gesture_statistics

June 15, 2017

1 TIMIT Gestures Statistics

1.1 Load Db and Calculate Gestures

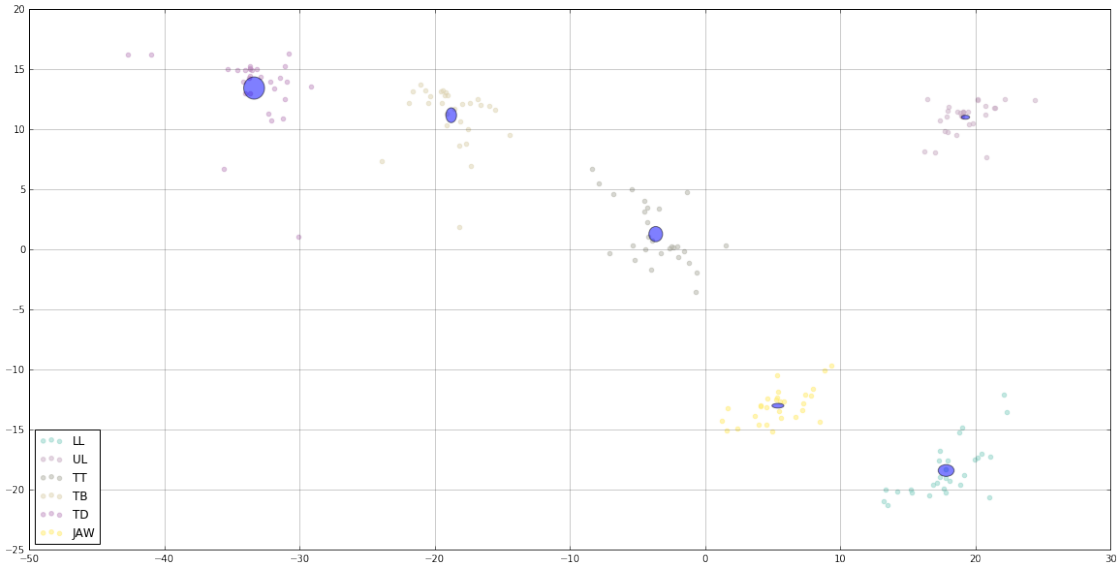
In [1]:
```
import timit_stats as tist
import gesture as ges
import os
import matplotlib.pyplot as plt

%pylab inline

trans_dir = "../USC-TIMIT/EMA/Data/M1/trans"
mat_dir = "../USC-TIMIT/EMA/Data/M1/mat"

gestures = {}

for fname in os.listdir(trans_dir):
    fname = os.path.splitext(fname)[0]
    t_fname = os.path.join(trans_dir, fname + ".trans")
    mat_fname = os.path.join(mat_dir, fname + ".mat")
    gest = tist.calc_gestures(mat_fname, t_fname,filter_critical_points=True, m=0.1)
    for g in gest:
        if g not in gestures:
            gestures[g] = ges.Gesture(g)
        gestures[g].extend(gest[g])
print "gestures calculation finished"
```

```
Populating the interactive namespace from numpy and matplotlib


critical_point.py:9: RuntimeWarning: invalid value encountered in double_scalars
  velocity = [math.sqrt(dx**2 + dy**2) for dx, dy in zip(delta_ax, delta_ay)]
critical_point.py:12: RuntimeWarning: invalid value encountered in double_scalars
  math.sqrt(delta_ax[i-1] ** 2 + delta_ay[i-1] ** 2))) for i in range(1, len(delta_ax))]


gestures calculation finished
```

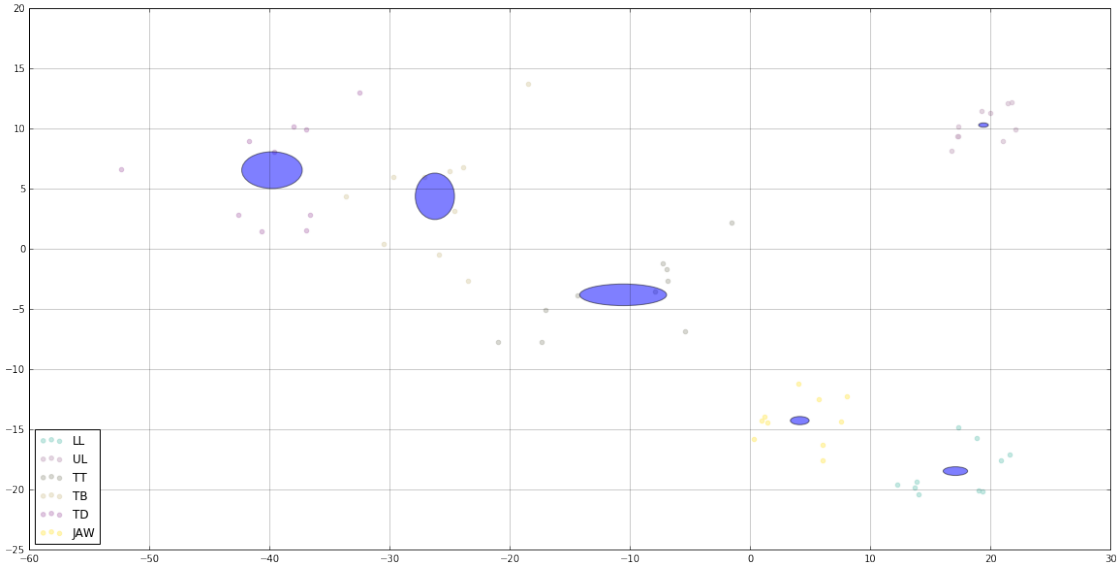
1.2 Plot Gestures

In [2]:
```
from matplotlib.patches import Ellipse

articulators = ["LL", "UL", "TT", "TB", "TD", "JAW"]

cmap = plt.get_cmap('Set3')
colors = [cmap(i) for i in np.linspace(0, 1, len(articulators))]
for g_name, g in gestures.items():
    fig1, ax1 = plt.subplots(figsize=(20, 10))
    fig1.suptitle("Gesture \"{}\" (samples = {})".format(g_name, len(g.params["LL_x"]))
                  fontsize=20, fontweight='bold')
#     ax1.set_xlim(-50, 40)
#     ax1.set_ylim(-30, 30)
    ax1.grid(color='black', linestyle='-', linewidth=1, alpha=0.2)
#     img = plt.imread("vt_bg.jpg")
#     ax1.imshow(img, extent=[-100, 40, -70, 50], alpha=0.3)
    g_m = g.get_mean()
    g_v = g.get_variance()

    for i in range(len(articulators)):
        a = articulators[i]
        a_x = g.params[a+"_x"]
        a_y = g.params[a+"_y"]
        ax1.scatter(a_x, a_y, color=colors[i], alpha=0.5, label=a)
#         plot mean ellipse
        e = Ellipse(xy=[g_m[a+"_x"], g_m[a+"_y"]],
                    width=g_v[a+"_x"]/5, height=g_v[a+"_y"]/5, alpha=0.5)
        ax1.add_artist(e)
        plt.legend(loc='lower left')

    plt.show()
```

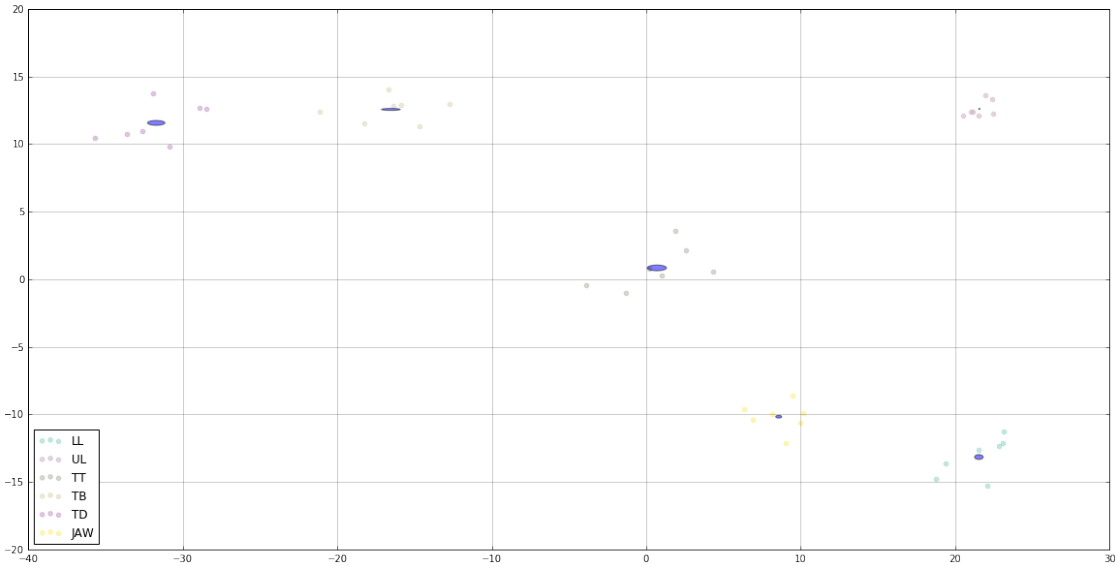
Gesture "iy" (samples = 29)



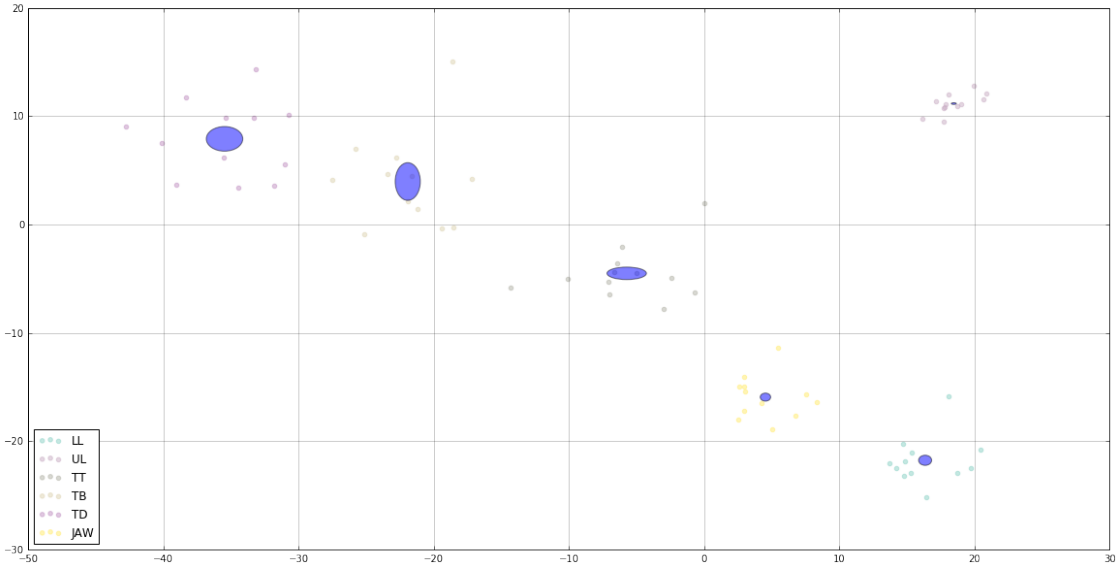
Gesture "aa" (samples = 10)



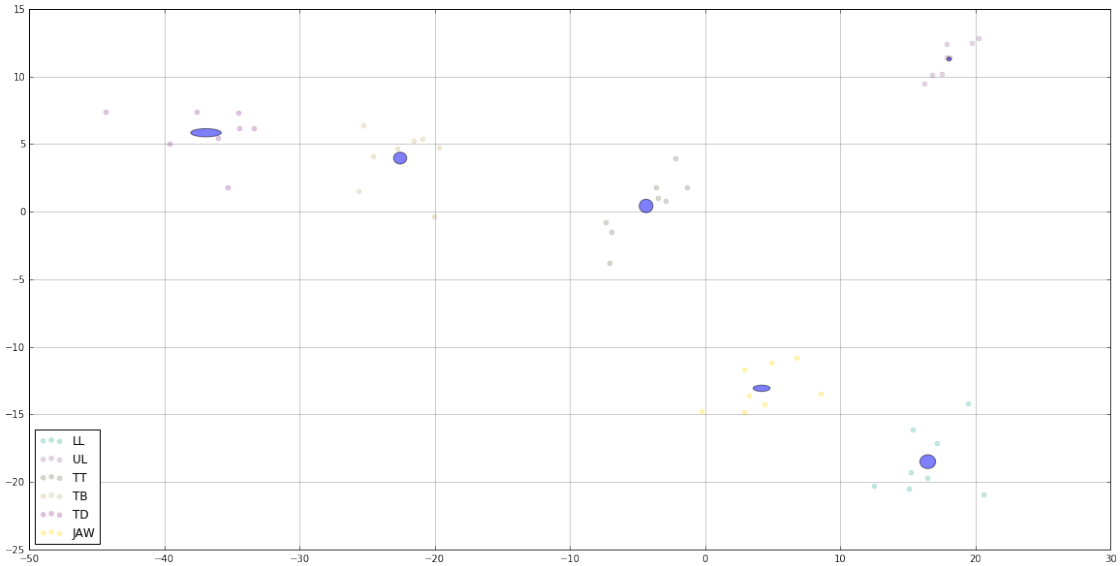
Gesture "ch" (samples = 7)



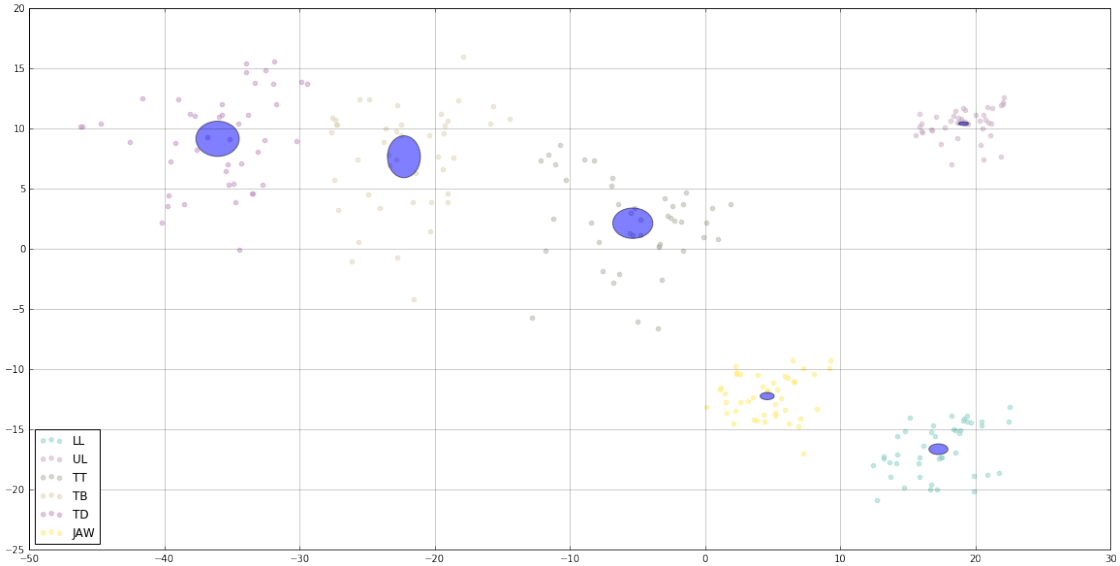
Gesture "ae" (samples = 12)



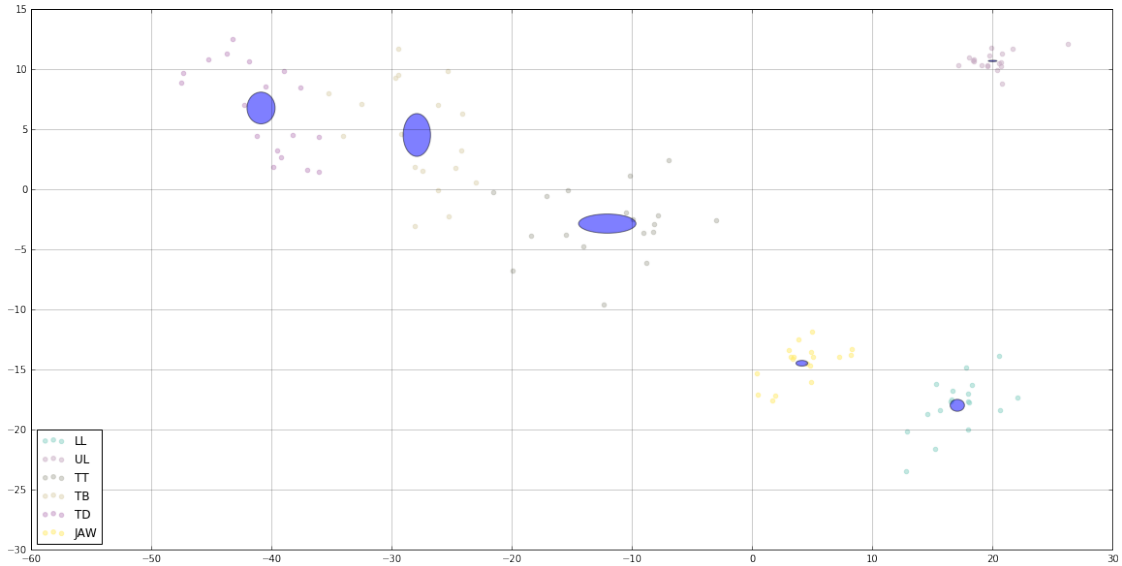
Gesture "eh" (samples = 8)



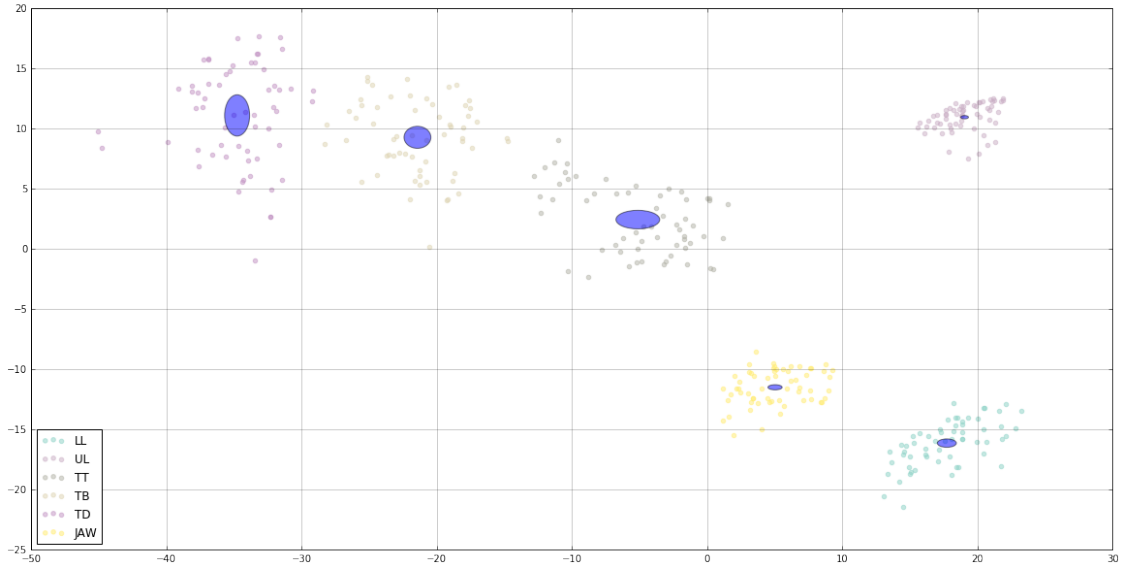
Gesture "ah" (samples = 44)



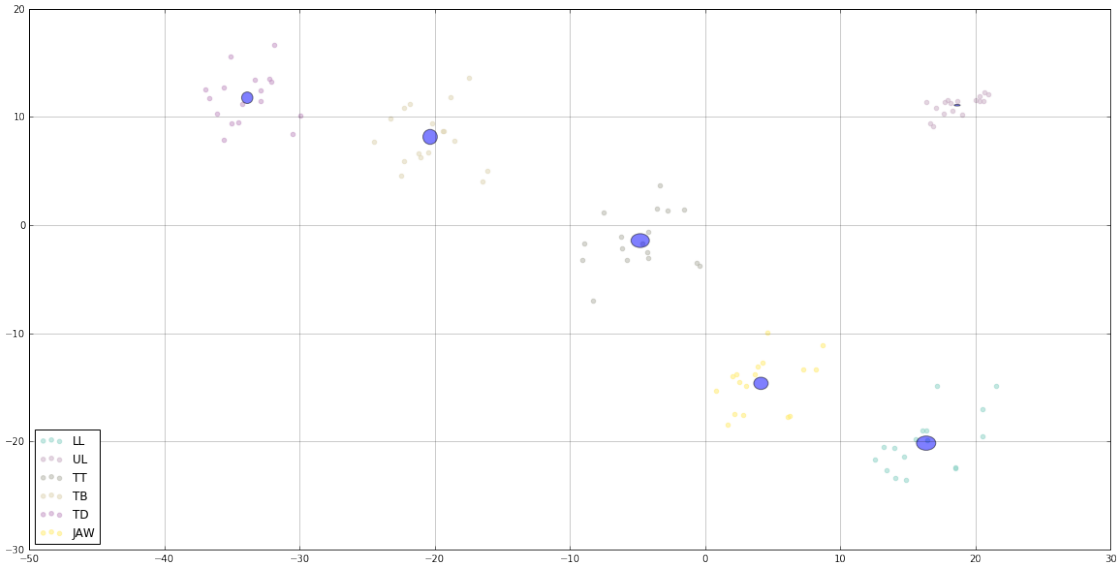
Gesture "ao" (samples = 18)



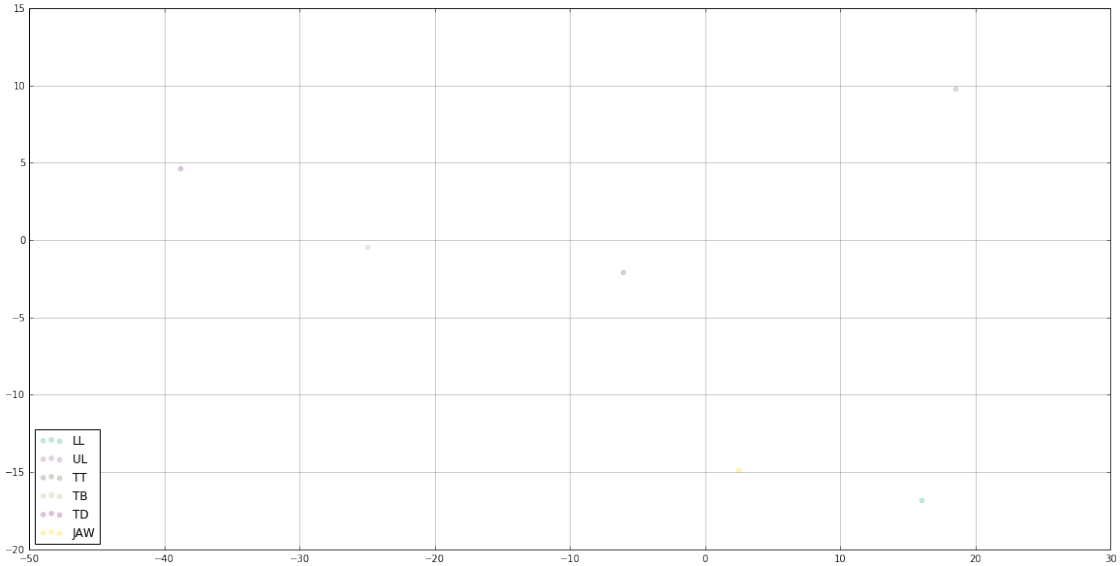
Gesture "ih" (samples = 60)



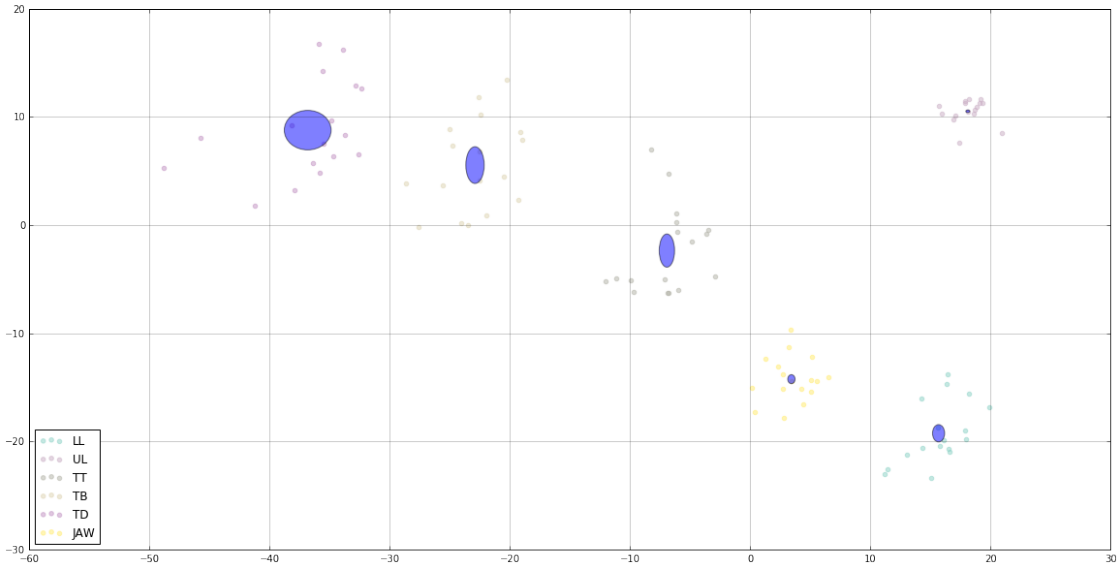
Gesture "ey" (samples = 17)



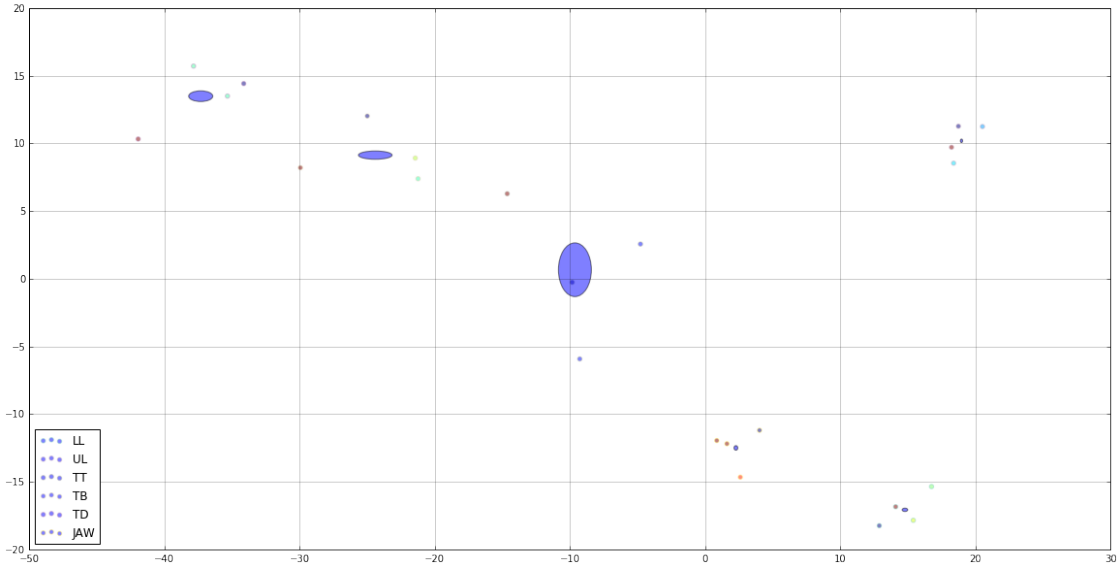
Gesture "aw" (samples = 1)



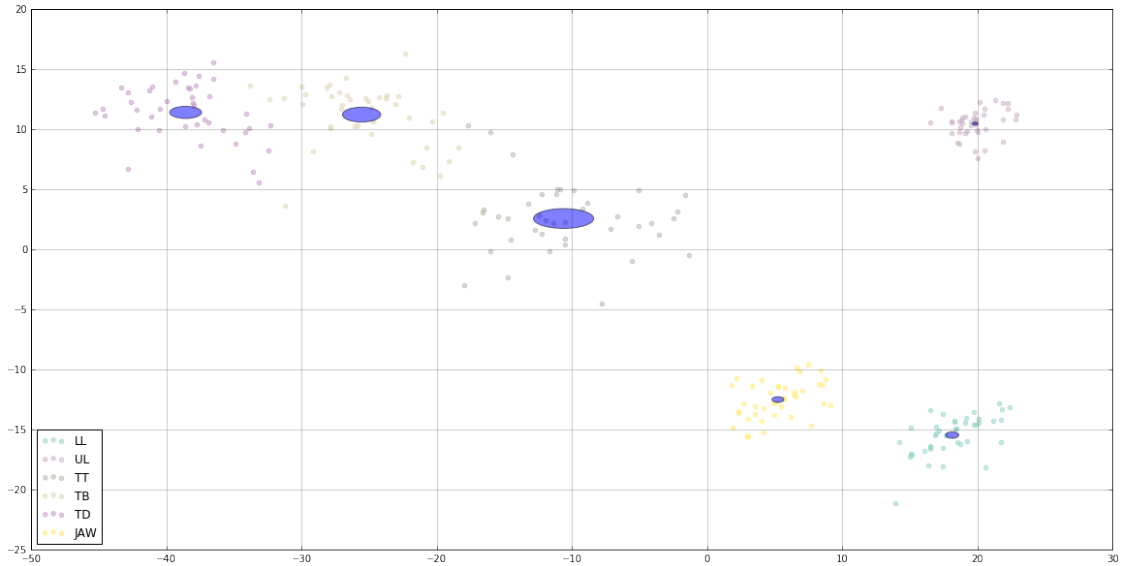
Gesture "ay" (samples = 17)



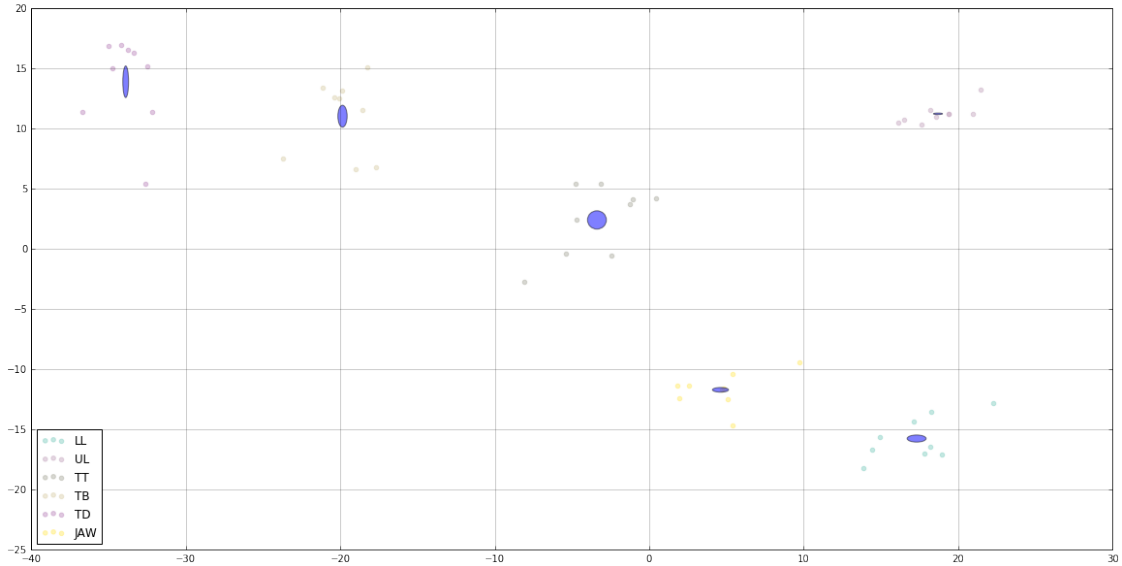
Gesture "uh" (samples = 4)



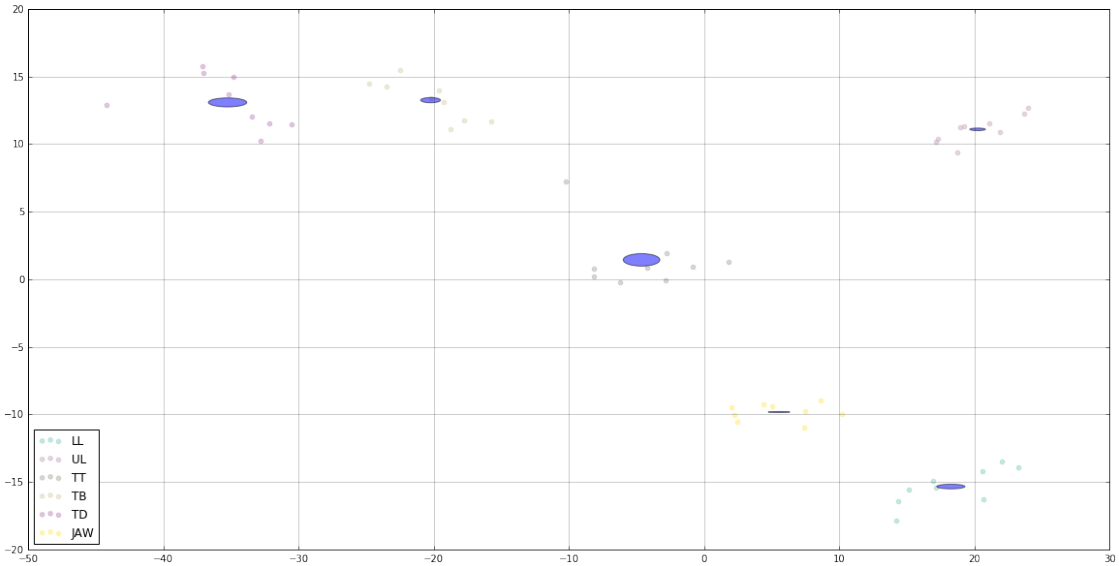
Gesture "er" (samples = 41)



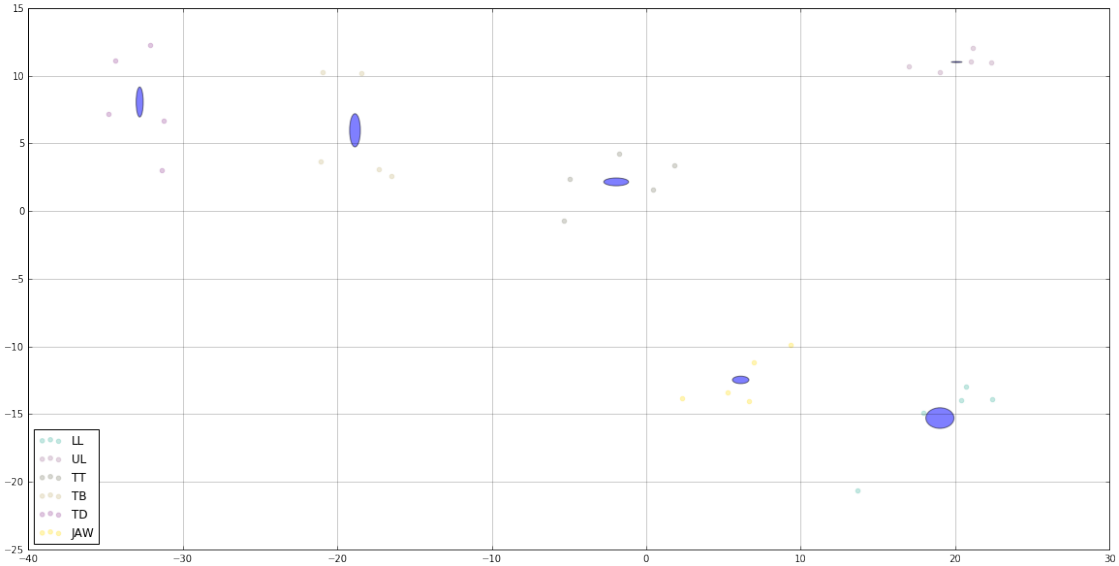
Gesture "ng" (samples = 9)



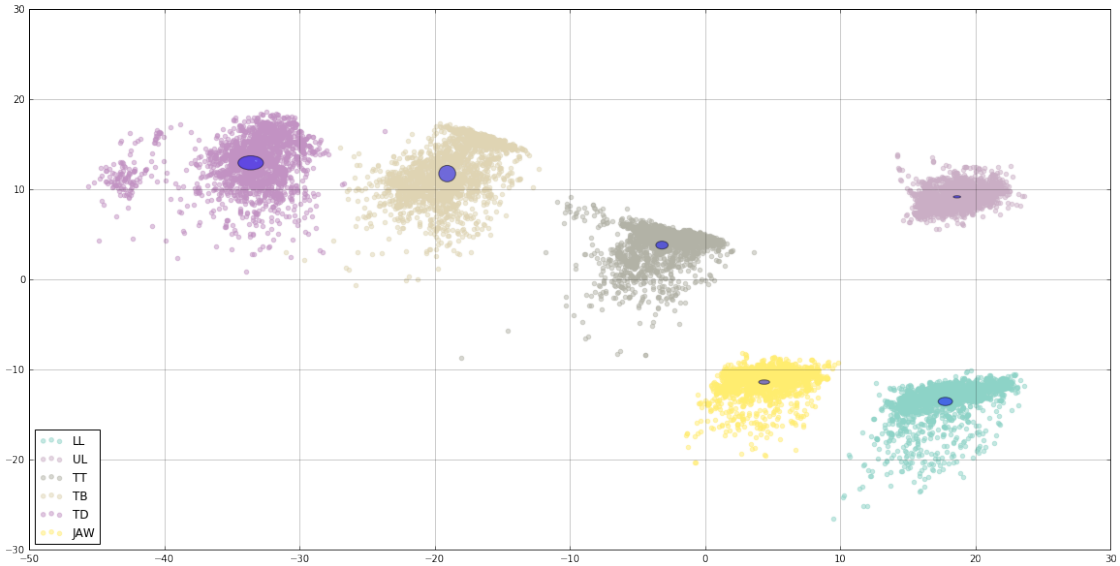
Gesture "sh" (samples = 9)



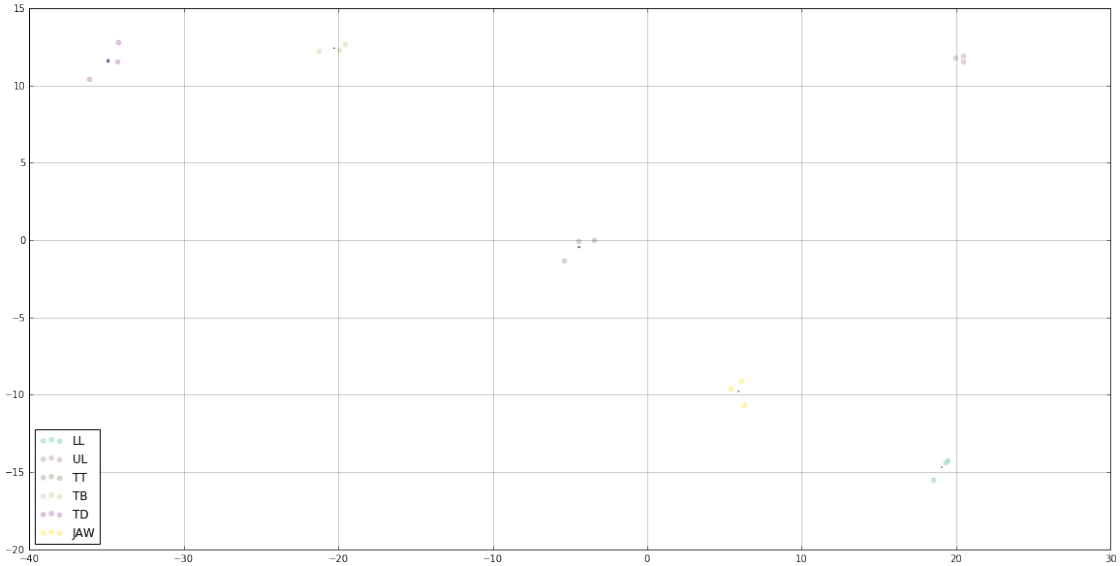
Gesture "th" (samples = 5)



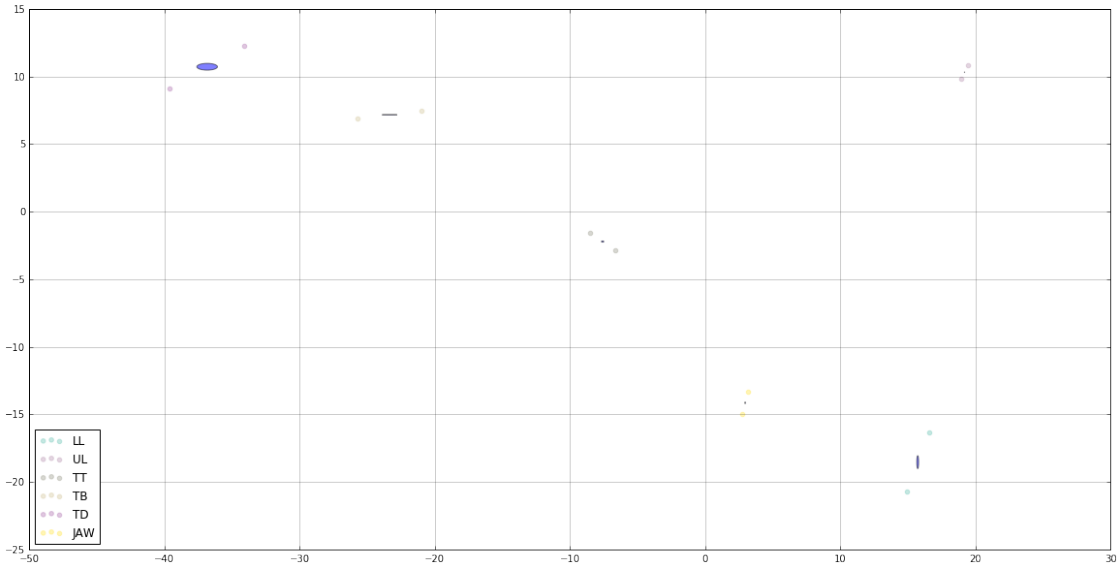
Gesture "sil" (samples = 2066)



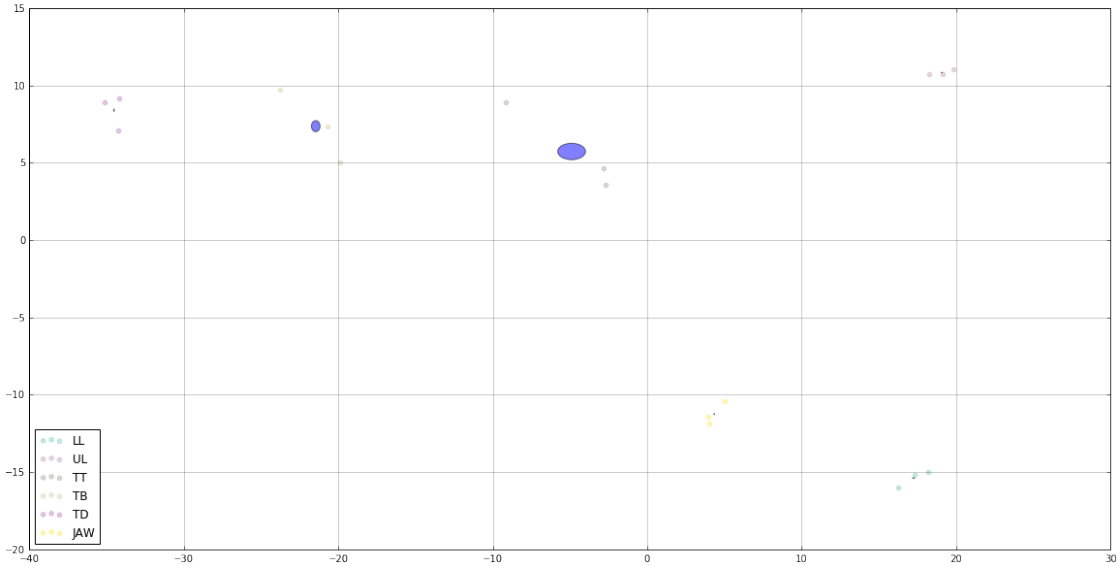
Gesture "zh" (samples = 3)



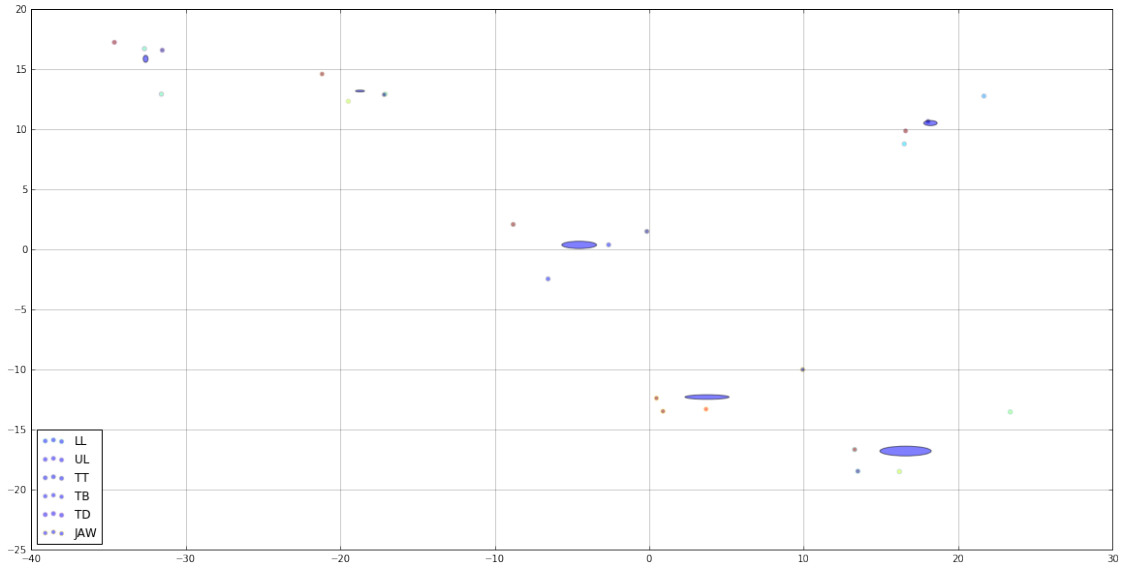
Gesture "oy" (samples = 2)



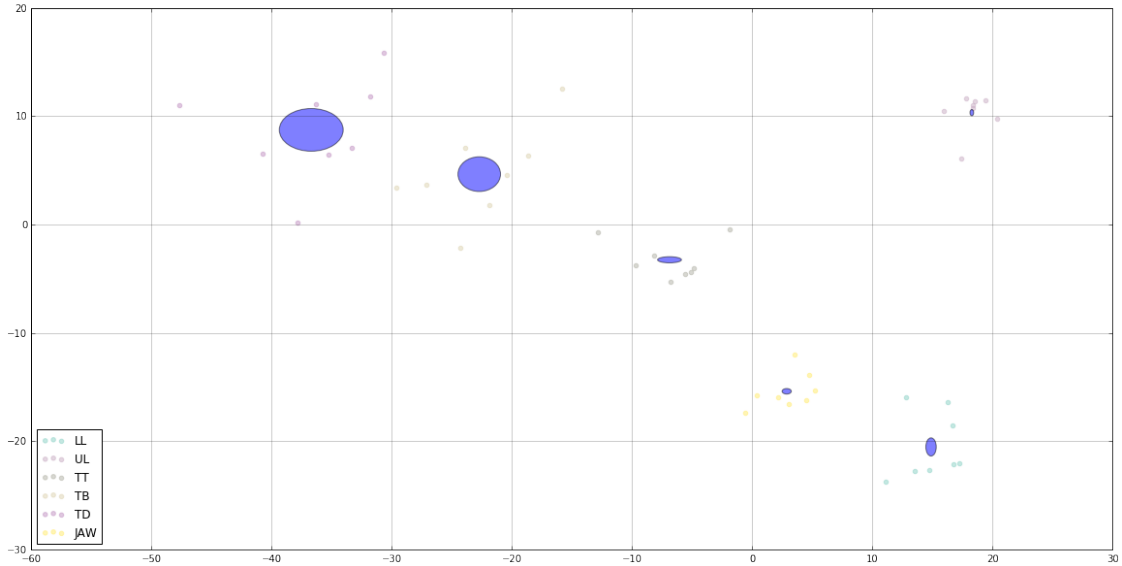
Gesture "dh" (samples = 3)



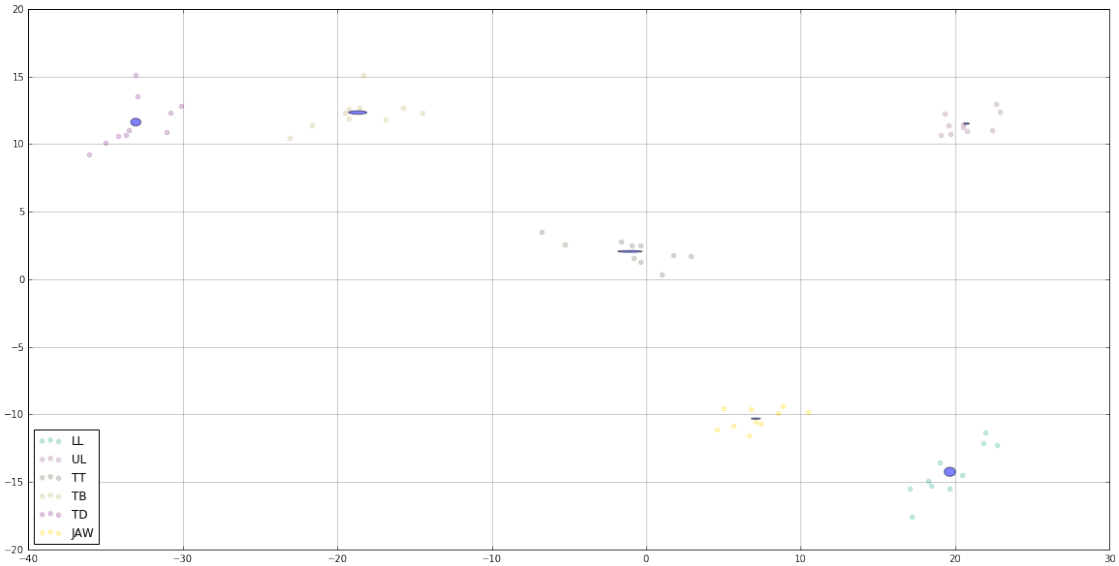
Gesture "y" (samples = 4)



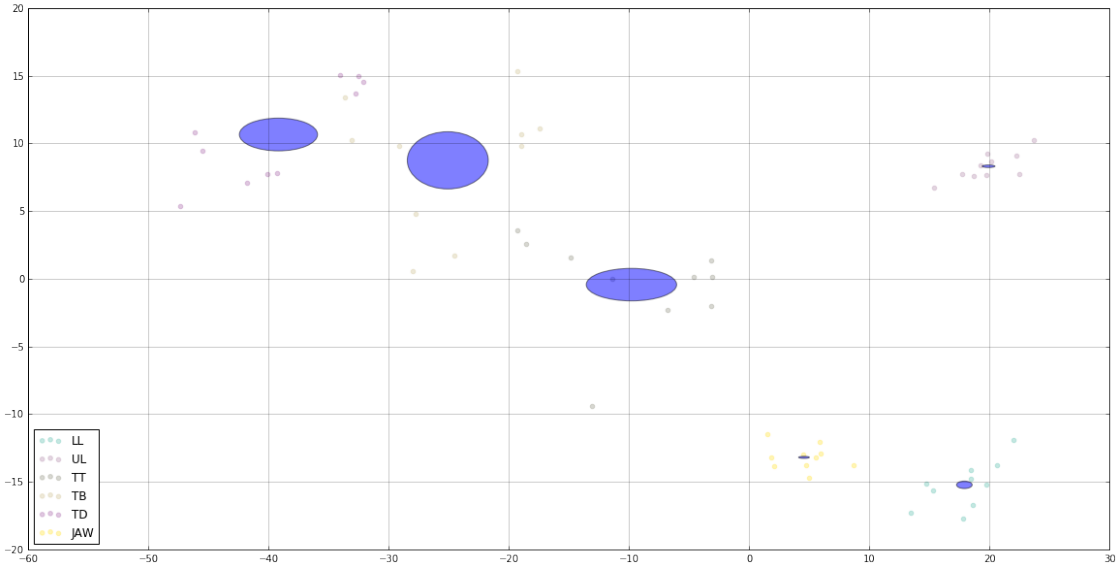
Gesture "hh" (samples = 8)



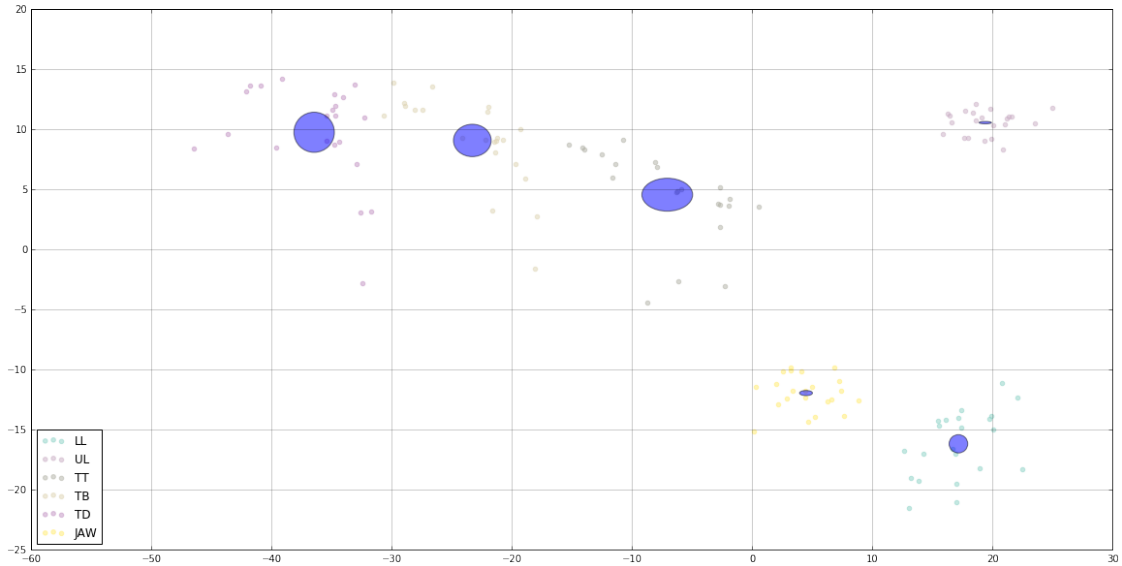
Gesture "jh" (samples = 10)



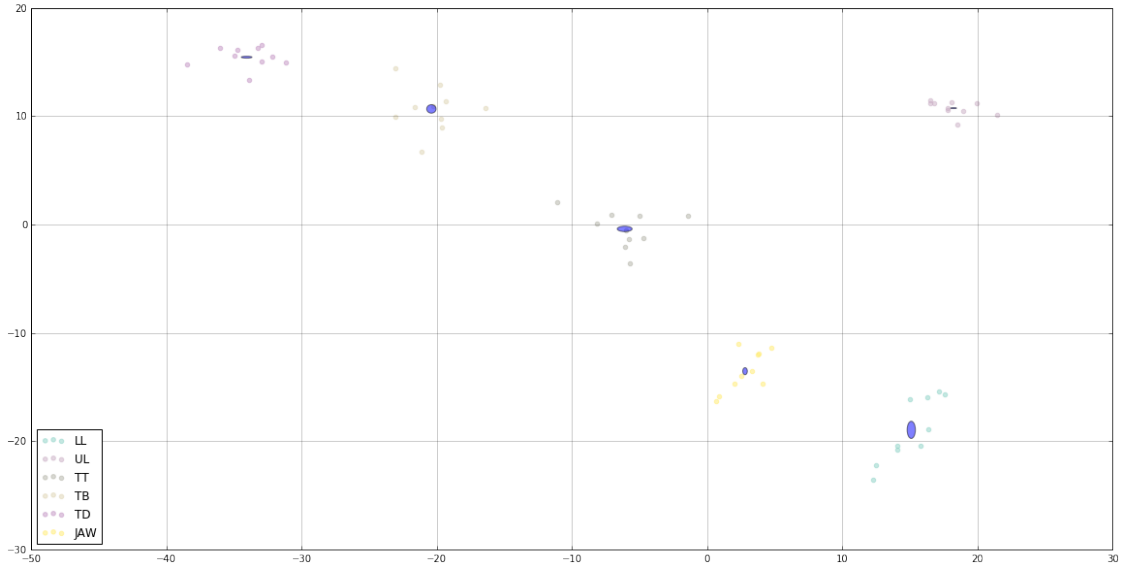
Gesture "b" (samples = 10)



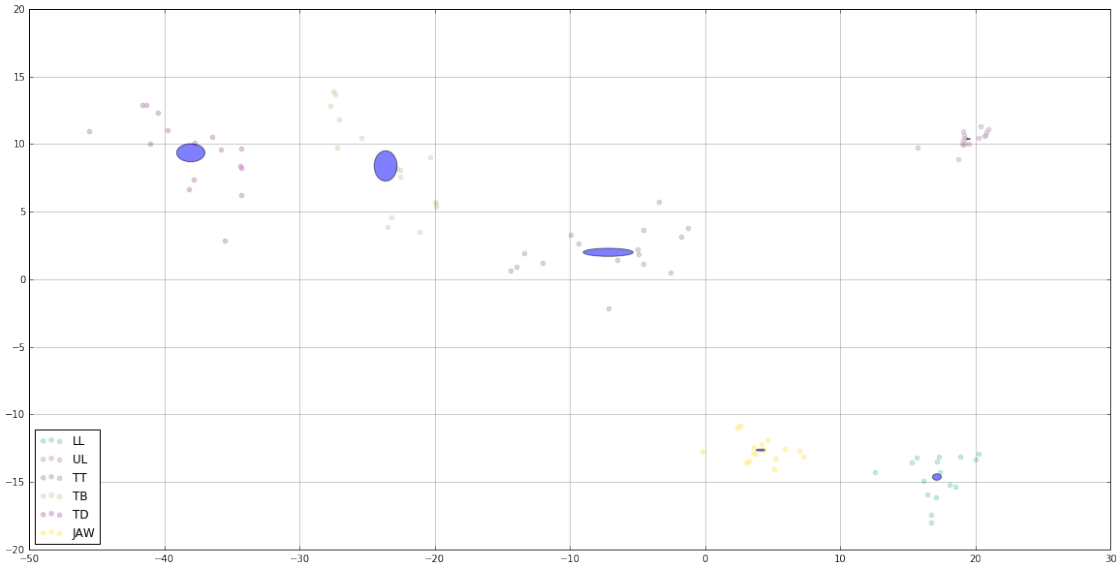
Gesture "d" (samples = 22)



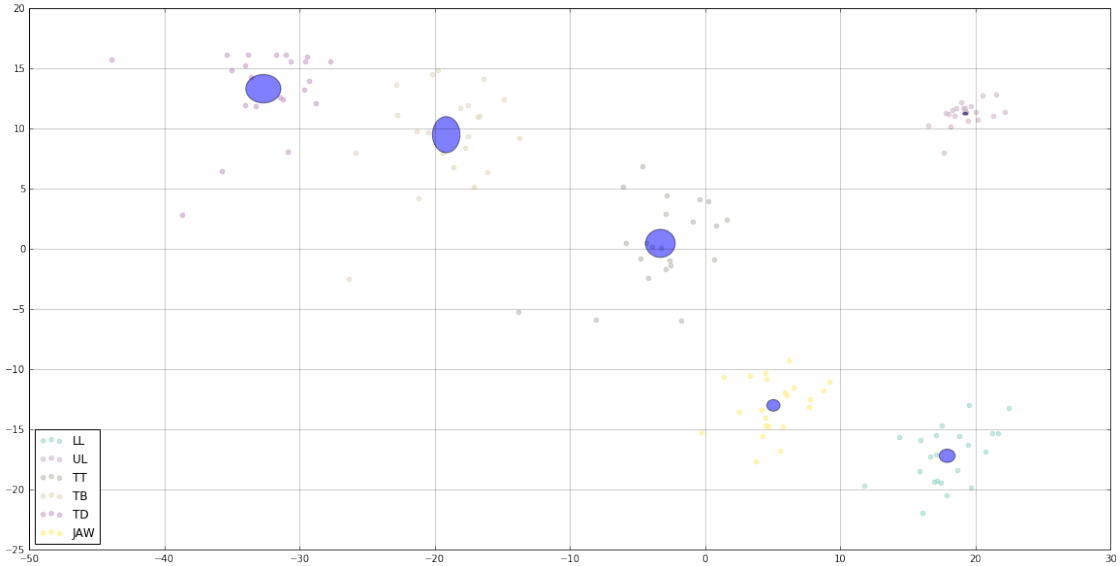
Gesture "g" (samples = 10)



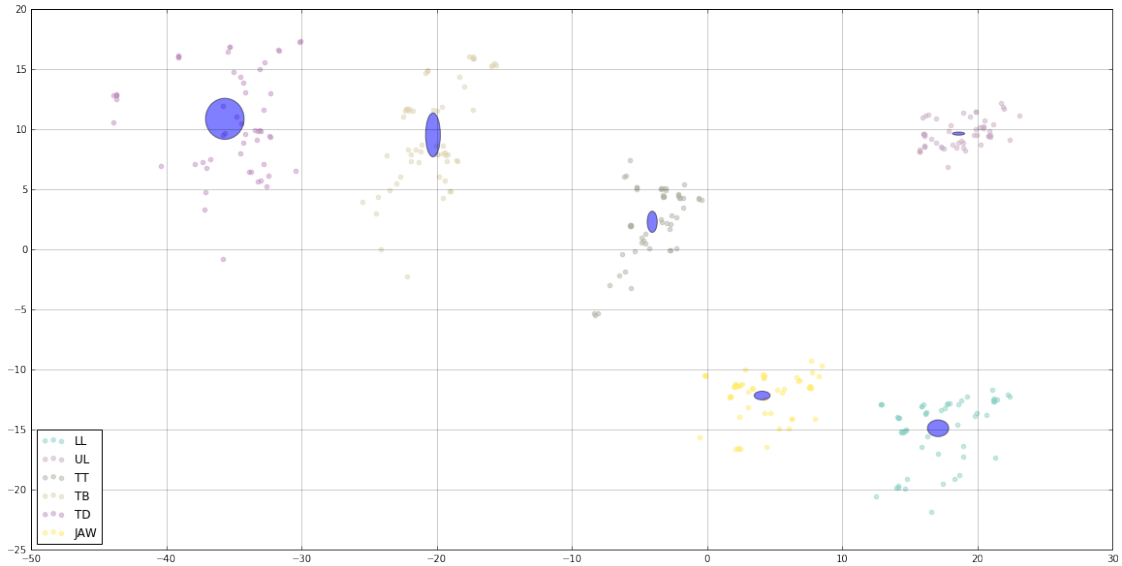
Gesture "f" (samples = 16)



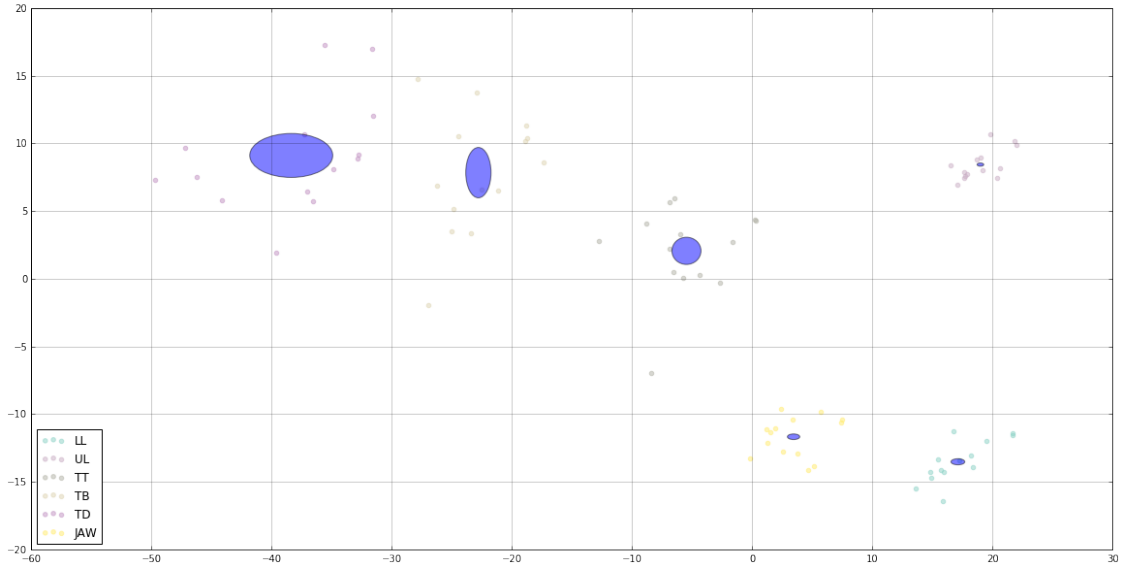
Gesture "k" (samples = 22)



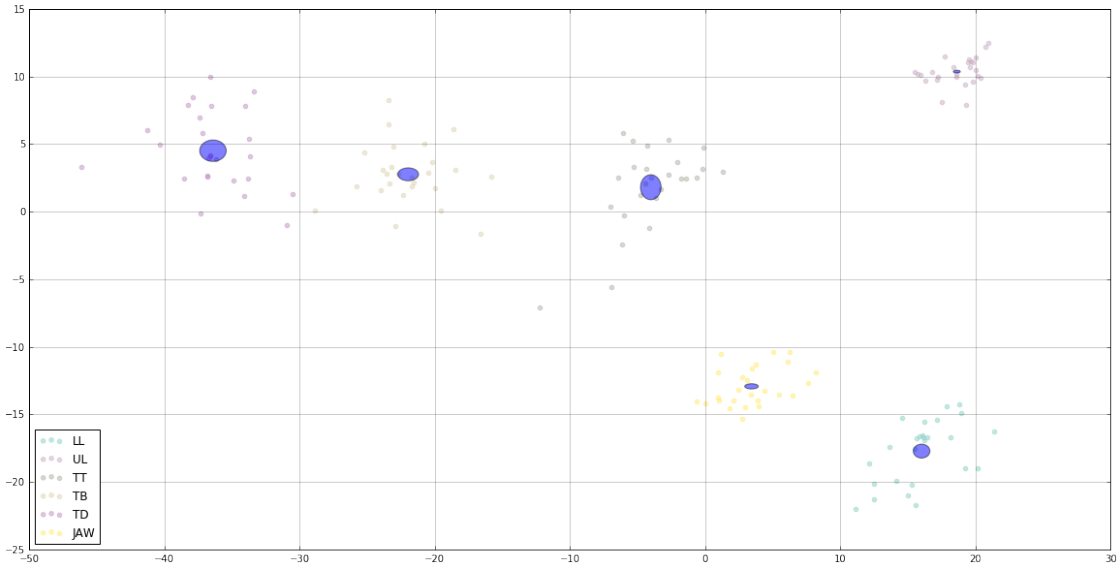
Gesture "sp" (samples = 57)



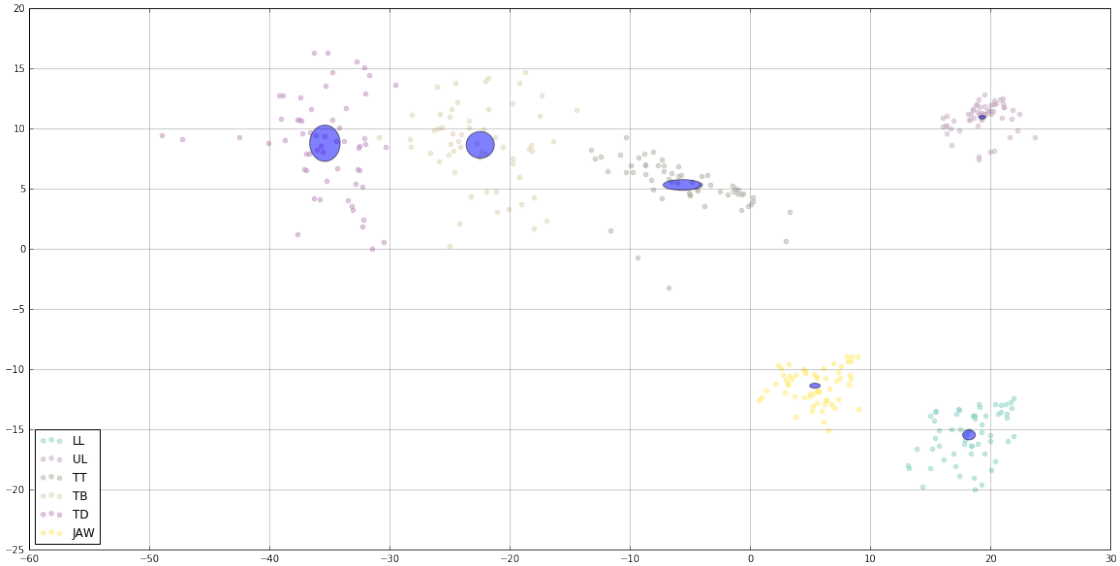
Gesture "m" (samples = 14)



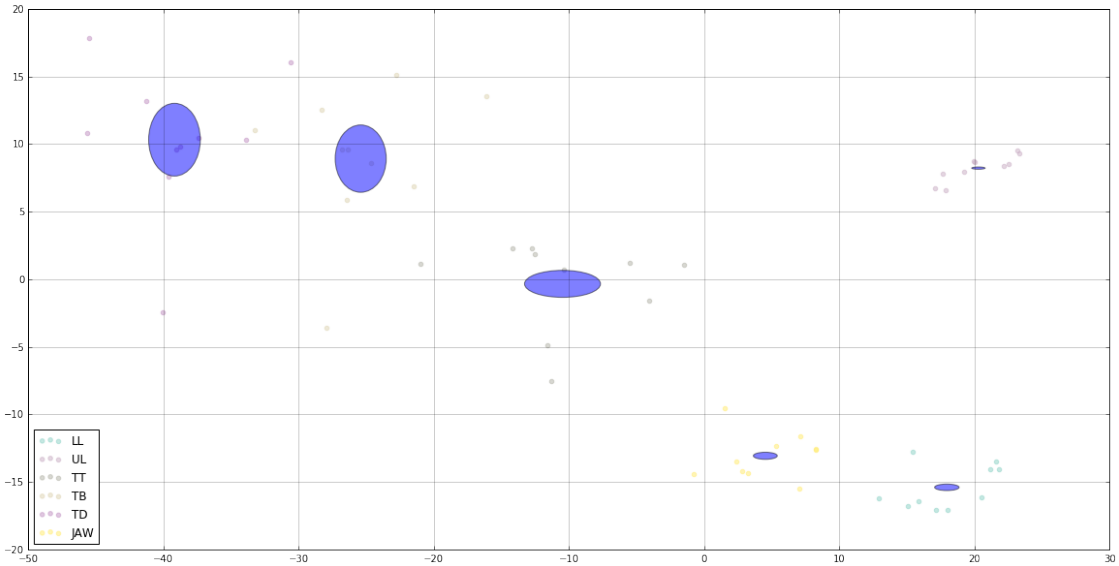
Gesture "l" (samples = 26)



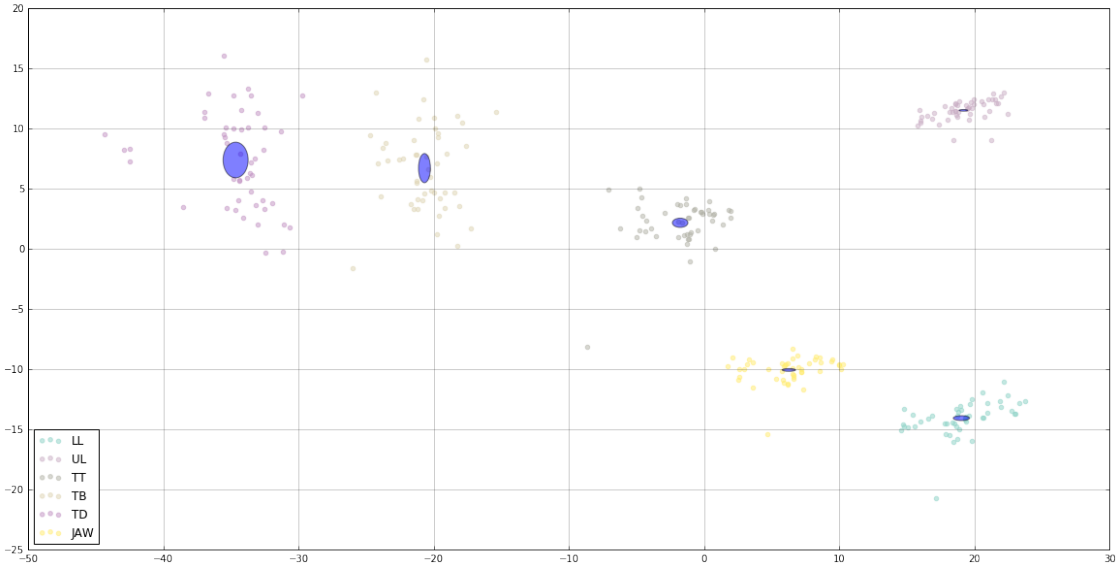
Gesture "n" (samples = 59)



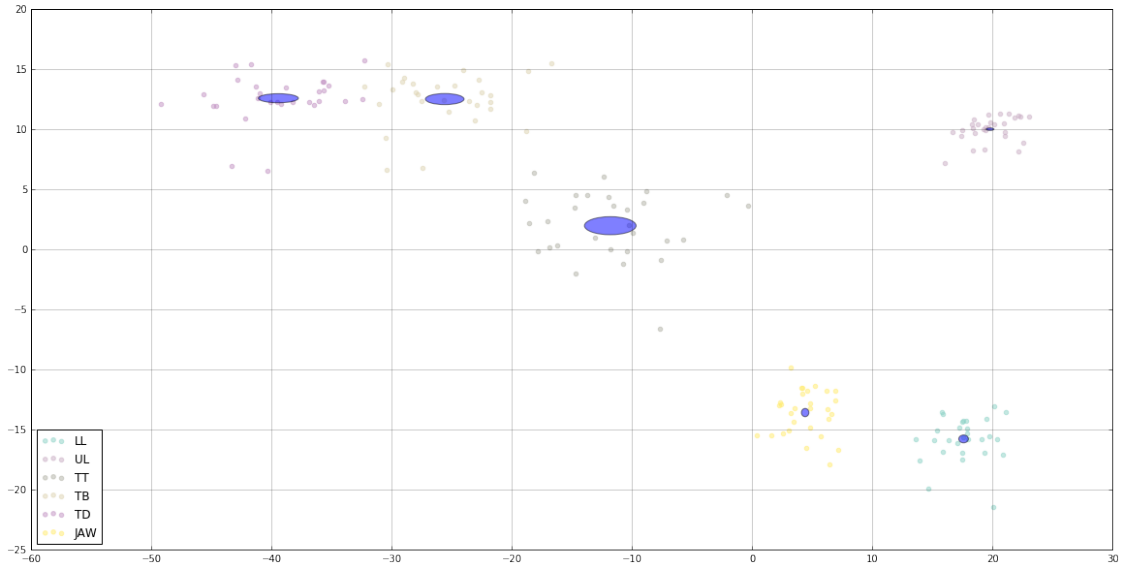
Gesture "p" (samples = 10)



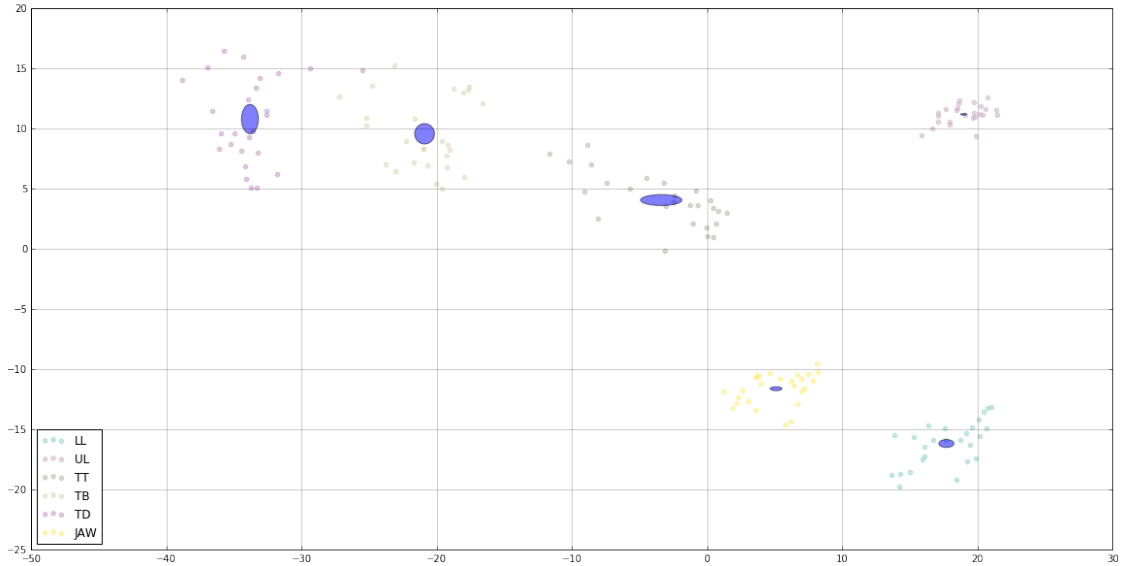
Gesture "s" (samples = 48)



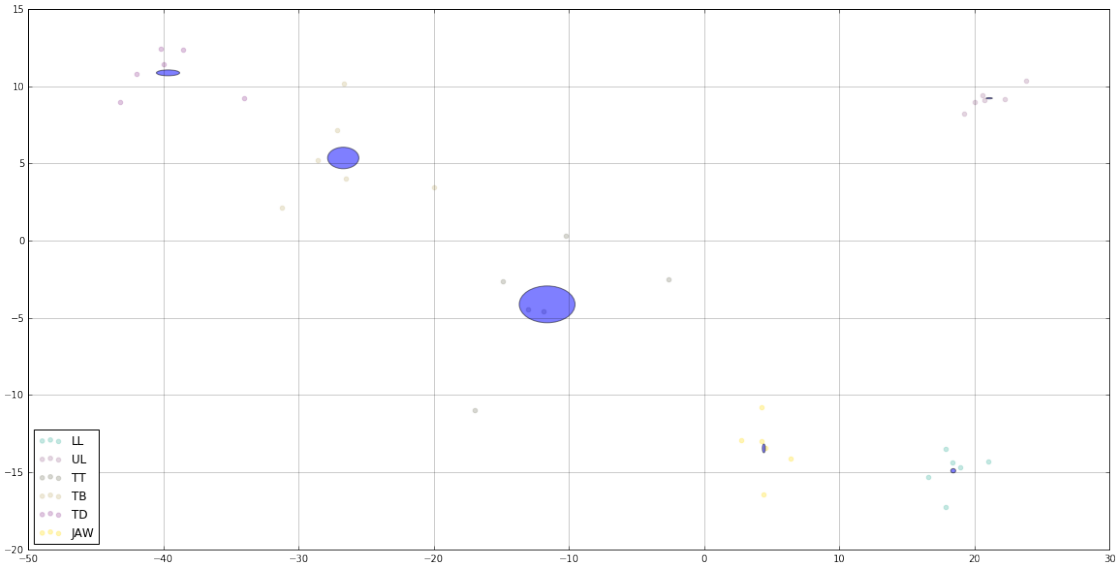
Gesture "r" (samples = 29)



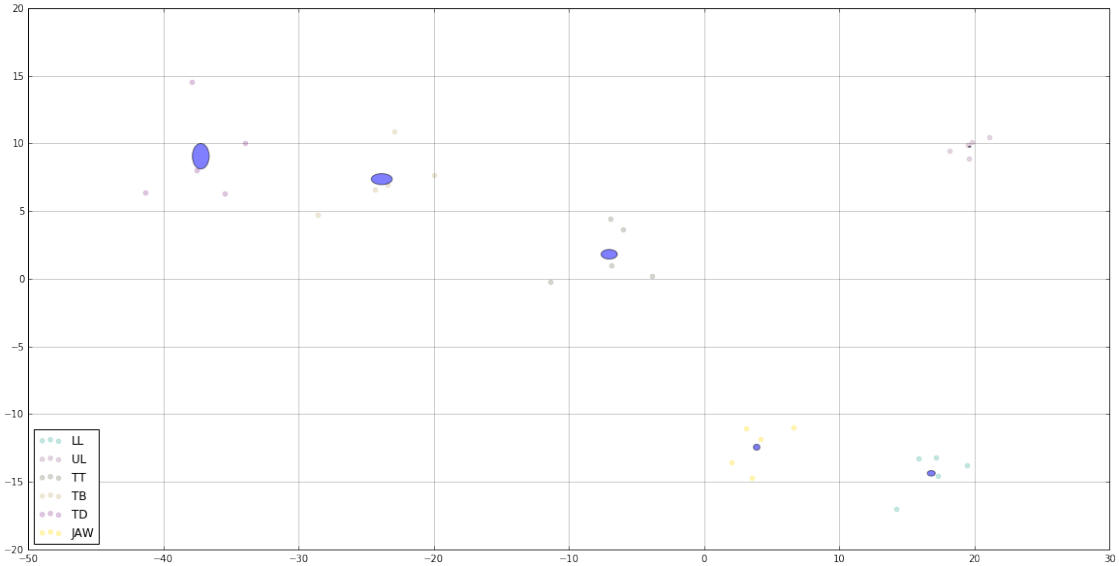
Gesture "t" (samples = 26)



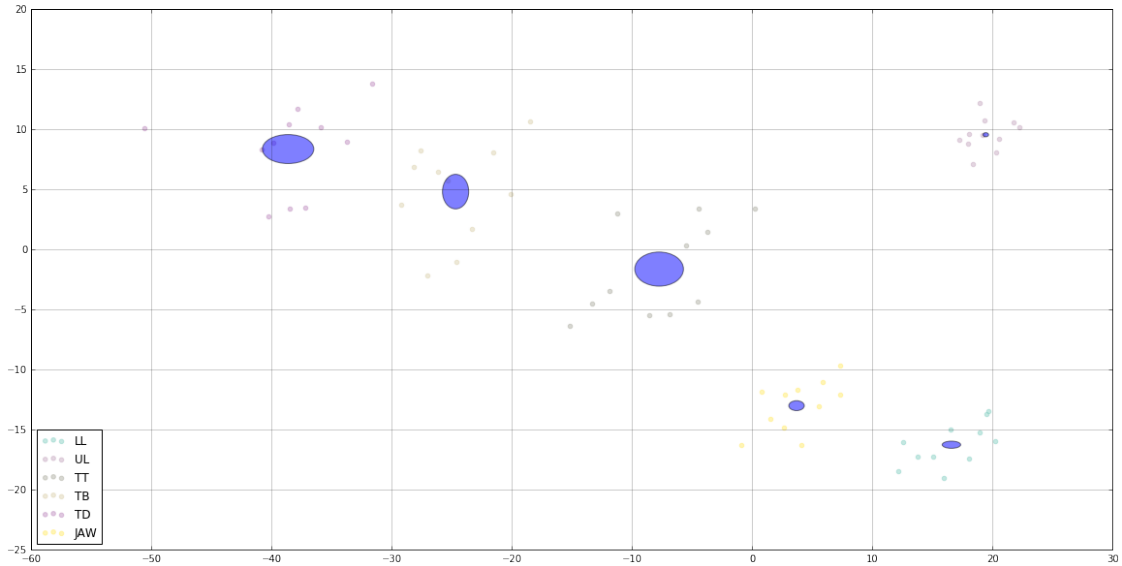
Gesture "w" (samples = 6)



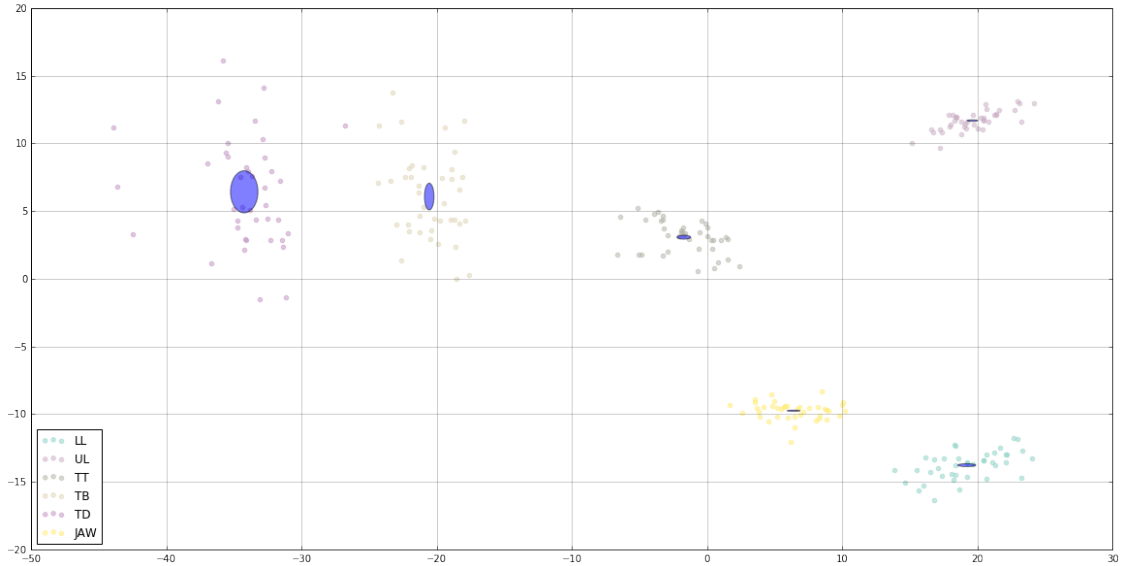
Gesture "v" (samples = 5)

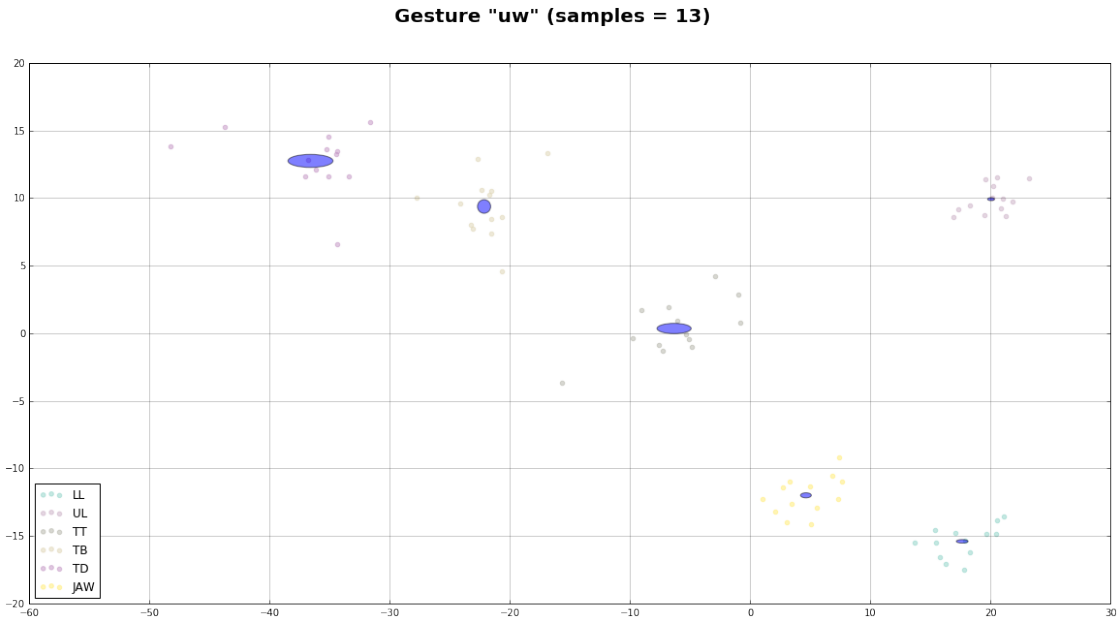


Gesture "ow" (samples = 11)



Gesture "z" (samples = 40)

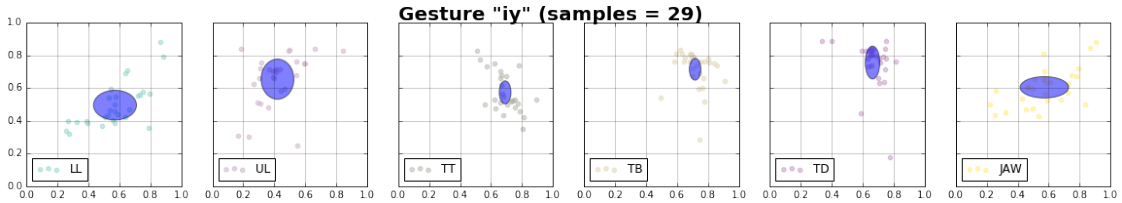


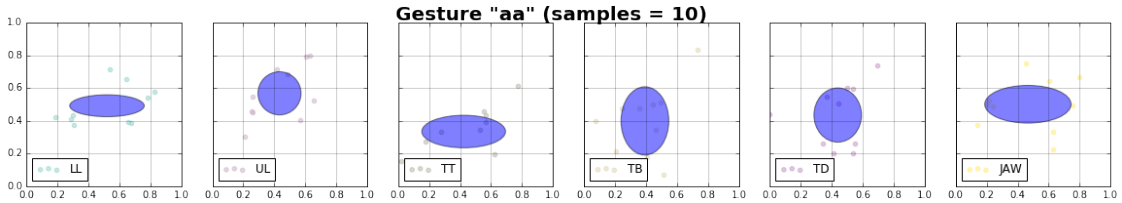


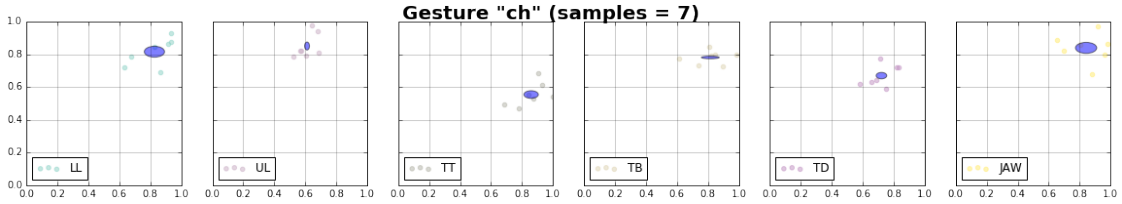
1.3 Normalize Gestures

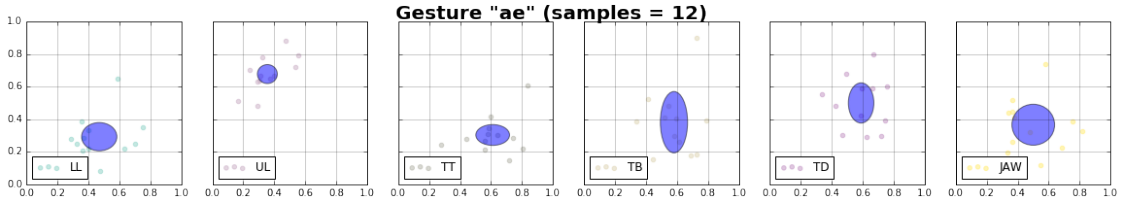
In [3]:
```
from matplotlib.patches import Ellipse

gestures, p_max, p_min = tist.normalize_gestures(gestures)

articulators = ["LL", "UL", "TT", "TB", "TD", "JAW"]

cmap = plt.get_cmap('Set3')
colors = [cmap(i) for i in np.linspace(0, 1, len(articulators))]
for g_name, g in gestures.items():
#     f, (ax1, ax2) = plt.subplots(1, 2, sharey=True)
    fig1, ax = plt.subplots(1, len(articulators), sharey=True, figsize=(20, 3))
    fig1.suptitle("Gesture \"{}\" (samples = {})".format(g_name,
                                                         len(g.params["LL_x"])),
                  fontsize=20, fontweight='bold')

    g_m = g.get_mean()
    g_v = g.get_variance()

    for i in range(len(articulators)):
        ax[i].grid(color='black', linestyle='-', linewidth=1, alpha=0.2)
        ax[i].set_xlim(0, 1)
        ax[i].set_ylim(0, 1)
        a = articulators[i]
        a_x = g.params[a+"_x"]
        a_y = g.params[a+"_y"]
```

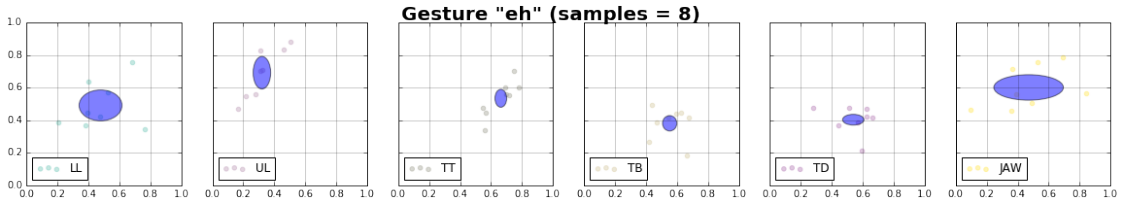
```
            ax[i].scatter(a_x, a_y, color=colors[i], alpha=0.5, label=a)
#             plot mean ellipse
            e = Ellipse(xy=[g_m[a+"_x"], g_m[a+"_y"]],
                        width=g_v[a+"_x"]*10, height=g_v[a+"_y"]*10, alpha=0.5)
            ax[i].add_artist(e)
            ax[i].legend(loc='lower left')

        plt.show()
```

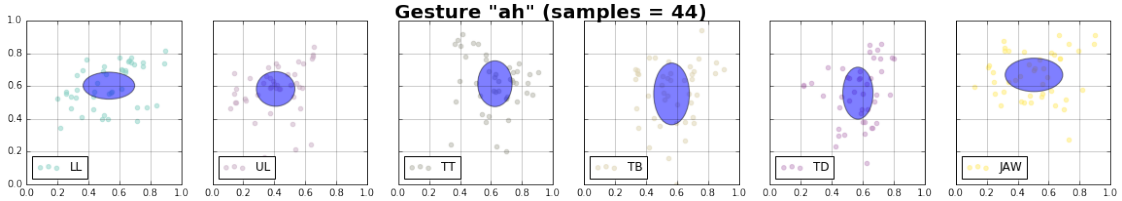


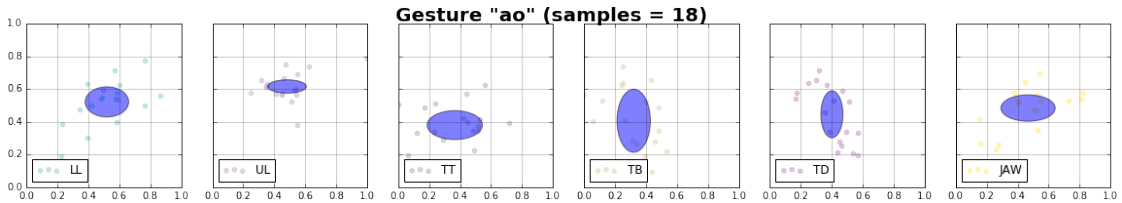


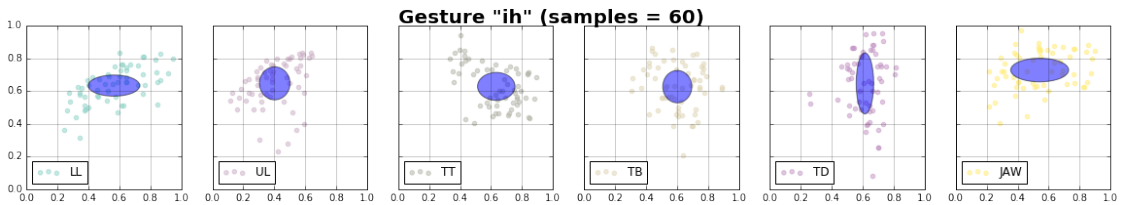


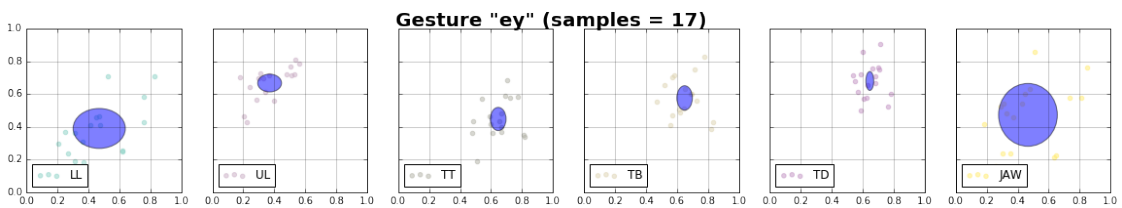


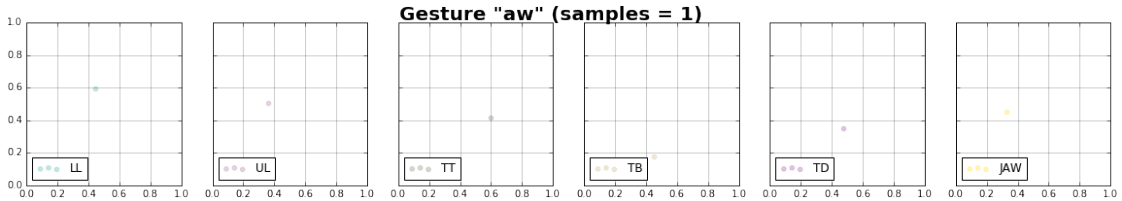

Gesture "eh" (samples = 8)
LL
UL
TT
TB
TD
JAW

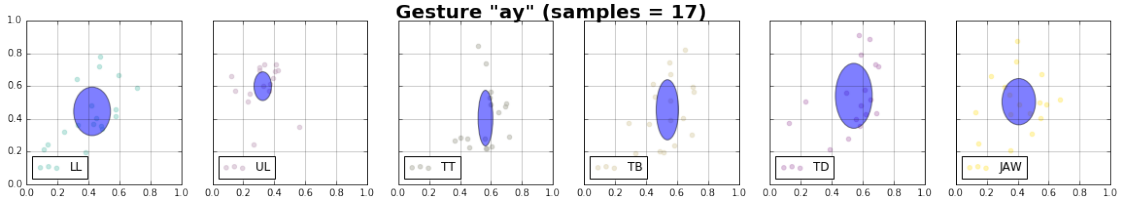

Gesture "ah" (samples = 44)
LL
UL
TT
TB
TD
JAW

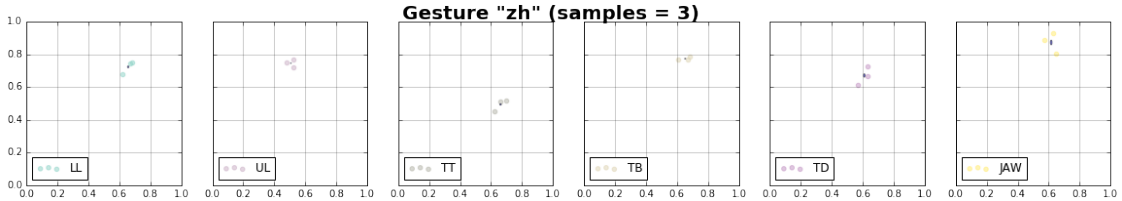

Gesture "ao" (samples = 18)
LL
UL
TT
TB
TD
JAW

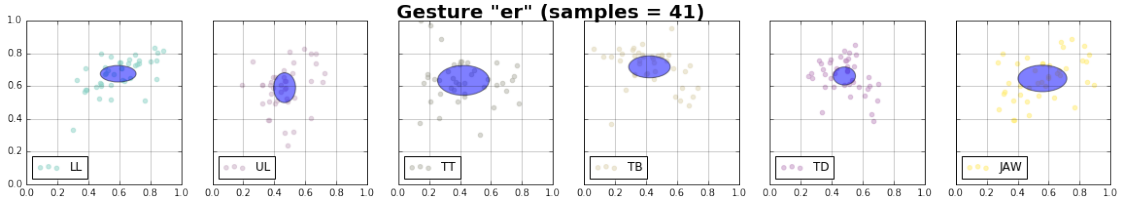

Gesture "ih" (samples = 60)
LL
UL
TT
TB
TD
JAW

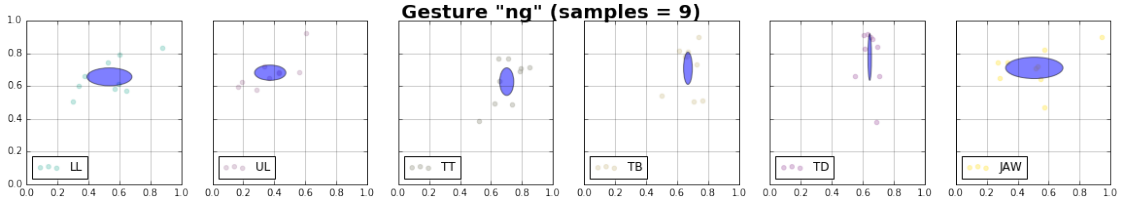

Gesture "ey" (samples = 17)
LL
UL
TT
TB
TD
JAW

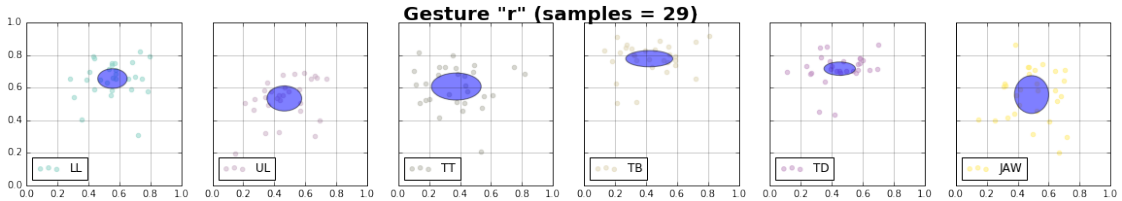

Gesture "aw" (samples = 1)
LL
UL
TT
TB
TD
JAW

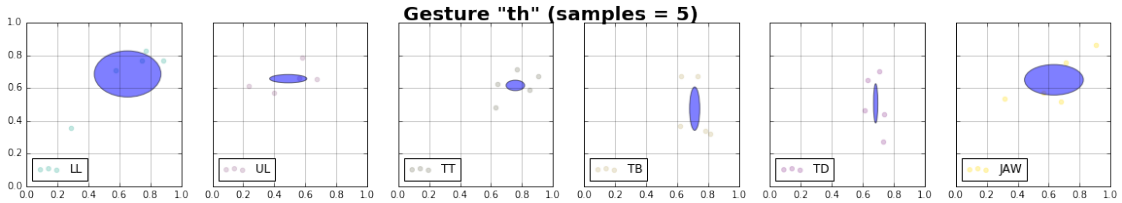

Gesture "ay" (samples = 17)
LL
UL
TT
TB
TD
JAW

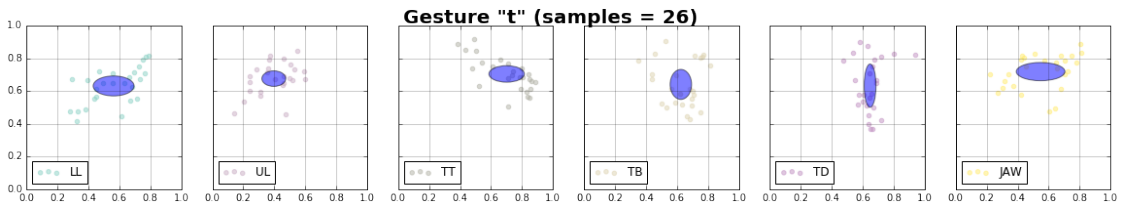

Gesture "zh" (samples = 3)
LL
UL
TT
TB
TD
JAW

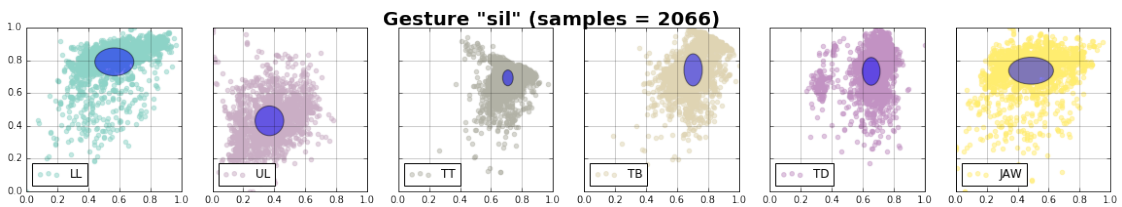

Gesture "er" (samples = 41)
LL
UL
TT
TB
TD
JAW

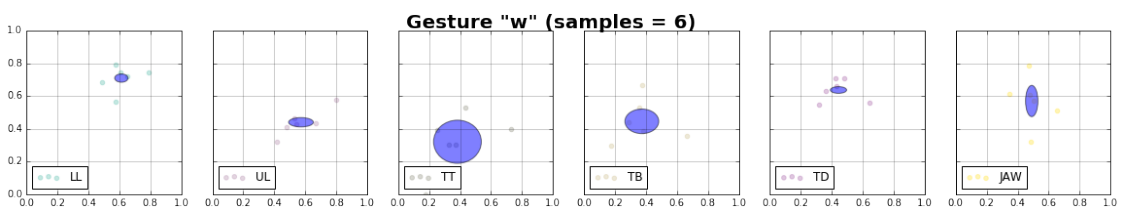

Gesture "ng" (samples = 9)
LL
UL
TT
TB
TD
JAW

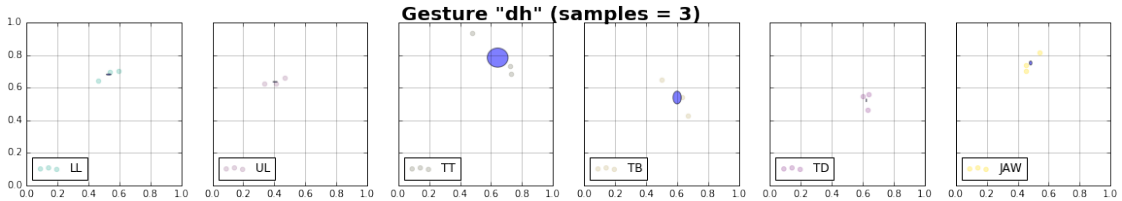

Gesture "r" (samples = 29)
LL
UL
TT
TB
TD
JAW

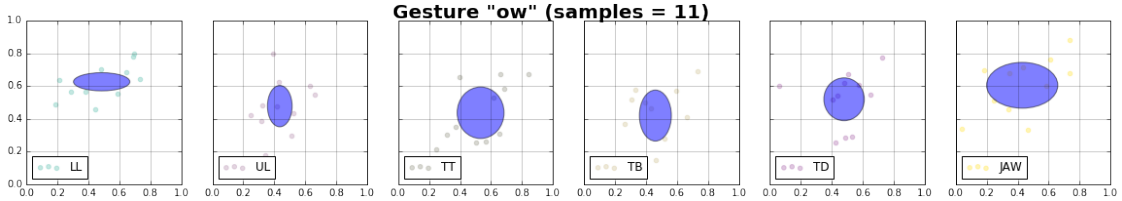

Gesture "th" (samples = 5)
LL
UL
TT
TB
TD
JAW

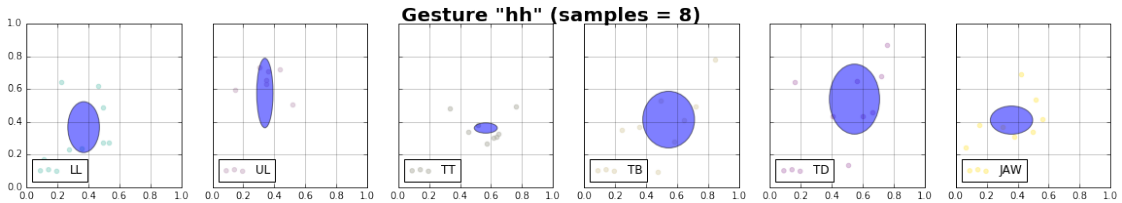

Gesture "t" (samples = 26)
LL
UL
TT
TB
TD
JAW

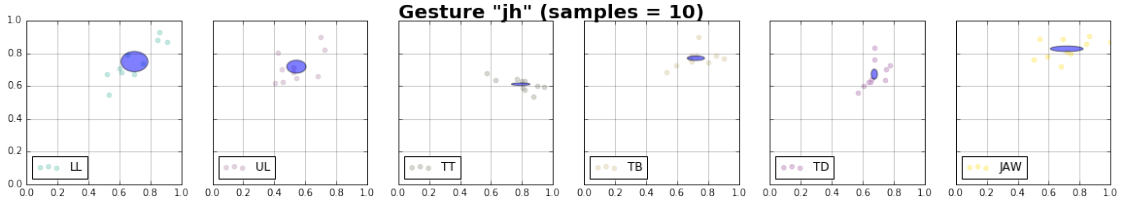

Gesture "sil" (samples = 2066)
LL
UL
TT
TB
TD
JAW

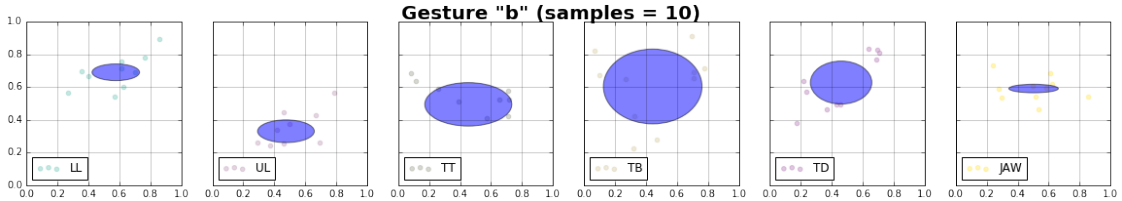

Gesture "w" (samples = 6)
LL
UL
TT
TB
TD
JAW

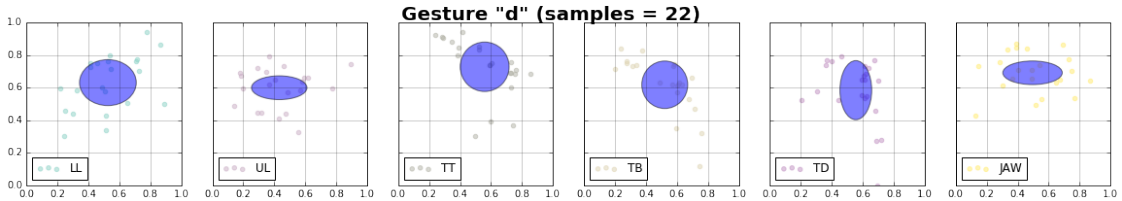

Gesture "dh" (samples = 3)
LL
UL
TT
TB
TD
JAW

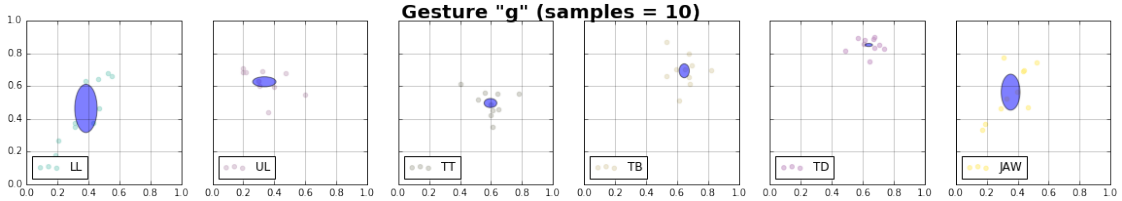

Gesture "ow" (samples = 11)
LL
UL
TT
TB
TD
JAW

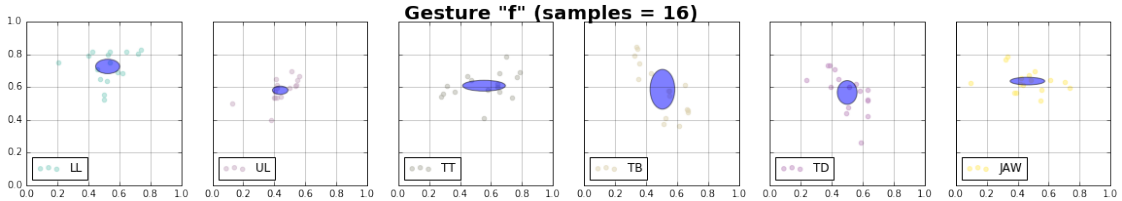

Gesture "hh" (samples = 8)
LL
UL
TT
TB
TD
JAW

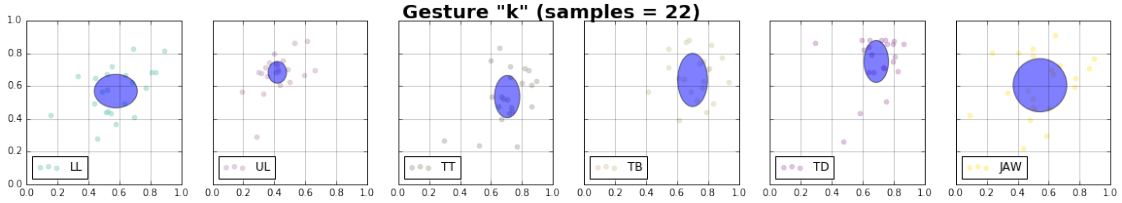

Gesture "jh" (samples = 10)
LL
UL
TT
TB
TD
JAW

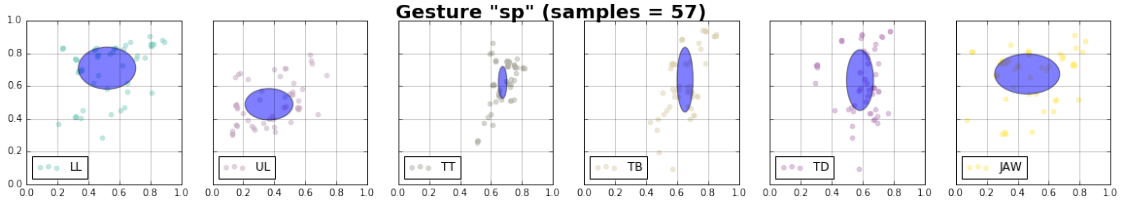

Gesture "b" (samples = 10)
LL
UL
TT
TB
TD
JAW

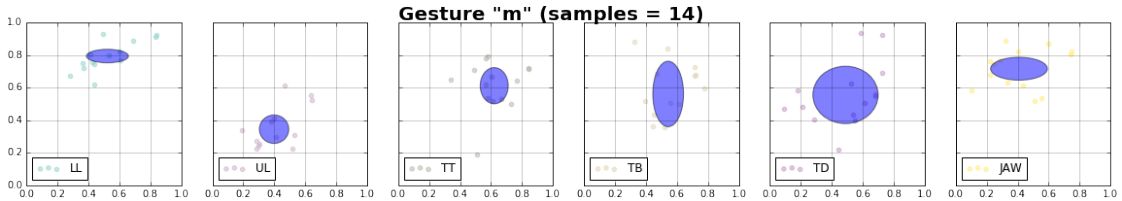

Gesture "d" (samples = 22)
LL
UL
TT
TB
TD
JAW

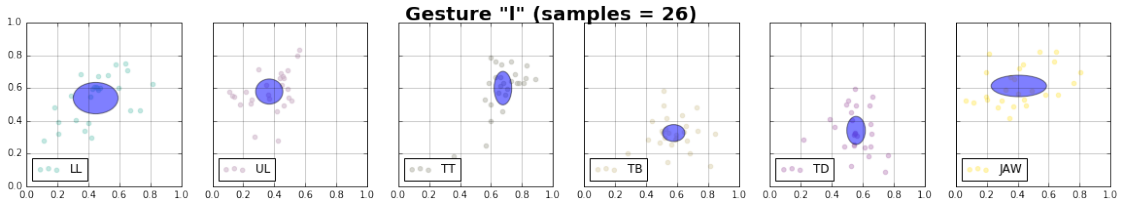

Gesture "g" (samples = 10)
LL
UL
TT
TB
TD
JAW

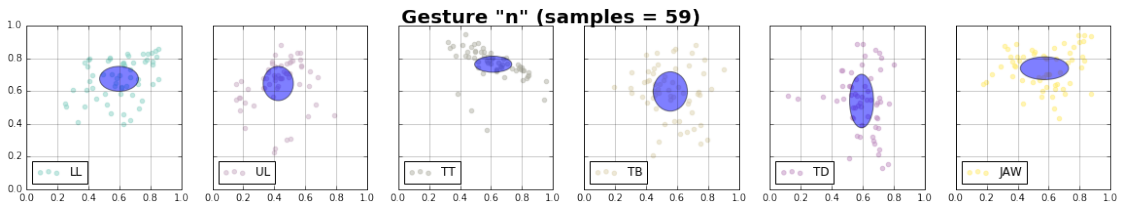

Gesture "f" (samples = 16)
LL
UL
TT
TB
TD
JAW

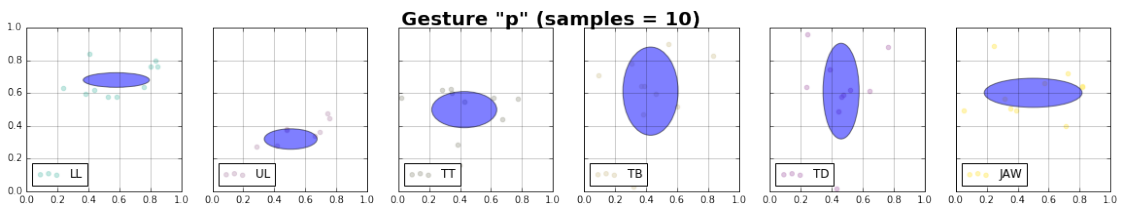

Gesture "k" (samples = 22)
LL
UL
TT
TB
TD
JAW

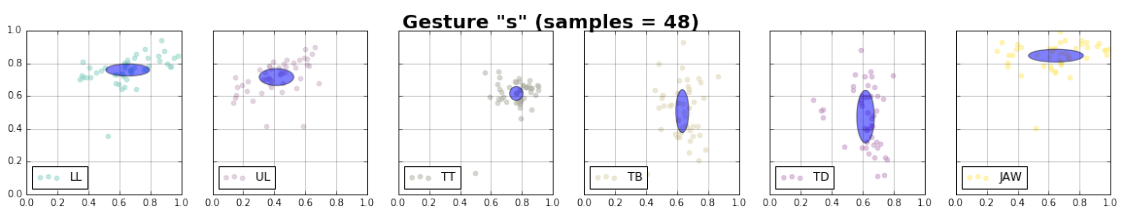

Gesture "sp" (samples = 57)
LL
UL
TT
TB
TD
JAW

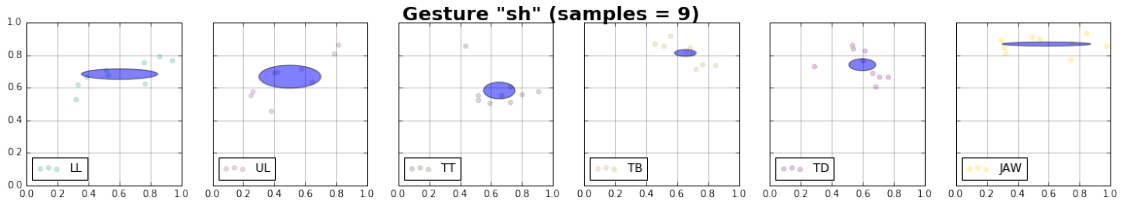

Gesture "m" (samples = 14)
LL
UL
TT
TB
TD
JAW

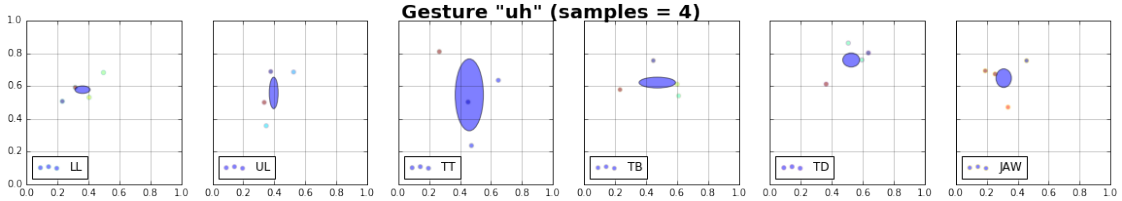

Gesture "l" (samples = 26)
LL
UL
TT
TB
TD
JAW

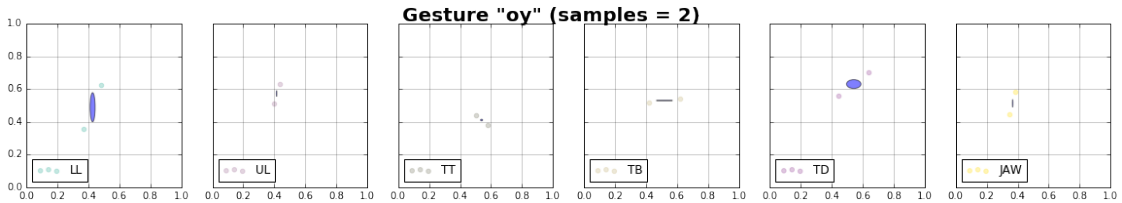

Gesture "n" (samples = 59)
LL
UL
TT
TB
TD
JAW

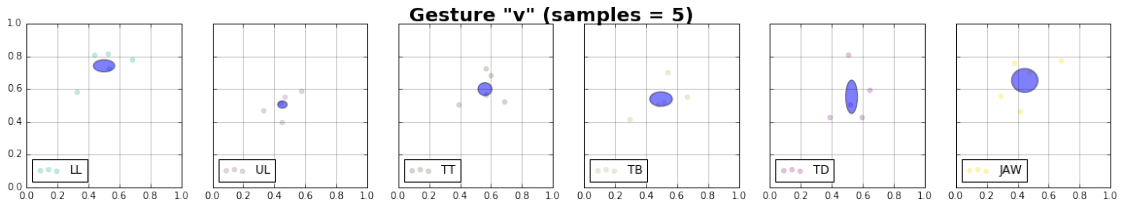

Gesture "p" (samples = 10)
LL
UL
TT
TB
TD
JAW

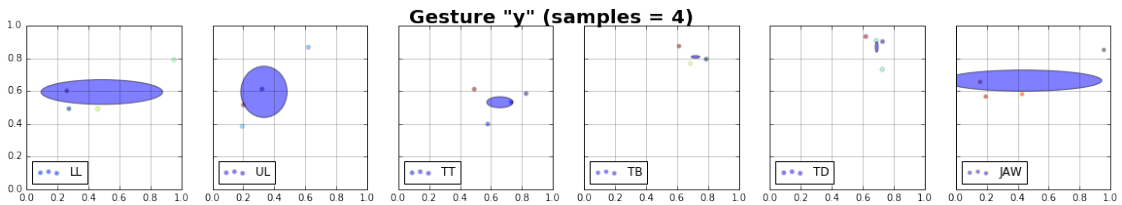

Gesture "s" (samples = 48)
LL
UL
TT
TB
TD
JAW

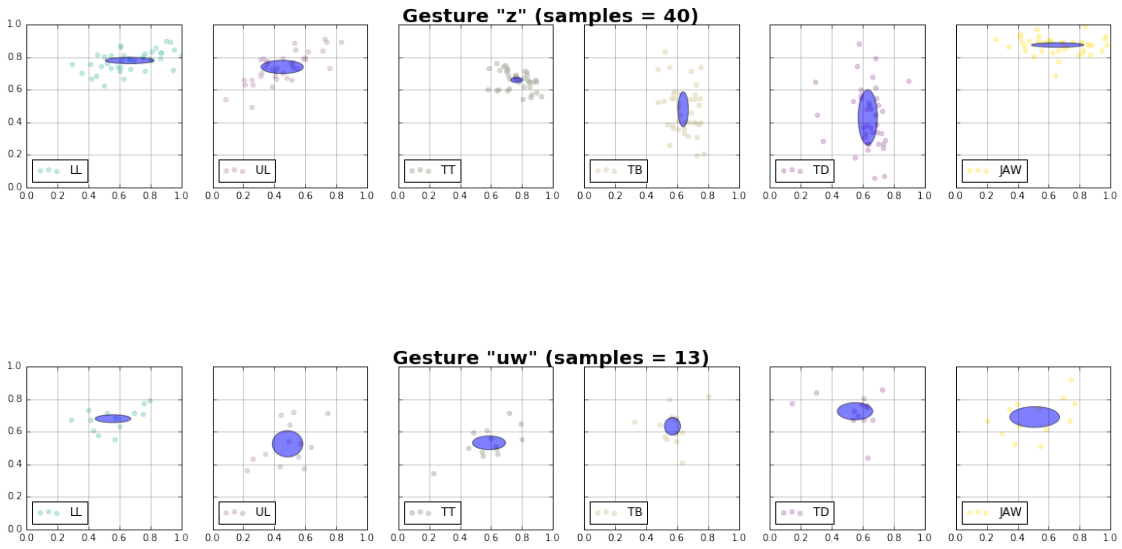

Gesture "sh" (samples = 9)
LL
UL
TT
TB
TD
JAW


Gesture "uh" (samples = 4)
LL
UL
TT
TB
TD
JAW


Gesture "oy" (samples = 2)
LL
UL
TT
TB
TD
JAW


Gesture "v" (samples = 5)
LL
UL
TT
TB
TD
JAW


Gesture "y" (samples = 4)
LL
UL
TT
TB
TD
JAW

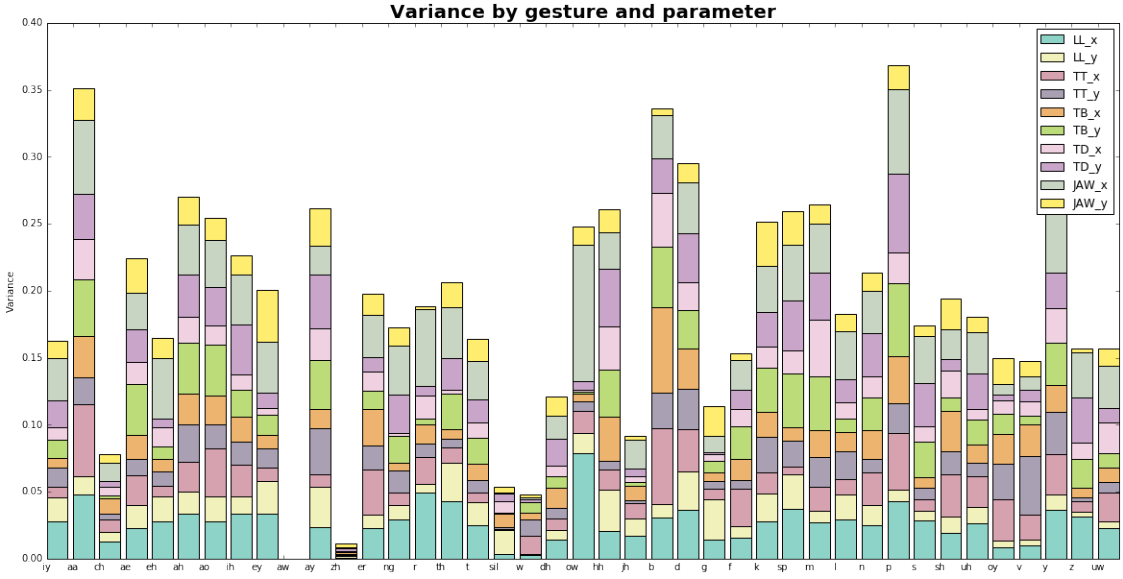


1.4 Variance analysis

```
In [4]: # a stacked bar plot
        import numpy as np
        import matplotlib.pyplot as plt

        articulators = ["LL", "TT", "TB", "TD", "JAW"]
        domains=["_x", "_y"]
        param_names = [a+d for a in articulators for d in domains]
        ind = np.arange(len(gestures))
        gestures_norm = gestures
        means={}
        variances={}
        for p in param_names:
            means[p] = {}
            variances[p] = {}

        for g in gestures_norm:
            g_m = gestures_norm[g].get_mean()
            g_v = gestures_norm[g].get_variance()
            for p in param_names:
                means[p][g] = g_m[p]*(p_max[p]-p_min[p]) + p_min[p]
                variances[p][g] = g_v[p]

        print "Means and variances calculated succesfully"

        # plor variances
        fig1, ax = plt.subplots(figsize=(20, 10))
        cmap = plt.get_cmap('Set3')
```

```
        colors = [cmap(i) for i in np.linspace(0, 1, len(param_names))]

        acc = [0]*len(gestures)
        for i in range(len(param_names)):
            p = param_names[i]
            plt.bar(ind, variances[p].values(), width=0.8, color=colors[i], bottom=acc, label=p
            acc = [x + y for x,y in zip(variances[p].values(), acc)]
            legend()


        plt.ylabel('Variance')
        plt.title('Variance by gesture and parameter', fontsize=20, fontweight='bold')
        plt.xticks(np.arange(len(gestures)), gestures.keys())
        plt.autoscale()
        plt.show()
```

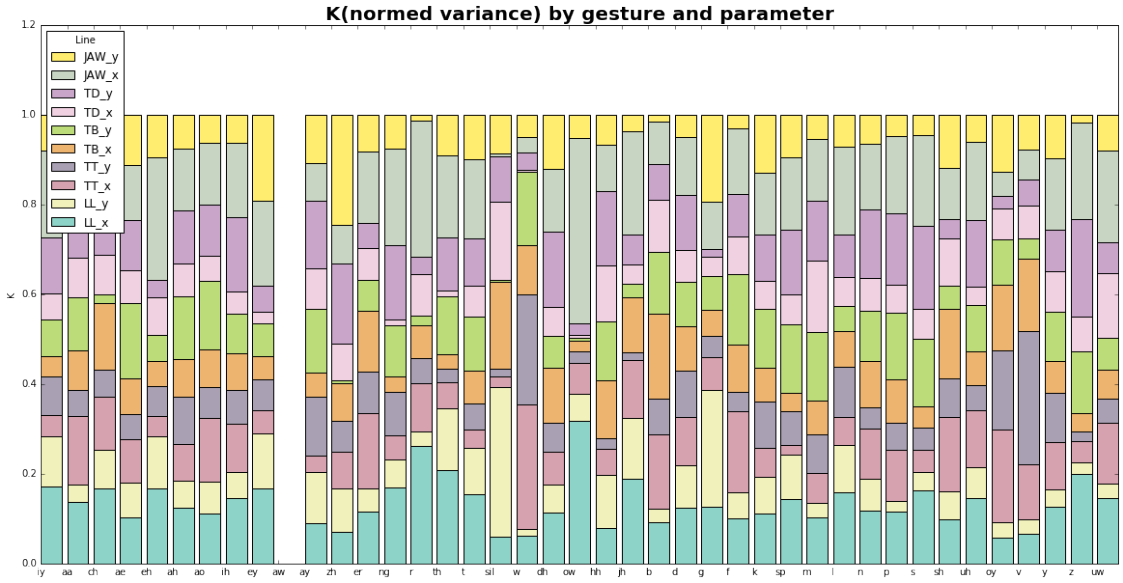
```
Means and variances calculated succesfully
```




```
In [5]: # plor variances
        fig1, ax = plt.subplots(figsize=(20, 10))
        cmap = plt.get_cmap('Set3')
        colors = [cmap(i) for i in np.linspace(0, 1, len(param_names))]

        acc1 = [0]*len(gestures)
        for i in range(len(param_names)):
            p = param_names[i]
            normed = [x/y for x,y in zip(variances[p].values(), acc)]
```

```
            plt.bar(ind, normed, width=0.8, color=colors[i], bottom=acc1, label=p)
            acc1 = [x + y for x,y in zip(normed, acc1)]
            legend()

        plt.ylabel('K')
        plt.title('K(normed variance) by gesture and parameter', fontsize=20, fontweight='bold
        plt.xticks(np.arange(len(gestures)), gestures.keys())
        # plt.yticks(np.arange(0, 81, 10))
        # plt.legend((p1[0], p2[0]), ('Men', 'Women'))
        plt.autoscale()
        handles, labels = ax.get_legend_handles_labels()
        ax.legend(handles[::-1], labels[::-1], title='Line', loc='upper left')
        plt.show()
```

```
C:\Users\s3628075\Anaconda2\lib\site-packages\ipykernel\__main__.py:9: RuntimeWarning: invalid
```



IMPORTANT: Do not normalize variance like this. Different sum of variances just means that some gestures demand more precise articulation than others.

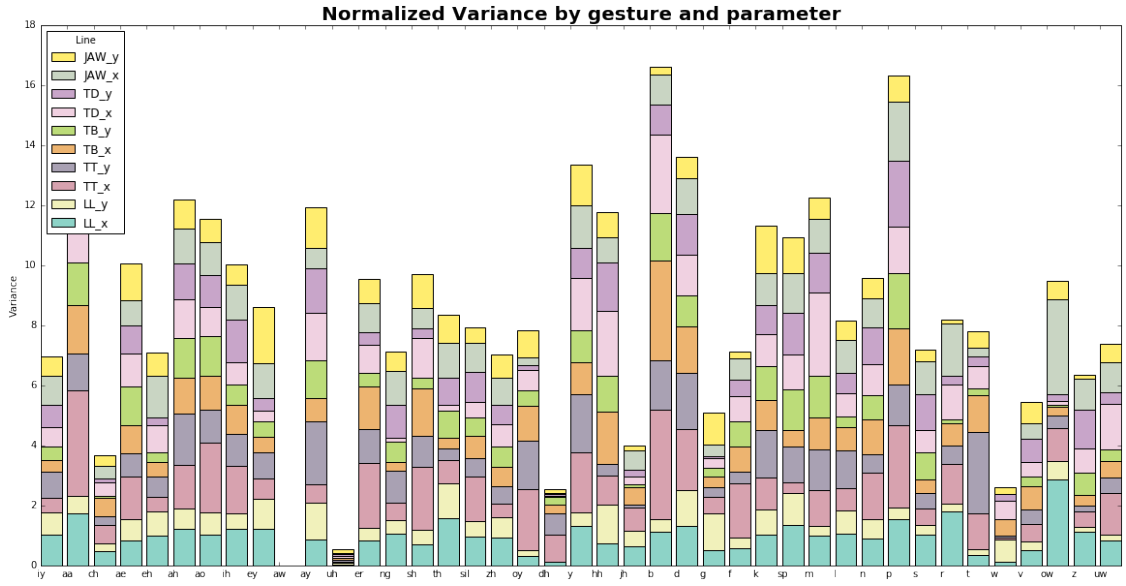
1.5 Calc overall mean and variance for each parameter

In [6]:
```
gestures = {}

        overall_ges = ges.Gesture("overall")

        for fname in os.listdir(trans_dir):
            fname = os.path.splitext(fname)[0]
            t_fname = os.path.join(trans_dir, fname + ".trans")
```

```
    mat_fname = os.path.join(mat_dir, fname + ".mat")
    gest = tist.calc_gestures(mat_fname, t_fname, filter_critical_points=True, m=0.1 )
    for g in gest:
        if g not in gestures:
            gestures[g] = ges.Gesture(g)
        gestures[g].extend(gest[g])
        overall_ges.extend(gest[g])

print "gestures calculation finished"

gestures_norm = gestures
means={}
variances={}
for p in param_names:
    means[p] = {}
    variances[p] = {}

for g in gestures_norm:
    g_m = gestures_norm[g].get_mean()
    g_v = gestures_norm[g].get_variance()
    for p in param_names:
        means[p][g] = g_m[p]*(p_max[p]-p_min[p]) + p_min[p]
        variances[p][g] = g_v[p]

print "Means and variances calculated succesfully"

overall_variance = overall_ges.get_variance()

# plot variances
fig1, ax = plt.subplots(figsize=(20, 10))
cmap = plt.get_cmap('Set3')
colors = [cmap(i) for i in np.linspace(0, 1, len(param_names))]

acc = [0]*len(gestures)
for i in range(len(param_names)):
    p = param_names[i]
    normed = [x/overall_variance[p] for x in variances[p].values()]
    plt.xticks(np.arange(len(gestures)),variances[p].values())
    plt.bar(ind, normed, width=0.8, color=colors[i], bottom=acc, label=p)
    acc = [x + y for x,y in zip(normed, acc)]
    legend()


plt.ylabel('Variance')
plt.title('Normalized Variance by gesture and parameter', fontsize=20, fontweight='bol
plt.xticks(np.arange(len(gestures)), gestures.keys())
handles, labels = ax.get_legend_handles_labels()
ax.legend(handles[::-1], labels[::-1], title='Line', loc='upper left')
```

```
        plt.autoscale()
        plt.show()
```

```
gestures calculation finished
Means and variances calculated succesfully
```



This is a really good graph. For each gesture, articulator with minimum variance is indeed the most important. At least in majority of cases. It is also notable that voiced consonants have less variance than unvoiced in general, though the distribution of variances for them look similar.

In [ ]: