory'])
TaskDf = TaskDf.dropna()
df = TaskDf.as_matrix()
dC = df[:,0].astype(str)
oS = df[:,1].astype(float)
```

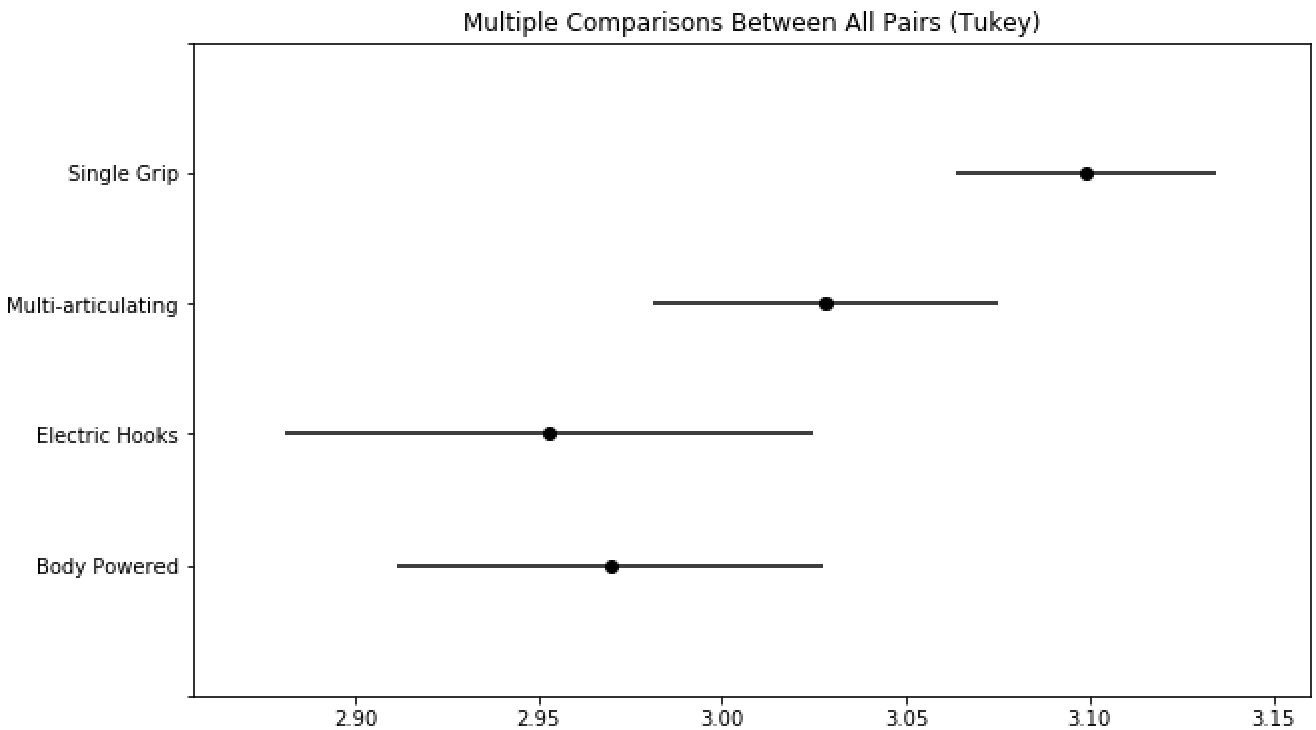
In [25]:

```
from ipykernel import kernelapp as app
from statsmodels.stats.multicomp import pairwise_tukeyhsd
tukey = pairwise_tukeyhsd(endog = oS,
                          groups = dC,
                          alpha = 0.05)
tukey.plot_simultaneous()    # Plot group confidence intervals
plt.vlines(x=49.57,ymin=-0.5,ymax=4.5, color="red")

tukey.summary()
```

Out[25]:

Multiple Comparison of Means - Tukey HSD,FWER=0.05

group1	group2	meandiff	lower	upper	reject
Body Powered	Electric Hooks	-0.0167	-0.1451	0.1116	False
Body Powered	Multi-articulating	0.0585	-0.0475	0.1645	False
Body Powered	Single Grip	0.1295	0.0355	0.2235	True
Electric Hooks	Multi-articulating	0.0752	-0.0437	0.1942	False
Electric Hooks	Single Grip	0.1462	0.0378	0.2546	True
Multi-articulating	Single Grip	0.071	-0.0096	0.1516	False



We have slightly different results than what we saw on the T-tests. We can no longer state that hands outperform hooks. The Tukey test does confirm what we saw on the T-test regarding Single grip. Single Grip hands did outperform Electric Hooks and Body Powered, however they did not outperform Multi-articulating, which the T-test stated.

Also of note, is that the performance on these 8 is more closely grouped than on opus, additionally the scores are lower. I investigate this in another document.

Significance among brands

I'm curious if we'll get something by looking at the specific brands

In [26]:

```
TaskDf = pd.concat([sht['PrimaryTerminalDevice'], sht['normalizedTask']], axis=1, keys=
['deviceCategory','normalizedTask'])
TaskDf = TaskDf.dropna()
df = TaskDf.as_matrix()
dC = df[:,0].astype(str)
oS = df[:,1].astype(float)
tukey = pairwise_tukeyhsd(endog = oS,
                          groups = dC,
                          alpha = 0.05)
tukey.plot_simultaneous()    # Plot group confidence intervals
tukey.summary()
```

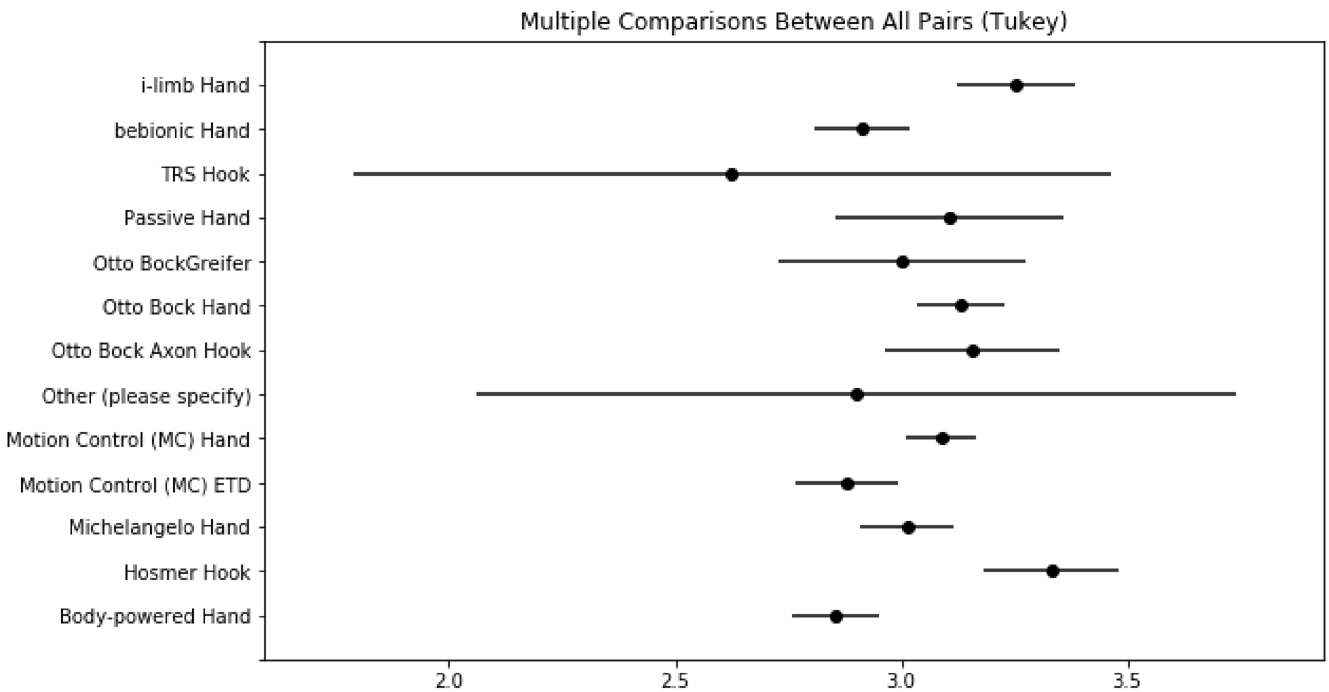
Out[26]:

Multiple Comparison of Means - Tukey HSD,FWER=0.05

group1	group2	meandiff	lower	upper	reject
Body-powered Hand	Hosmer Hook	0.4763	0.2364	0.7163	True
Body-powered Hand	Michelangelo Hand	0.1575	-0.0201	0.335	False
Body-powered Hand	Motion Control (MC) ETD	0.0266	-0.165	0.2181	False
Body-powered Hand	Motion Control (MC) Hand	0.2341	0.0979	0.3703	True
Body-powered Hand	Other (please specify)	0.045	-0.9488	1.0387	False
Body-powered Hand	Otto Bock Axon Hook	0.3017	0.0077	0.5956	True
Body-powered Hand	Otto Bock Hand	0.2758	0.1093	0.4424	True
Body-powered Hand	Otto BockGreifer	0.1479	-0.2437	0.5395	False
Body-powered Hand	Passive Hand	0.2517	-0.117	0.6205	False
Body-powered Hand	TRS Hook	-0.23	-1.2238	0.7637	False
Body-powered Hand	bebionic Hand	0.0582	-0.123	0.2395	False
Body-powered Hand	i-limb Hand	0.3998	0.1848	0.6148	True
Hosmer Hook	Michelangelo Hand	-0.3189	-0.5648	-0.073	True
Hosmer Hook	Motion Control (MC) ETD	-0.4498	-0.7059	-0.1936	True
Hosmer Hook	Motion Control (MC) Hand	-0.2423	-0.4602	-0.0243	True
Hosmer Hook	Other (please specify)	-0.4314	-1.4396	0.5768	False
Hosmer Hook	Otto Bock Axon Hook	-0.1747	-0.5143	0.165	False
Hosmer Hook	Otto Bock Hand	-0.2005	-0.4386	0.0376	False
Hosmer Hook	Otto BockGreifer	-0.3284	-0.7554	0.0986	False
Hosmer Hook	Passive Hand	-0.2246	-0.6307	0.1815	False
Hosmer Hook	TRS Hook	-0.7064	-1.7146	0.3018	False
Hosmer Hook	bebionic Hand	-0.4181	-0.6667	-0.1695	True
Hosmer Hook	i-limb Hand	-0.0765	-0.3507	0.1976	False
Michelangelo Hand	Motion Control (MC) ETD	-0.1309	-0.3299	0.0681	False
Michelangelo Hand	Motion Control (MC) Hand	0.0766	-0.0699	0.2231	False
Michelangelo Hand	Other (please specify)	-0.1125	-1.1077	0.8827	False
Michelangelo Hand	Otto Bock Axon Hook	0.1442	-0.1547	0.4431	False
Michelangelo Hand	Otto Bock Hand	0.1184	-0.0567	0.2934	False
Michelangelo Hand	Otto BockGreifer	-0.0095	-0.4048	0.3858	False
Michelangelo Hand	Passive Hand	0.0943	-0.2784	0.4669	False
Michelangelo Hand	TRS Hook	-0.3875	-1.3827	0.6077	False
Michelangelo Hand	bebionic Hand	-0.0992	-0.2884	0.0899	False
Michelangelo Hand	i-limb Hand	0.2424	0.0207	0.464	True

Motion Control (MC) ETD	Motion Control (MC) Hand	0.2075	0.0444	0.3706	True
Motion Control (MC) ETD	Other (please specify)	0.0184	-0.9794	1.0162	False
Motion Control (MC) ETD	Otto Bock Axon Hook	0.2751	-0.0323	0.5824	False
Motion Control (MC) ETD	Otto Bock Hand	0.2492	0.06	0.4384	True
Motion Control (MC) ETD	Otto BockGreifer	0.1214	-0.2804	0.5231	False
Motion Control (MC) ETD	Passive Hand	0.2251	-0.1544	0.6047	False
Motion Control (MC) ETD	TRS Hook	-0.2566	-1.2544	0.7412	False
Motion Control (MC) ETD	bebionic Hand	0.0316	-0.1706	0.2339	False
Motion Control (MC) ETD	i-limb Hand	0.3732	0.1403	0.6062	True
Motion Control (MC) Hand	Other (please specify)	-0.1891	-1.1778	0.7996	False
Motion Control (MC) Hand	Otto Bock Axon Hook	0.0676	-0.2087	0.3439	False
Motion Control (MC) Hand	Otto Bock Hand	0.0418	-0.0912	0.1747	False
Motion Control (MC) Hand	Otto BockGreifer	-0.0861	-0.4647	0.2924	False
Motion Control (MC) Hand	Passive Hand	0.0177	-0.3372	0.3725	False
Motion Control (MC) Hand	TRS Hook	-0.4641	-1.4528	0.5246	False
Motion Control (MC) Hand	bebionic Hand	-0.1759	-0.3268	-0.0249	True
Motion Control (MC) Hand	i-limb Hand	0.1657	-0.0244	0.3559	False
Other (please specify)	Otto Bock Axon Hook	0.2567	-0.7657	1.2791	False
Other (please specify)	Otto Bock Hand	0.2309	-0.7624	1.2242	False
Other (please specify)	Otto BockGreifer	0.103	-0.9517	1.1576	False
Other (please specify)	Passive Hand	0.2068	-0.8396	1.2531	False
Other (please specify)	TRS Hook	-0.275	-1.6702	1.1202	False
Other (please specify)	bebionic Hand	0.0133	-0.9826	1.0091	False
Other (please specify)	i-limb Hand	0.3549	-0.6477	1.3574	False
Otto Bock Axon Hook	Otto Bock Hand	-0.0258	-0.3183	0.2666	False
Otto Bock Axon Hook	Otto BockGreifer	-0.1537	-0.6132	0.3058	False
Otto Bock Axon Hook	Passive Hand	-0.0499	-0.4901	0.3902	False
Otto Bock Axon Hook	TRS Hook	-0.5317	-1.5541	0.4907	False
Otto Bock Axon Hook	bebionic Hand	-0.2434	-0.5445	0.0576	False
Otto Bock Axon Hook	i-limb Hand	0.0982	-0.2243	0.4206	False
Otto Bock Hand	Otto BockGreifer	-0.1279	-0.5183	0.2626	False
Otto Bock Hand	Passive Hand	-0.0241	-0.3916	0.3434	False
Otto Bock Hand	TRS Hook	-0.5059	-1.4992	0.4874	False
Otto Bock Hand	bebionic Hand	-0.2176	-0.3964	-0.0388	True
Otto Bock Hand	i-limb Hand	0.124	-0.0889	0.3369	False
Otto BockGreifer	Passive Hand	0.1038	-0.4068	0.6144	False

Otto BockGreifer	TRS Hook	-0.378	-1.4326	0.6767	False
Otto BockGreifer	bebionic Hand	-0.0897	-0.4867	0.3072	False
Otto BockGreifer	i-limb Hand	0.2519	-0.1616	0.6653	False
Passive Hand	TRS Hook	-0.4818	-1.5281	0.5646	False
Passive Hand	bebionic Hand	-0.1935	-0.5679	0.1809	False
Passive Hand	i-limb Hand	0.1481	-0.2438	0.54	False
TRS Hook	bebionic Hand	0.2883	-0.7076	1.2841	False
TRS Hook	i-limb Hand	0.6299	-0.3727	1.6324	False
bebionic Hand	i-limb Hand	0.3416	0.117	0.5662	True



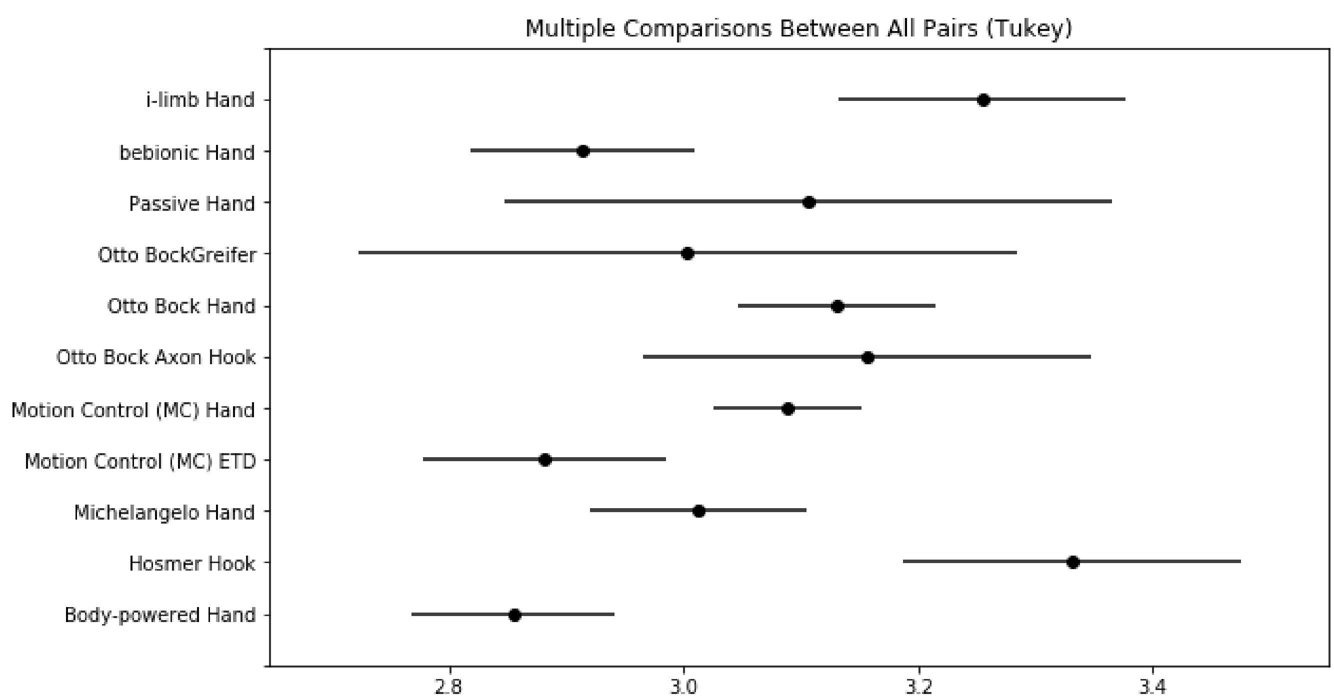
The TRS Hook and "other" are mucking up the scale, let's remove those

In [27]:
```
TaskDf = pd.concat([sht['PrimaryTerminalDevice'], sht['normalizedTask']], axis=1, keys=
['primaryTD','normalizedTask'])
TaskDf["primaryTD"] = TaskDf["primaryTD"].replace('Other.*', np.nan, regex=True)
TaskDf["primaryTD"] = TaskDf["primaryTD"].replace('TRS.*', np.nan, regex=True)
TaskDf = TaskDf.dropna()
df = TaskDf.as_matrix()
dC = df[:,0].astype(str)
oS = df[:,1].astype(float)
tukey = pairwise_tukeyhsd(endog = oS,
                         groups = dC,
                         alpha = 0.05)
tukey.plot_simultaneous()    # Plot group confidence intervals
tukey.summary()
```

Out[27]: Multiple Comparison of Means - Tukey HSD,FWER=0.05

group1	group2	meandiff	lower	upper	reject
Body-powered Hand	Hosmer Hook	0.4763	0.2431	0.7096	True
Body-powered Hand	Michelangelo Hand	0.1575	-0.0152	0.3301	False
Body-powered Hand	Motion Control (MC) ETD	0.0266	-0.1596	0.2128	False
Body-powered Hand	Motion Control (MC) Hand	0.2341	0.1016	0.3665	True
Body-powered Hand	Otto Bock Axon Hook	0.3017	0.0159	0.5874	True
Body-powered Hand	Otto Bock Hand	0.2758	0.1139	0.4377	True
Body-powered Hand	Otto BockGreifer	0.1479	-0.2328	0.5286	False
Body-powered Hand	Passive Hand	0.2517	-0.1068	0.6102	False
Body-powered Hand	bebionic Hand	0.0582	-0.118	0.2344	False
Body-powered Hand	i-limb Hand	0.3998	0.1908	0.6088	True
Hosmer Hook	Michelangelo Hand	-0.3189	-0.558	-0.0798	True
Hosmer Hook	Motion Control (MC) ETD	-0.4498	-0.6988	-0.2007	True
Hosmer Hook	Motion Control (MC) Hand	-0.2423	-0.4541	-0.0304	True
Hosmer Hook	Otto Bock Axon Hook	-0.1747	-0.5049	0.1555	False
Hosmer Hook	Otto Bock Hand	-0.2005	-0.432	0.0309	False
Hosmer Hook	Otto BockGreifer	-0.3284	-0.7435	0.0867	False
Hosmer Hook	Passive Hand	-0.2246	-0.6194	0.1702	False
Hosmer Hook	bebionic Hand	-0.4181	-0.6598	-0.1765	True
Hosmer Hook	i-limb Hand	-0.0765	-0.3431	0.19	False
Michelangelo Hand	Motion Control (MC) ETD	-0.1309	-0.3243	0.0626	False
Michelangelo Hand	Motion Control (MC) Hand	0.0766	-0.0658	0.2191	False
Michelangelo Hand	Otto Bock Axon Hook	0.1442	-0.1463	0.4348	False
Michelangelo Hand	Otto Bock Hand	0.1184	-0.0518	0.2886	False
Michelangelo Hand	Otto BockGreifer	-0.0095	-0.3938	0.3748	False
Michelangelo Hand	Passive Hand	0.0943	-0.268	0.4566	False
Michelangelo Hand	bebionic Hand	-0.0992	-0.2831	0.0846	False
Michelangelo Hand	i-limb Hand	0.2424	0.0269	0.4579	True
Motion Control (MC) ETD	Motion Control (MC) Hand	0.2075	0.0489	0.3661	True
Motion Control (MC) ETD	Otto Bock Axon Hook	0.2751	-0.0237	0.5739	False
Motion Control (MC) ETD	Otto Bock Hand	0.2492	0.0653	0.4332	True
Motion Control (MC) ETD	Otto BockGreifer	0.1214	-0.2692	0.5119	False
Motion Control (MC) ETD	Passive Hand	0.2251	-0.1438	0.5941	False
Motion Control (MC) ETD	bebionic Hand	0.0316	-0.165	0.2283	False

Motion Control (MC) ETD	i-limb Hand	0.3732	0.1467	0.5997	True
Motion Control (MC) Hand	Otto Bock Axon Hook	0.0676	-0.201	0.3362	False
Motion Control (MC) Hand	Otto Bock Hand	0.0418	-0.0875	0.171	False
Motion Control (MC) Hand	Otto BockGreifer	-0.0861	-0.4541	0.2819	False
Motion Control (MC) Hand	Passive Hand	0.0177	-0.3273	0.3626	False
Motion Control (MC) Hand	bebionic Hand	-0.1759	-0.3226	-0.0291	True
Motion Control (MC) Hand	i-limb Hand	0.1657	-0.0191	0.3506	False
Otto Bock Axon Hook	Otto Bock Hand	-0.0258	-0.3101	0.2585	False
Otto Bock Axon Hook	Otto BockGreifer	-0.1537	-0.6004	0.293	False
Otto Bock Axon Hook	Passive Hand	-0.0499	-0.4779	0.378	False
Otto Bock Axon Hook	bebionic Hand	-0.2434	-0.5361	0.0492	False
Otto Bock Axon Hook	i-limb Hand	0.0982	-0.2154	0.4117	False
Otto Bock Hand	Otto BockGreifer	-0.1279	-0.5075	0.2517	False
Otto Bock Hand	Passive Hand	-0.0241	-0.3814	0.3332	False
Otto Bock Hand	bebionic Hand	-0.2176	-0.3914	-0.0438	True
Otto Bock Hand	i-limb Hand	0.124	-0.083	0.331	False
Otto BockGreifer	Passive Hand	0.1038	-0.3926	0.6002	False
Otto BockGreifer	bebionic Hand	-0.0897	-0.4756	0.2962	False
Otto BockGreifer	i-limb Hand	0.2519	-0.1501	0.6538	False
Passive Hand	bebionic Hand	-0.1935	-0.5575	0.1705	False
Passive Hand	i-limb Hand	0.1481	-0.2329	0.5291	False
bebionic Hand	i-limb Hand	0.3416	0.1232	0.56	True



I really like the above graph, it tells us a lot of information the bands are 95% confidence intervals and the dots are the means. If the bands are narrow, then the brand probably has a lot more data.

Unfortunately the ETD has narrow bands and is on the lower end of the score. It is interesting to note that on both the normalized opus and the normalized task, the bebionic hand and the ETD performed similarly. I was curious about this so I performed some further analysis.

But before that I included a chart below that contains all the brands their score on the Normalized Opus, Normalized Task and the number of respondents included for that brand.

In [30]:
```
groupbyPrimaryDNT = sht["normalizedTask"].groupby(sht["PrimaryTerminalDevice"])
groupbyPrimaryDNO = sht["normalizedOpus"].groupby(sht["PrimaryTerminalDevice"])
sortedNT = groupbyPrimaryDNT.mean().sort_values(ascending=False)
sortedNO = groupbyPrimaryDNO.mean().sort_values(ascending=False)
pd.concat([sortedNO, sortedNT, groupbyPrimaryDNT.count()], axis=1, keys=['Normalized Opu
s', 'Normalized Task', 'Count']).sort_values(['Normalized Opus', 'Normalized Task'], asc
ending=False)
```

Out[30]:

	Normalized Opus	Normalized Task	Count
Hosmer Hook	3.408458	3.331376	45
i-limb Hand	3.397015	3.254859	61
Otto BockGreifer	3.394602	3.002976	14
Other (please specify)	3.384615	2.900000	2
Michelangelo Hand	3.326328	3.012495	113
Otto Bock Axon Hook	3.282110	3.156702	27
Otto Bock Hand	3.262560	3.130862	145
Passive Hand	3.253799	3.106771	16
Motion Control (MC) Hand	3.199094	3.089112	459
Motion Control (MC) ETD	2.988510	2.881623	87
bebionic Hand	2.982478	2.913254	105
Body-powered Hand	2.948173	2.855042	136
TRS Hook	2.885417	2.625000	2

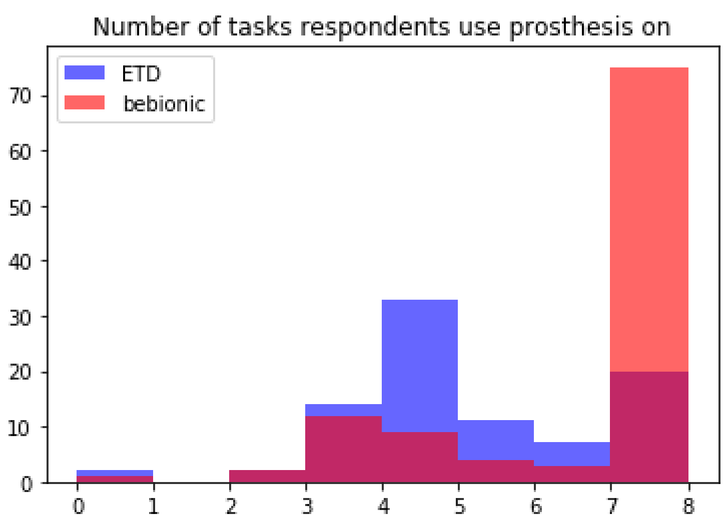
There is a distinct jump in scores between Motion Control hand and the ETD. Further bebionic and ETD have very similar scores, let's investigate

In [40]:
```
print("The summary stats for the ETD are")
print(sht.numberTasksUseProsthesisTask[sht['PrimaryTerminalDevice']=='Motion Control (M
C) ETD'].dropna().describe())
print()
print("The summary stats for the bebionic are")
print(sht.numberTasksUseProsthesisTask[sht['PrimaryTerminalDevice']== 'bebionic Hand'].d
ropna().describe())
```

```
The summary stats for the ETD are
count    89.000000
mean      4.876404
std       1.958781
min       0.000000
25%       4.000000
50%       4.000000
75%       6.000000
max       8.000000
Name: numberTasksUseProsthesisTask, dtype: float64

The summary stats for the bebionic are
count    106.000000
mean       6.735849
std        2.089894
min        0.000000
25%        5.000000
50%        8.000000
75%        8.000000
max        8.000000
Name: numberTasksUseProsthesisTask, dtype: float64
```

Lots of bebionic users!

In [41]:
```
plt.hist(sht.numberTasksUseProsthesisTask[sht['PrimaryTerminalDevice']=='Motion Control
 (MC) ETD'].dropna(), alpha=0.6, color='b', label = "ETD", bins=8)
plt.hist(sht.numberTasksUseProsthesisTask[sht['PrimaryTerminalDevice']== 'bebionic
Hand'].dropna(), alpha=0.6, color='r', label = "bebionic", bins=8)
plt.title("Number of tasks respondents use prosthesis on")
plt.legend()
plt.show()
```



ETD wearers again are only using device on about half of the tasks! This is what is bringing this score down.