Bicycle Crash analysis NEISS data 1999 to 2018

National Electronic Injury Surveillance System

File: app_neiss_hospital_injuries.ipynb
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- The datafiles can be downloaded from: https://www.cpsc.gov/cgibin/NEISSQuery/home.aspx (https://www.cpsc.gov/cgibin/NEISSQuery/home.aspx)

  "CPSC's National Electronic Injury Surveillance System (NEISS) is a national probability sample of hospitals in the U.S. and its territories. Patient information is collected from each NEISS hospital for every emergency visit involving an injury associated with consumer products."

  https://catalog.data.gov/dataset/cpscs-national-electronic-injury-surveillance-system-neiss (https://catalog.data.gov/dataset/cpscs-national-electronic-injury-surveillance-system-neiss)

  https://www.cpsc.gov/cgibin/NEISSQuery/home.aspx (https://www.cpsc.gov/cgibin/NEISSQuery/home.aspx)

In [1]:
```
# Imports

import calendar
from code_id_translator import *
from datetime import datetime
import graphviz
from IPython.display import display
import ipywidgets as widgets
from ipywidgets import interact, fixed
import matplotlib.dates as mdates
from matplotlib.lines import Line2D
import matplotlib.pyplot as plt
from neiss_backend import *
import numpy as np
import os
import pandas as pd
import pickle
import re
from scipy.stats import chi2_contingency
from scipy.stats import chi2
from sklearn import metrics
from sklearn import preprocessing
from sklearn.discriminant_analysis import LinearDiscriminantAnalysis
from sklearn.feature_selection import SelectKBest, f_classif, mutual_inf
o_classif, chi2, f_regression, mutual_info_regression
from sklearn.feature_selection import SelectPercentile, SelectFpr, Selec
tFdr, SelectFwe, GenericUnivariateSelect
from sklearn.linear_model import LinearRegression, LogisticRegression
from sklearn.metrics import mean_squared_error, r2_score, scorer
from sklearn.model_selection import train_test_split, GridSearchCV
from sklearn.naive_bayes import GaussianNB
from sklearn.pipeline import make_pipeline
from sklearn.pipeline import Pipeline
from sklearn.preprocessing import StandardScaler
from sklearn.svm import SVC
from sklearn.tree import DecisionTreeClassifier
from sklearn.tree import export_graphviz, plot_tree
import seaborn as sns
import sys
from time_based_graphs import *
import xlrd
```

In [2]:
```
%matplotlib inline
plt.style.use('seaborn-whitegrid')
```

In [3]:
```
class Includes():
    TimeBasedGraphs = True
    PearsonChiSquared = True
    PythonCorr = True
    LinearRegressionChi2 = True
    LogisticRegression = True
    GaussianNB = True
    DecisionTree = True
    LdaSvmPipeline = True
```

- Selection of geographic areas called primary sampling units (PSU) that are defined within sampling strata.

https://www.cdc.gov/nchs/nhis/singleton_psu.htm (https://www.cdc.gov/nchs/nhis/singleton_psu.htm)

Read the pickled neissYYYY.xlsx file

convert_neiss_original_data_to_pckl.ipynb is used to create the pickled file

Note: The pckl file is expected to be found in the _IPYNB__*DIRECTORY*/data/NEISS/neiss_data.pckl

- If the neiss_data.pckl file exists read it as the data file. - Otherwise, raise an exception. See convert_neiss_original_data_to_pckl.ipynb for the creation of the file

In [4]:
```
neiss_pathname = os.getcwd() + '/data/NEISS'

pckl_fname = neiss_pathname + '/neiss_data.pckl'
if os.path.exists(pckl_fname):
    print("Reading {}  ... ".format(pckl_fname), end="")
    dfNeiss = pickle.load( open( pckl_fname, "rb" ) )
    print("done!")
else:
    raise Exception(
        'ERROR:  {} does not exist\n  Use "convert_neiss_original_data_t
o_pckl.ipynb" to create the pckl file'.format(
            pckl_fname))
```

```
Reading /Users/mcorbett/Boston University/MET_CS677_DataScienceWithPyth
on/Project/data/NEISS/neiss_data.pckl  ... done!
```

In [5]:
```
dfNeiss.shape
```

Out[5]:
```
(7352927, 19)
```

In [6]:
```
dfNeiss.head()
```

Out[6]:

	CPSC_Case_Number	Treatment_Date	Age	Sex	Race	Other_Race	Body_Part	Diagnosis	Ot
0	100001	1999-12-24	41	2	1.0	0	31	71	
1	100002	1999-12-27	80	1	2.0	0	31	57	
2	100003	1999-12-27	4	1	1.0	0	75	53	
3	100005	1999-12-28	18	1	0.0	NaN	94	53	
4	100009	1999-12-28	19	2	0.0	NaN	92	64	

In [ ]:
```

```

Update Neiss with column code dictionary from Excel file

In [7]:
```
column_codes_fname = neiss_pathname + '/column_codes.xlsx'
column_dictionary = getColumnCodeDictionary(column_codes_fname)
Neiss.setColumnCodeDictionary(column_dictionary)
```

- Code to take the Neiss dictionaries for column codes and write them out to the column_codes.xlsx file.

In [8]:
```
neiss = Neiss(dfNeiss)
```

In [9]:
```
dfNeiss.shape
```

Out[9]: (7352927, 19)

Build a categorical dataframe (with a subset of the overall data 3000 random rows)

The dataframe is built of columns that are only categorical in nature.

In [10]:
```
class DataFramePruner():
    def __init__(self, dict_prune=dict(), max_output_rows=None, keep_end
=True):
        '''
        Prune a dataframe based on a dictionary and the maximum number o
f output rows

        Args:
          dict_prune  (dict):  Of the form {col_name : max_output_catego
ries, ...}
          max_output_rows (int):  If none, all rows are kept.  Otherwis
e, the dataframe is clipped to this number of rows maximum.
          keep_end (bool):  True, max_output_rows is relative to the end
of the dataframe.  False, from beginning.
        '''
        self.dict_prune = dict_prune
        self.max_output_rows = max_output_rows
        self.keep_end = keep_end

    def _limitColumnCategoriesTo(df, column_name, num_categories):
        '''
         Get the top 'num_categories' most frequent names in self.df[col
umn_name]

         Args:
             column_name (str):  The name of the column to limit the cat
egories on
             num_categories (int):  The maximum number of unique values
 to retain in 'column_name'
        '''
        selected = df[column_name].value_counts()[:num_categories].index
.tolist()
        return df[df[column_name].isin(selected)]

    def prune(self, df):
        for column_name in self.dict_prune.keys():
            df = DataFramePruner._limitColumnCategoriesTo(df, column_nam
e, self.dict_prune[column_name])

        if None != self.max_output_rows:
            if True == self.keep_end:
                df = df[-self.max_output_rows : ]
            else:
                df = df[0 : self.max_output_rows]

        return df
```

In [11]:
```
class NeissSubset():
    def __init__(self, df, categories, dataframe_pruner=None):
        self.df = df.copy()
        self.categories = categories.copy()

        self.df = self.df.xs(self.categories, axis=1)
        self.df.dropna(inplace=True)
        self.df['Race'] = [int(x) for x in self.df['Race']]

        if None != dataframe_pruner:
            self.df = dataframe_pruner.prune(self.df)

        self.updateCodeIdVariables()

    def updateCodeIdVariables(self):
        # Get the code ID translator for the dataframe
        self.codeIdTranslator = CodeIdTranslatorDataFrame(self.df, self.
categories)
        self.codeIdTranslator.transformColumns()

        # Get the code ID translators for the dataframe
        currentState = self.codeIdTranslator.getState()

        self.codeIdTranslator.setState('id')
        self.dfIdToCode = self.codeIdTranslator.getDataFrame().copy()

        self.codeIdTranslator.setState('code')
        self.dfCodeToId = self.codeIdTranslator.getDataFrame().copy()

        self.codeIdTranslator.setState(currentState)

    def limitColumnCategoriesTo(self, column_name, num_categories):
        '''
         Get the top 'num_categories' most frequent names in self.df[col
umn_name]

         Args:
             column_name (str):  The name of the column to limit the cat
egories on
             num_categories (int):  The maximum number of unique values
 to retain in 'column_name'
        '''
        selected = self.df[column_name].value_counts()[:num_categories].
index.tolist()
        self.df = self.df[self.df[column_name].isin(selected)]
        #self.updateCodeIdVariables()

    def limitMaxRowsTo(self, num_rows):
        self.df = self.df.sample(num_rows)
        #self.updateCodeIdVariables()

    def getDataFrame(self):
        return self.df

    def getCategories(self):
        return self.categories
```

```
    def getCodeIdTranslator(self):
        return self.codeIdTranslator

    def getIdToCodeDataframe(self):
        return self.dfIdToCode

    def getCodeToIdDataframe(self):
        return self.dfCodeToId
```

In [12]:
```
output_choice = 'Diagnosis'

max_output_rows = 1000000
pruner = DataFramePruner(dict_prune={output_choice : 10}, max_output_row
s=max_output_rows, keep_end=True)

neissSubset = NeissSubset(dfNeiss,
    categories=['Sex', 'Race', 'Body_Part', 'Diagnosis', 'Disposition',
'Location',
    'Fire_Involvement', 'Product_1', 'Product_2', 'PSU', 'Stratum' ],
    dataframe_pruner=pruner)
```

In [13]:
```
neissSubset.getDataFrame().shape
```

Out[13]:
```
(1000000, 11)
```

In [14]:
```
neissSubset.getDataFrame().head()
```

Out[14]:

	Sex	Race	Body_Part	Diagnosis	Disposition	Location	Fire_Involvement	Product_1	Prc
33328	3	2	16	10	1	9	1	396	
33329	3	2	5	5	1	2	1	580	
33331	3	2	9	10	1	2	1	165	
33332	2	2	6	2	1	2	1	79	
33333	2	2	11	4	1	2	1	519	

Show the IdToCode and CodeToId translators for the neissSubset dataframe

In [15]:
```
neissSubset.getIdToCodeDataframe().head()
```

Out[15]:

	Sex	Race	Body_Part	Diagnosis	Disposition	Location	Fire_Involvement	Product_1	Prc
33328	3	2	16	10	1	9	1	396	
33329	3	2	5	5	1	2	1	580	
33331	3	2	9	10	1	2	1	165	
33332	2	2	6	2	1	2	1	79	
33333	2	2	11	4	1	2	1	519	

In [16]:
```
neissSubset.getCodeToIdDataframe().head()
```

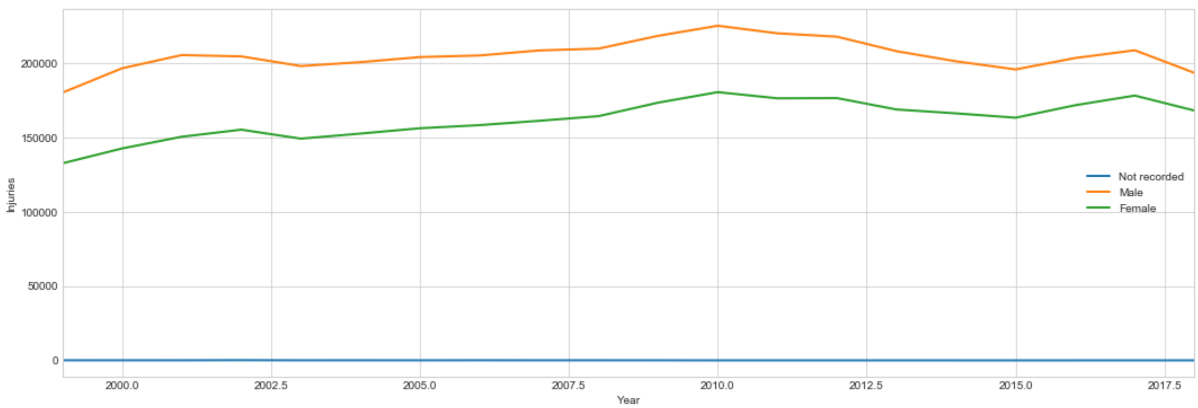
Out[16]:

	Sex	Race	Body_Part	Diagnosis	Disposition	Location	Fire_Involvement	Product_1	Prc
33328	2	1	82	71	1	9	0	1290	
33329	2	1	34	57	1	1	0	1807	
33331	2	1	38	71	1	1	0	610	
33332	1	1	35	53	1	1	0	374	
33333	1	1	76	56	1	1	0	1616	

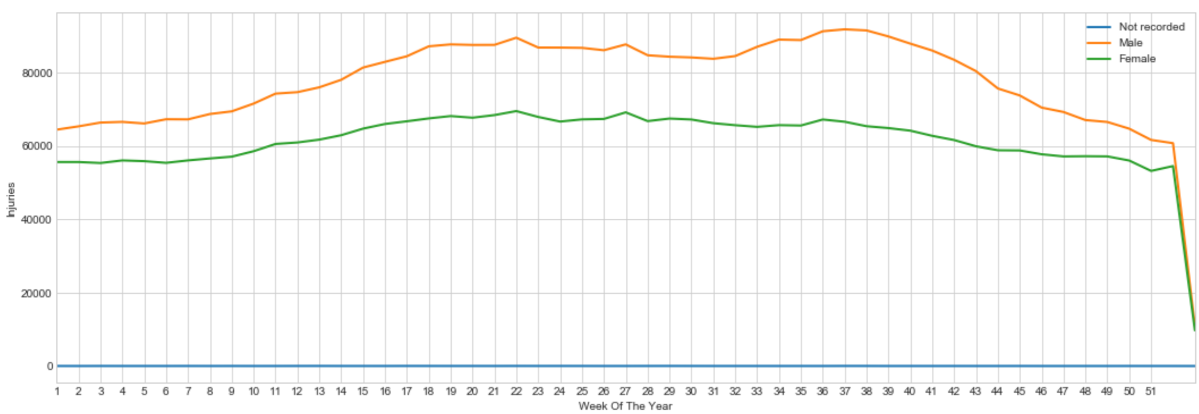
Show time based graphs of male/female injuries - whole dataframe used

In [17]:
```
if True == Includes.TimeBasedGraphs:
    stat_name = 'Sex'
    date_name = 'Treatment_Date'

    TimeBasedGraphs(dfNeiss, Neiss.getColumnDictionary(stat_name), date_
name, stat_name).show()
```

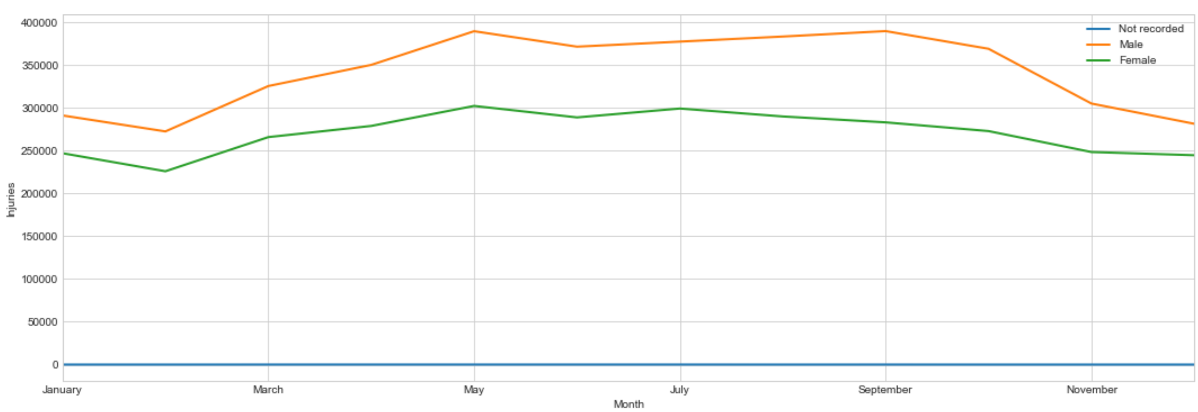
Injuries Per Year



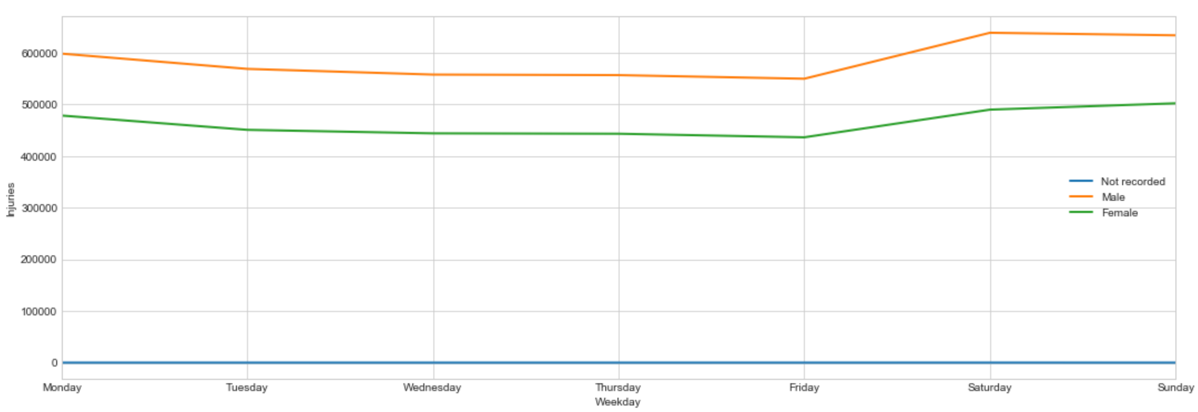
Injuries per week (1 ... 52) of the year



Injuries Per Month of the Year



Injuries Per Weekday of the Year



Functions/Classes used for the python correlations and pearson chi squared correlations

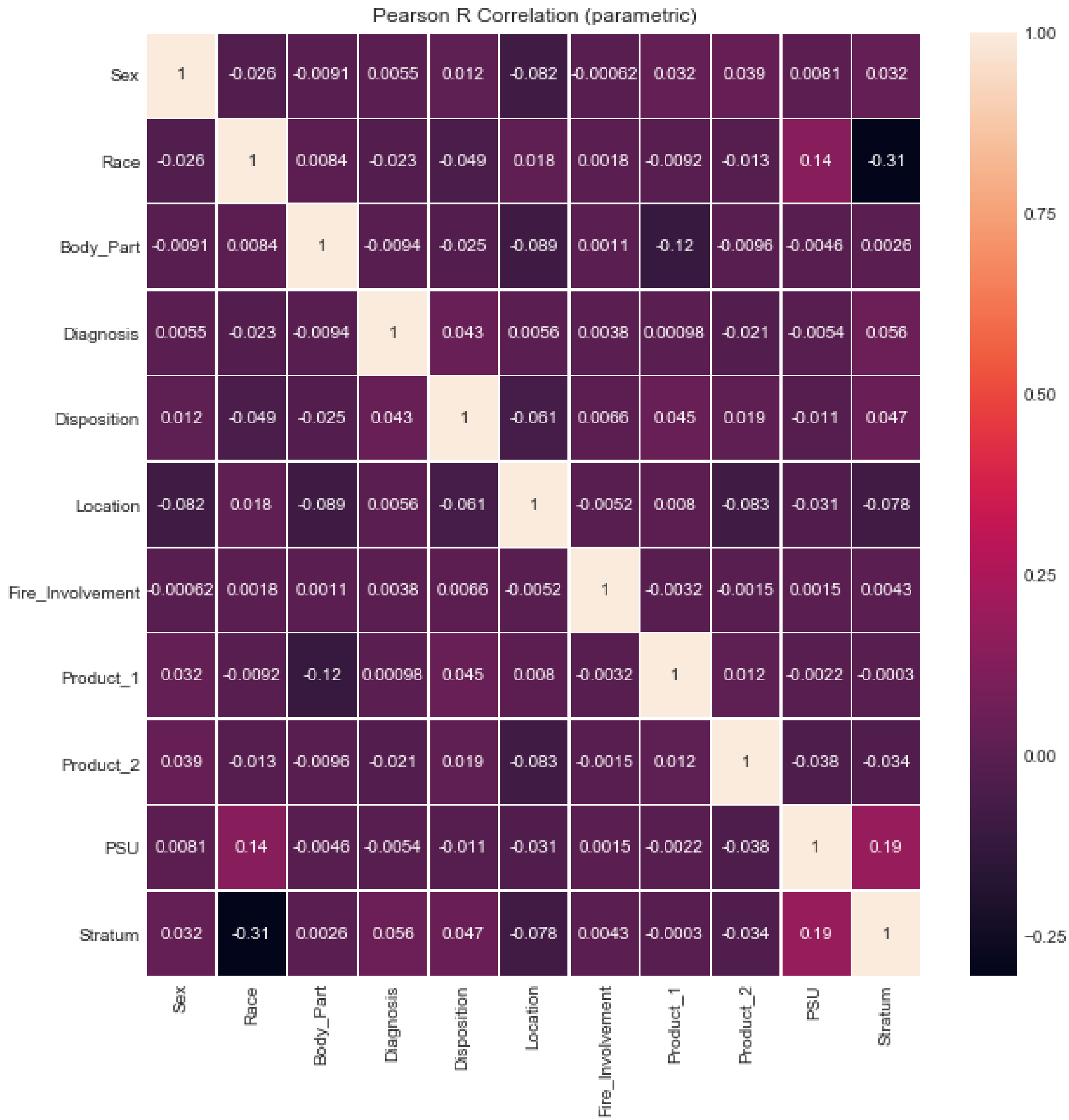
In [18]:
```
def getHighCorrelations(df, dfCategoricalCorrMatrix, minValue):
    '''
    For each column in the dataframe determine which rows equal or excee
d the minimum value

    Args:
        df (pd.DataFrame):    The original dataframe
        dfCategoricalCorrMatrix  (list of (row_name, col_name) tuples):
 The categorical matrix
        minValue (int):  The value the row/column cell must equal or exc
eed

    Returns:
      A list of tuples containing (row, column) where the value equalled
or exceeded the minimum value
    '''
    high_correlations = []
    for yIndex, y in enumerate(dfCategoricalCorrMatrix.index):
        for xIndex, x in enumerate(dfCategoricalCorrMatrix.columns):
            #if xIndex >= yIndex:
            #    break

            if (x != y) and (dfCategoricalCorrMatrix[y][x] > minValue):
                Y = y
                X = x
                if len(df[X].unique()) > len(df[Y].unique()):
                    # Keep the smallest item on the X axis
                    Y, X = X, Y

                if (Y, X) not in high_correlations:
                    high_correlations.insert(-1, (Y, X))
    high_correlations.sort()
    return high_correlations
```

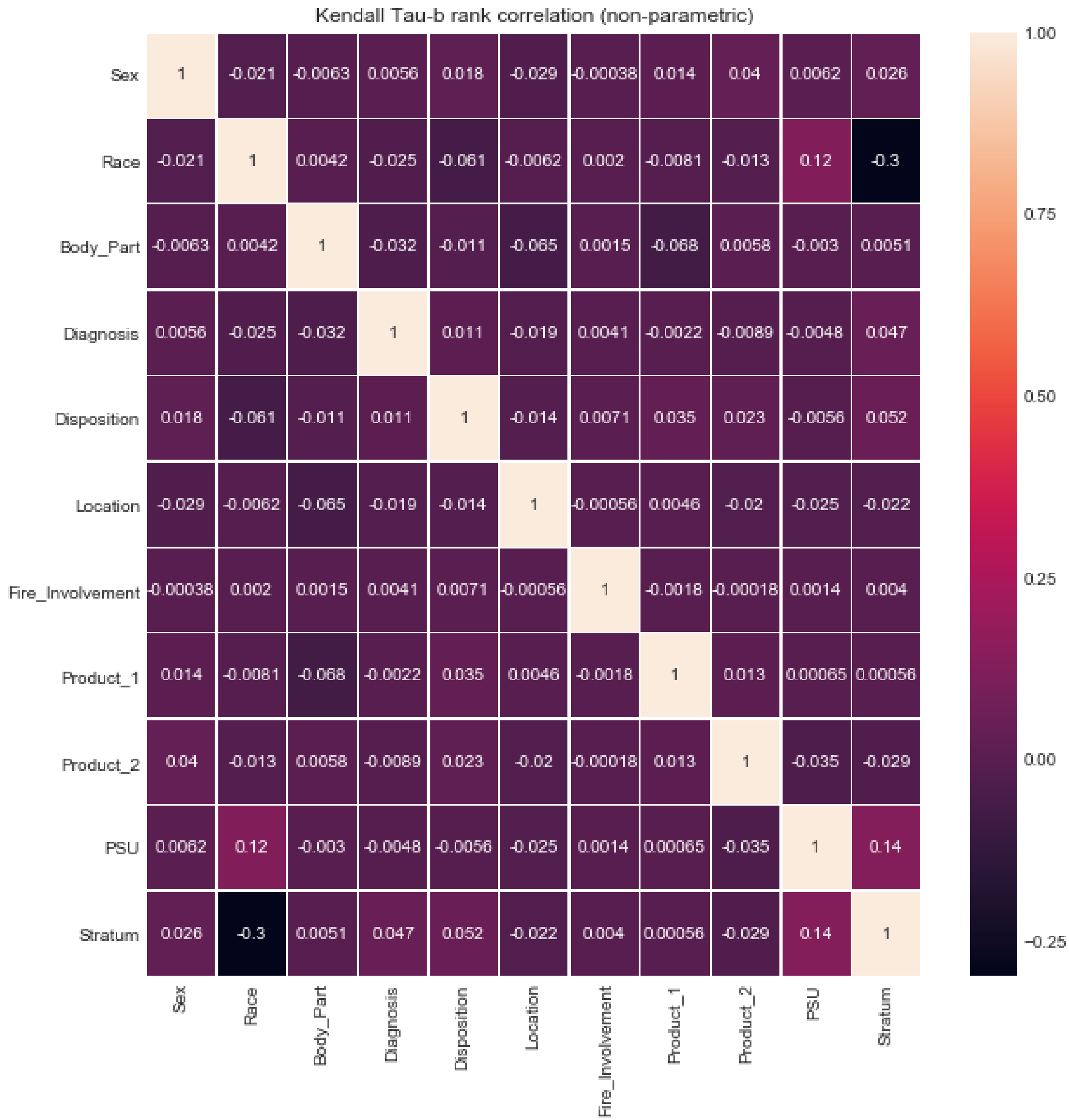
In [19]:
```
class UserSelectableSwarmScatterPlots():
    def __init__(self, high_correlations, code_id_translator):
        self.button = widgets.Button(description="Click Me!")
        self.output = widgets.Output()
        self.high_correlations = high_correlations
        self.code_id_translator = code_id_translator

    def show(self):
        button = widgets.Button(description="Click Me!")
        output = widgets.Output()

        #print(self.high_correlations.values)
        select = self.high_correlations[0]
        #print(select)
        lCorrelations = ['{}, {}'.format(y, x) for y, x in self.high_cor
relations]
        correlationDropDownSel = widgets.Dropdown(
            options=lCorrelations,
            value=lCorrelations[0],
            description='correlations',
            disabled=False,
        )

        typeDropDownSel = widgets.Dropdown(
            options=['swarm', 'scatter'],
            value='swarm',
            description='plot_type',
            disabled=False,
        )

        wHBox = widgets.HBox([correlationDropDownSel, typeDropDownSel])
        wVBox = widgets.VBox([wHBox, button, output])

        display(wVBox)

        def on_button_clicked(b):
            with output:
                sel = correlationDropDownSel.value
                (xSel, ySel) = [x.strip() for x in sel.split(',')]
                print('-{}-, -{}-'.format(xSel, ySel))

                correlations(self.code_id_translator, xSel, ySel, typeDr
opDownSel.value)

                #sns.pairplot(dfSel, hue=xSel)

        button.on_click(on_button_clicked)
```

In [20]:
```
class CategoricalMatrixHeatMap:
    def __init__(self, title, dfCategoricalMatrix):
        self.title = title
        self.dfCategoricalMatrix = dfCategoricalMatrix

    def show(self, figsize=(10, 10)):
        fig, ax = plt.subplots(figsize=figsize)

        g = sns.heatmap(self.dfCategoricalMatrix, annot=True, linewidths
=0.4, ax=ax)
        g.set_title(self.title)

        # Fix the top and bottom margins of the heatmap
        bottom_y, top_y = plt.ylim()
        bottom_y += 0.5
        top_y -= 0.5
        plt.ylim(bottom_y, top_y)
        plt.show()
```

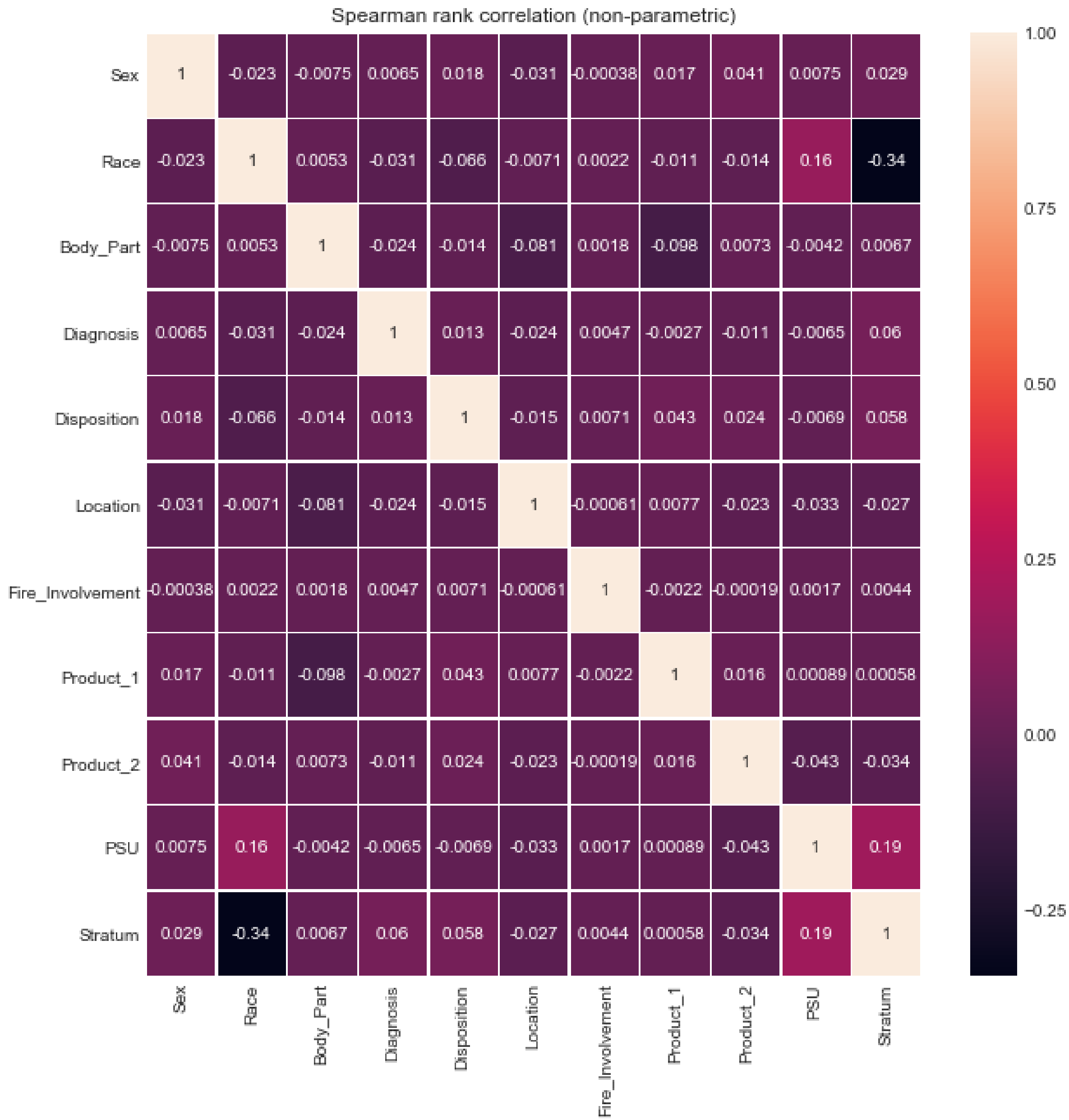
Python (pandas.DataFrame.corr) - dataframe subset used

In [21]:
```
if True == Includes.PythonCorr:
    methods = {
        'pearson' : 'Pearson R Correlation (parametric)',  # not good fo
r categorical data
            # For pearson:
            # both variables should be normally distributed
            # There should be no significant outliers
            # Each variable should be continuous
            # The two variables have a linear relationship
            # The observations are paired observations.
            # Should support homoscedascity.  Homoscedascity simply refe
rs to ‘equal variances’.
        'kendall' : 'Kendall Tau-b rank correlation (non-parametric)',
            # The variables are measured on an ordinal or continuous sca
le.
            # Desirable if your data appears to follow a monotonic relat
ionship.
        'spearman' : 'Spearman rank correlation (non-parametric)'
            # Does not assume that both datasets are normally distribute
d
        }

    dfCategoricalMatrices = {}
    for key in methods.keys():
        dfCategoricalMatrices[key] = neissSubset.getDataFrame().corr(met
hod = key)
        heatMap = CategoricalMatrixHeatMap(methods[key], dfCategoricalMa
trices[key])
        heatMap.show()
```


Pearson R Correlation (parametric)
Sex
Race
Body_Part
Diagnosis
Disposition
Location
Fire_Involvement
Product_1
Product_2
PSU
Stratum
1 -0.026 -0.0091 0.0055 0.012 -0.082 -0.00062 0.032 0.039 0.0081 0.032
-0.026 1 0.0084 -0.023 -0.049 0.018 0.0018 -0.0092 -0.013 0.14 -0.31
-0.0091 0.0084 1 -0.0094 -0.025 -0.089 0.0011 -0.12 -0.0096 -0.0046 0.0026
0.0055 -0.023 -0.0094 1 0.043 0.0056 0.0038 0.00098 -0.021 -0.0054 0.056
0.012 -0.049 -0.025 0.043 1 -0.061 0.0066 0.045 0.019 -0.011 0.047
-0.082 0.018 -0.089 0.0056 -0.061 1 -0.0052 0.008 -0.083 -0.031 -0.078
-0.00062 0.0018 0.0011 0.0038 0.0066 -0.0052 1 -0.0032 -0.0015 0.0015 0.0043
0.032 -0.0092 -0.12 0.00098 0.045 0.008 -0.0032 1 0.012 -0.0022 -0.0003
0.039 -0.013 -0.0096 -0.021 0.019 -0.083 -0.0015 0.012 1 -0.038 -0.034
0.0081 0.14 -0.0046 -0.0054 -0.011 -0.031 0.0015 -0.0022 -0.038 1 0.19
0.032 -0.31 0.0026 0.056 0.047 -0.078 0.0043 -0.0003 -0.034 0.19 1
1.00
0.75
0.50
0.25
0.00
−0.25



	Sex	Race	Body_Part	Diagnosis	Disposition	Location	Fire_Involvement	Product_1	Product_2	PSU	Stratum
Sex	1	-0.021	-0.0063	0.0056	0.018	-0.029	-0.00038	0.014	0.04	0.0062	0.026
Race	-0.021	1	0.0042	-0.025	-0.061	-0.0062	0.002	-0.0081	-0.013	0.12	-0.3
Body_Part	-0.0063	0.0042	1	-0.032	-0.011	-0.065	0.0015	-0.068	0.0058	-0.003	0.0051
Diagnosis	0.0056	-0.025	-0.032	1	0.011	-0.019	0.0041	-0.0022	-0.0089	-0.0048	0.047
Disposition	0.018	-0.061	-0.011	0.011	1	-0.014	0.0071	0.035	0.023	-0.0056	0.052
Location	-0.029	-0.0062	-0.065	-0.019	-0.014	1	-0.00056	0.0046	-0.02	-0.025	-0.022
Fire_Involvement	-0.00038	0.002	0.0015	0.0041	0.0071	-0.00056	1	-0.0018	-0.00018	0.0014	0.004
Product_1	0.014	-0.0081	-0.068	-0.0022	0.035	0.0046	-0.0018	1	0.013	0.00065	0.00056
Product_2	0.04	-0.013	0.0058	-0.0089	0.023	-0.02	-0.00018	0.013	1	-0.035	-0.029
PSU	0.0062	0.12	-0.003	-0.0048	-0.0056	-0.025	0.0014	0.00065	-0.035	1	0.14
Stratum	0.026	-0.3	0.0051	0.047	0.052	-0.022	0.004	0.00056	-0.029	0.14	1



In [22]:
```
#if True == Includes.PythonCorr:
#    for key in dfCategoricalMatrices.keys():
#        print('{}:\n{}'.format(key, dfCategoricalMatrices))
#        print()
```

In [23]:
```
if True == Includes.PythonCorr:
    highCorrelationsPythonCorr = getHighCorrelations(
        neissSubset.getDataFrame(),
        dfCategoricalMatrices['spearman'],
        0.1)
```

In [24]:
```
#if True == Includes.PythonCorr:
#    for n in highCorrelationsPythonCorr:
#        print(n)
```

In [25]:
```
if True == Includes.PythonCorr:
    plots = UserSelectableSwarmScatterPlots(highCorrelationsPythonCorr,
neissSubset.getCodeIdTranslator())
    plots.show()
```

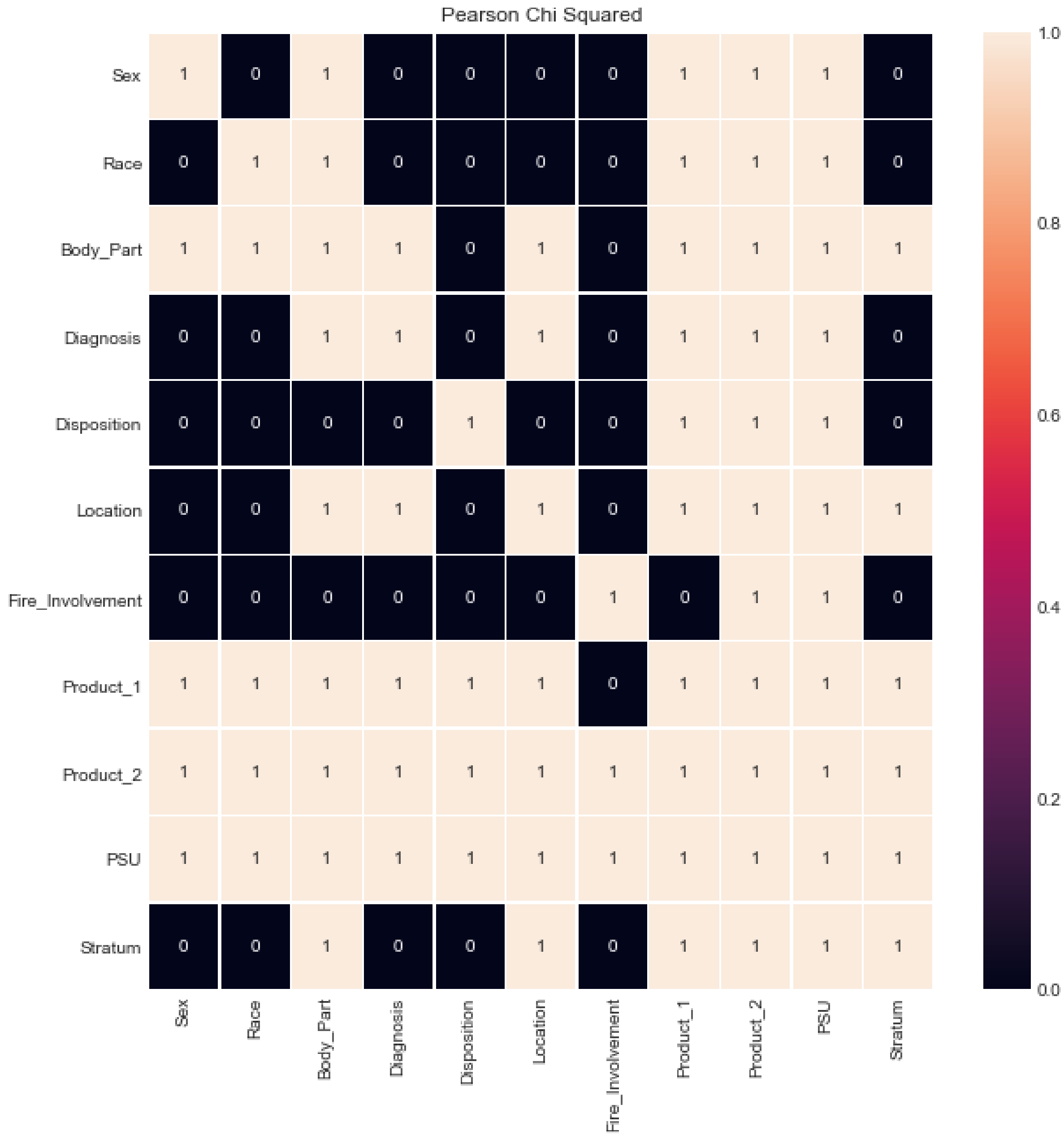
- Analysis: The pandas.DataFrame.corr method is not that great when used with categorical data given an output with many categories.

PearsonChiSquared - dataframe subset used

https://machinelearningmastery.com/chi-squared-test-for-machine-learning/ (https://machinelearningmastery.com/chi-squared-test-for-machine-learning/)

'The Pearson’s chi-squared statistical hypothesis is an example of a test for independence between categorical variables.'

In [26]:
```
if True == Includes.PearsonChiSquared:
    pearsonChiSquared = PearsonChiSquared(neissSubset.getDataFrame())
    dfPersonChiSquaredCategoricalCorrMatrix = pearsonChiSquared.getCorrM
atrixDataframe(neissSubset.getCategories())
    #print(dfCategoricalCorrMatrix.head())

    heatMap = CategoricalMatrixHeatMap('Pearson Chi Squared', dfPersonCh
iSquaredCategoricalCorrMatrix)
    heatMap.show()
```



In [27]:
```
if True == Includes.PearsonChiSquared:
    highCorrelationsPearsonChiSquared = getHighCorrelations(
        neissSubset.getDataFrame(),
        dfPersonChiSquaredCategoricalCorrMatrix,
        0.95)
```

In [28]:
```
#if True == Includes.PearsonChiSquared:
#    for n in highCorrelationsPearsonChiSquared:
#        print(n)
```

In [29]:
```
if True == Includes.PearsonChiSquared:
    plots = UserSelectableSwarmScatterPlots(highCorrelationsPearsonChiSq
uared, neissSubset.getCodeIdTranslator())
    plots.show()
```

- Analysis: Pearson ChiSquared is a better measure of correlation between categorical data than the three python functions shown below (used with pandas.DataFrame.corr):

  'pearson' : 'Pearson R Correlation (parametric)', # not good for categorical data

  'kendall' : 'Kendall Tau-b rank correlation (non-parametric)'

  'spearman' : 'Spearman rank correlation (non-parametric)'

Linear regression (using chi2 & KBest) - dataframe subset used

[https://scikit-learn.org/stable/modules/generated/sklearn.feature_selection.SelectKBest.html (https://scikit-learn.org/stable/modules/generated/sklearn.feature_selection.SelectKBest.html)](https://scikit-learn.org/stable/modules/generated/sklearn.feature_selection.SelectKBest.html)

- f_classif: ANOVA F-value between label/feature for classification tasks.
- mutual_info_classif: Mutual information for a discrete target.
- chi2: Chi-squared stats of non-negative features for classification tasks.
- f_regression: F-value between label/feature for regression tasks.
- mutual_info_regression: Mutual information for a continuous target.
- SelectPercentile: Select features based on percentile of the highest scores.
- SelectFpr: Select features based on a false positive rate test.
- SelectFdr: Select features based on an estimated false discovery rate.
- SelectFwe: Select features based on family-wise error rate.
- GenericUnivariateSelect: Univariate feature selector with configurable mode.

In [30]:
```
if True == Includes.LinearRegressionChi2:
    class WorkingLinearRegressionChi2():
        def __init__(self, outputFeature, categories, dfIdToCode, k_feat
ures=2):
            self.outputFeature = outputFeature
            self.categories = categories.copy()
            self.dfKBest = dfIdToCode.copy()

            self.categories.remove(self.outputFeature)

            self.y = self.dfKBest[self.outputFeature]
            self.selector = SelectKBest(chi2, k=k_features)
            self.selector.fit(self.dfKBest[self.categories].values, self
.y)
            self.selector.get_support()

            self.selected_columns = np.asarray(self.categories)[self.sel
ector.get_support()]
            self.X = self.dfKBest[self.selected_columns]


        def plot_scatter(X,Y,R=None):
            plt.scatter(X, Y, s=32, marker='o', facecolors='none', edgec
olors='k')
            if R is not None:
                plt.scatter(X, R, color='red', linewidth=0.5)
            plt.show()

        def showShape(self):
            print('X.shape={}'.format(self.X.shape))
            print()

        def showSelectedColumns(self):
            print('selected_columns={}'.format(self.selected_columns))
            print()

        def showSelectorScores(self):
            print('selector.scores_={}'.format(self.selector.scores_))
            print()

        def showSelectorSupport(self):
            print('selector.get_support()={}'.format(self.selector.get_s
upport()))
            print()

        def showPlots(self):
            for category in self.X:
                print('x=', category)
                x = np.asarray(self.dfKBest[category]).reshape(-1, 1)
                regressor = LinearRegression(normalize=True).fit(x, self
.y)
                y_pred    = regressor.predict(x)
                WorkingLinearRegressionChi2.plot_scatter(x, self.y, y_pr
ed)
                print("R-squared score: {:.4f}".format(r2_score(self.y,
y_pred)))
```

```
                print()
                print()
```

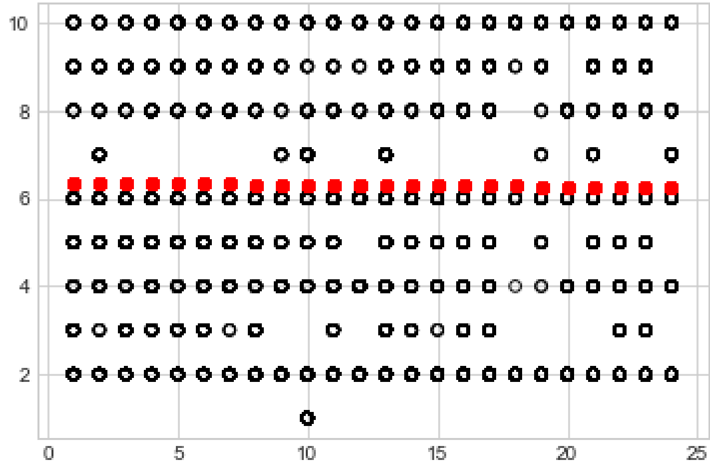
In [31]:
```
if True == Includes.LinearRegressionChi2:
    linearRegressionChi2 = WorkingLinearRegressionChi2(
        output_choice,
        neissSubset.getCategories(),
        neissSubset.getIdToCodeDataframe(),
        k_features=5)
```

In [32]:
```
if True == Includes.LinearRegressionChi2:
    linearRegressionChi2.showShape()
    linearRegressionChi2.showSelectedColumns()
    linearRegressionChi2.showSelectorScores()
    linearRegressionChi2.showSelectorSupport()
```

```
X.shape=(1000000, 5)

selected_columns=['Body_Part' 'Location' 'Product_1' 'Product_2' 'PSU']

selector.scores_=[8.72381044e+02 6.76128427e+02 3.46631214e+05 2.491715
16e+04
 8.74721628e+04 8.11917568e-02 2.10697710e+06 9.77344423e+06
 9.79400124e+04 6.12615193e+03]

selector.get_support()=[False False  True False  True False  True  True
True False]
```

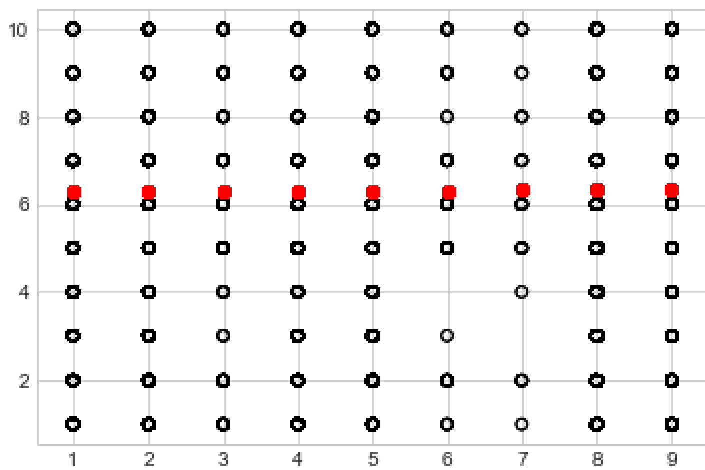
In [33]:
```
if True == Includes.LinearRegressionChi2:
    linearRegressionChi2.showPlots()
```

x= Body_Part



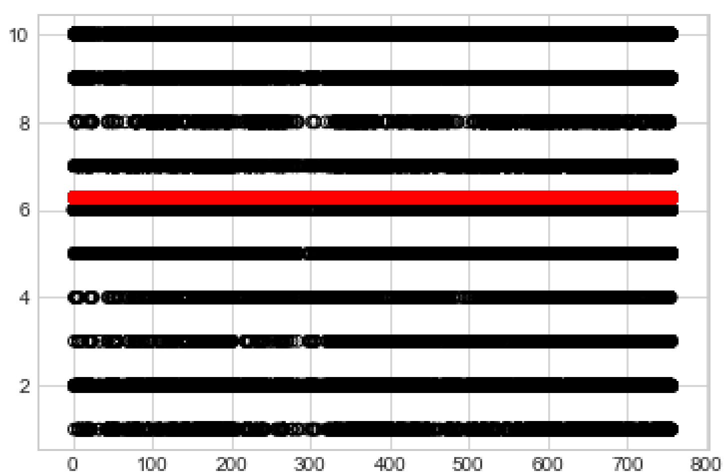
R-squared score: 0.0001

x= Location



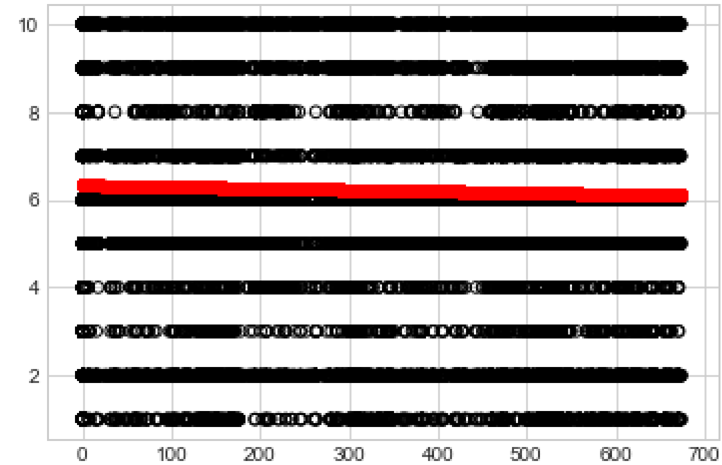
R-squared score: 0.0000

x= Product_1



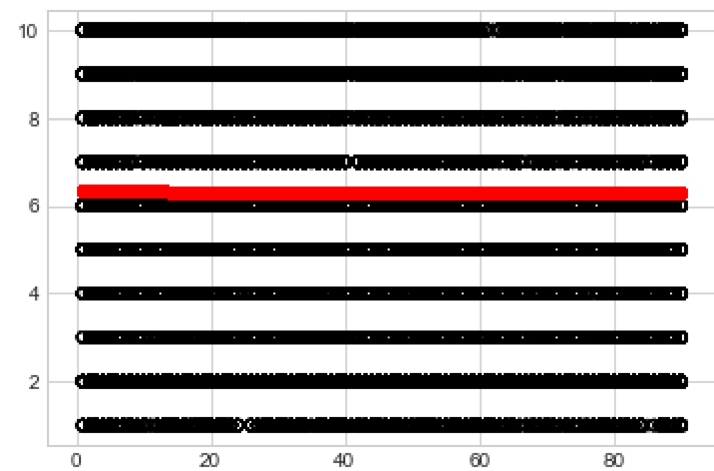
```
R-squared score: 0.0000
```

```
x= Product_2
```




```
R-squared score: 0.0004
```

```
x= PSU
```




```
R-squared score: 0.0000
```

- Analysis: The data does not follow a linear regression model

Logistic Regression

In [34]:
```
class WorkingHeatmap():
    '''
    Plots a seaborn fixing the edges of the plot
    '''

    def __init__(self, x_label, y_label,
                 title='WorkingHeatmap',
                 y_bottom_adjust=-1.5, y_top_adjust=-0.5,
                 x_left_adjust=None, x_right_adjust=None,
                 normalize_columns=False):
        self.x_label              = x_label
        self.y_label              = y_label
        self.title                = title
        self.y_bottom_adjust      = y_bottom_adjust
        self.y_top_adjust         = y_top_adjust
        self.x_left_adjust        = x_left_adjust
        self.x_right_adjust       = x_right_adjust
        self.normalize_columns    = normalize_columns

    def plot(self,
        data, vmin=None, vmax=None, cmap=None, center=None, robust=False
,
        annot=None, fmt='.2g', annot_kws=None, linewidths=0, linecolor=
'white',
        cbar=True, cbar_kws=None, cbar_ax=None, square=False, xticklabel
s='auto',
        yticklabels='auto', mask=None, ax=None, **kwargs):

        if type(data) != pd.DataFrame:
            data = pd.DataFrame(data)

        dN = data
        if True == self.normalize_columns:
            dT = data.copy()
            dS = dT.sum(axis=0)[:, np.newaxis]
            dN = dT.astype('float') / dS.T.astype('float')


        g = sns.heatmap(
            dN, vmin, vmax, cmap, center, robust,
            annot, fmt, annot_kws, linewidths, linecolor,
            cbar, cbar_kws, cbar_ax, square, xticklabels,
            yticklabels, mask, ax, **kwargs)
        g.set_title(self.title)
        ax.set_xlabel(self.x_label)
        ax.set_ylabel(self.y_label)

        if self.y_bottom_adjust or self.y_top_adjust or self.x_left_adju
st or self.x_right_adjust:

            if self.y_bottom_adjust or self.y_top_adjust:
                bottom_y, top_y = ax.get_ylim()

                if self.y_bottom_adjust:
                    bottom_y += self.y_bottom_adjust
```

```
            if self.y_top_adjust:
                top_y += self.y_top_adjust

            ax.set_ylim(bottom=bottom_y, top=top_y)

        if self.x_left_adjust or self.x_right_adjust:
            left_x, right_x = ax.get_xlim()

            if self.x_left_adjust:
                left_x += self.x_left_adjust

            if self.x_right_adjust:
                right_x += self.x_right_adjust

            ax.set_xlim(left=left_x, right=right_x)
```

In [35]:
```
if True == Includes.LogisticRegression:
    class WorkingLogisticRegression():
        '''
        Based loosly on:  https://acadgild.com/blog/logistic-regression-
multiclass-classification
        '''
        def __init__(self, outputFeature, categories, dfIdToCode, codeId
Translator, max_iter=5000):
            self.outputFeature = outputFeature
            self.categories = categories.copy()
            self.df = dfIdToCode.copy()
            self.codeIdTranslator = codeIdTranslator

            self.categories.remove(self.outputFeature)

            self.inputs = self.df[self.categories]
            self.output = self.df[self.outputFeature]

            self.x_train, self.x_test, self.y_train, self.y_test = train
_test_split(
                self.inputs, self.output, test_size=1/7.0, random_state=
122)

            # Standardize the data
            scaler = StandardScaler()

            # Fit on training set only.
            scaler.fit(self.x_train)

            # Apply transform to both the training set and the test set.
            self.x_train = scaler.transform(self.x_train)
            self.x_test = scaler.transform(self.x_test)

            # Fit the model
            # For multiclass problems, only ‘newton-cg’, ‘sag’, ‘saga’ a
nd ‘lbfgs’ handle multinomial loss.
            self.model = LogisticRegression(solver = 'newton-cg', multi_
class='multinomial', max_iter=max_iter)
            self.model.fit(self.x_train, self.y_train)

            # Validate the fitting
            # use the model to make predictions with the test data
            self.y_pred = self.model.predict(self.x_test)

            self.probs = self.model.predict_proba(self.x_test)
            test_score = self.model.score(self.x_test, self.y_test)
            print('test_score =', test_score)

            # how did our model perform?
            self.count_misclassified = (self.y_test != self.y_pred).sum
()
            self.accuracy = metrics.accuracy_score(self.y_test, self.y_p
red)

            self.confusion_matrix = metrics.confusion_matrix(self.y_test
, self.y_pred)
```

```
            # Create predicted versus actual dataframe
            target_names = self.output.unique()

            target_dict = column_dictionary[self.outputFeature]

            dfTest = pd.DataFrame(self.y_test, columns=[self.outputFeatu
re])
            self.codeIdTranslator._transform(dfTest, 'idToCode', self.ou
tputFeature)
            y_test = [target_dict[x] for x in dfTest[self.outputFeature
]]
            self.y_test = y_test
            #print('y_test={}'.format( np.sort(np.unique(y_test)) ))

            dfPred = pd.DataFrame(self.y_pred, columns=[self.outputFeatu
re])
            self.codeIdTranslator._transform(dfPred, 'idToCode', self.ou
tputFeature)
            y_pred = [target_dict[x] for x in dfPred[self.outputFeature
]]
            #print('y_pred={}'.format( np.sort(np.unique(y_pred)) ))

            dfTargetNames = pd.DataFrame(target_names, columns=[self.out
putFeature])
            self.codeIdTranslator._transform(dfTargetNames, 'idToCode',
self.outputFeature)
            target_names =  [target_dict[x] for x in dfTargetNames[self.
outputFeature]]
            #print('target_names={}'.format( np.sort(np.unique(target_na
mes)) ))

            self.dfPredictedVersusActual = pd.DataFrame(self.probs, colu
mns=target_names).round(4)
            self.dfPredictedVersusActual.insert(0, 'target_class',    y_
test)
            self.dfPredictedVersusActual.insert(1, 'predicted_class', y_
pred)

        def showAccuracy(self):
            print('Accuracy: {:.2f}'.format(self.accuracy))

        def showMissclassifiedSamples(self):
            print('Misclassified samples: {} out of {}'.format(self.coun
t_misclassified, len(self.y_test)))

        def showConfusionMatrix(self):
            labels=np.unique(self.y_test)
            fig, ax = plt.subplots(figsize=(14, 14))

            heatmap = WorkingHeatmap(title='WorkingLogisticRegression',
                x_label='actual', y_label='predicted',
                y_bottom_adjust=0.5, y_top_adjust=-0.5,
                normalize_columns=True)

            # This sets the yticks "upright" with 0, as opposed to sidew
ays with 90.
```

```
            plt.yticks(rotation=0)  # does not appear to be working...

            heatmap.plot(
                self.confusion_matrix.T, square=True, annot=True, fmt='.
2f', cbar=False,
                ax=ax, xticklabels=labels, yticklabels=labels)

            plt.show()

        def getPredictedVersusActualDataframe(self):
            #state = self.codeIdTranslator.getState()
            return self.dfPredictedVersusActual
```

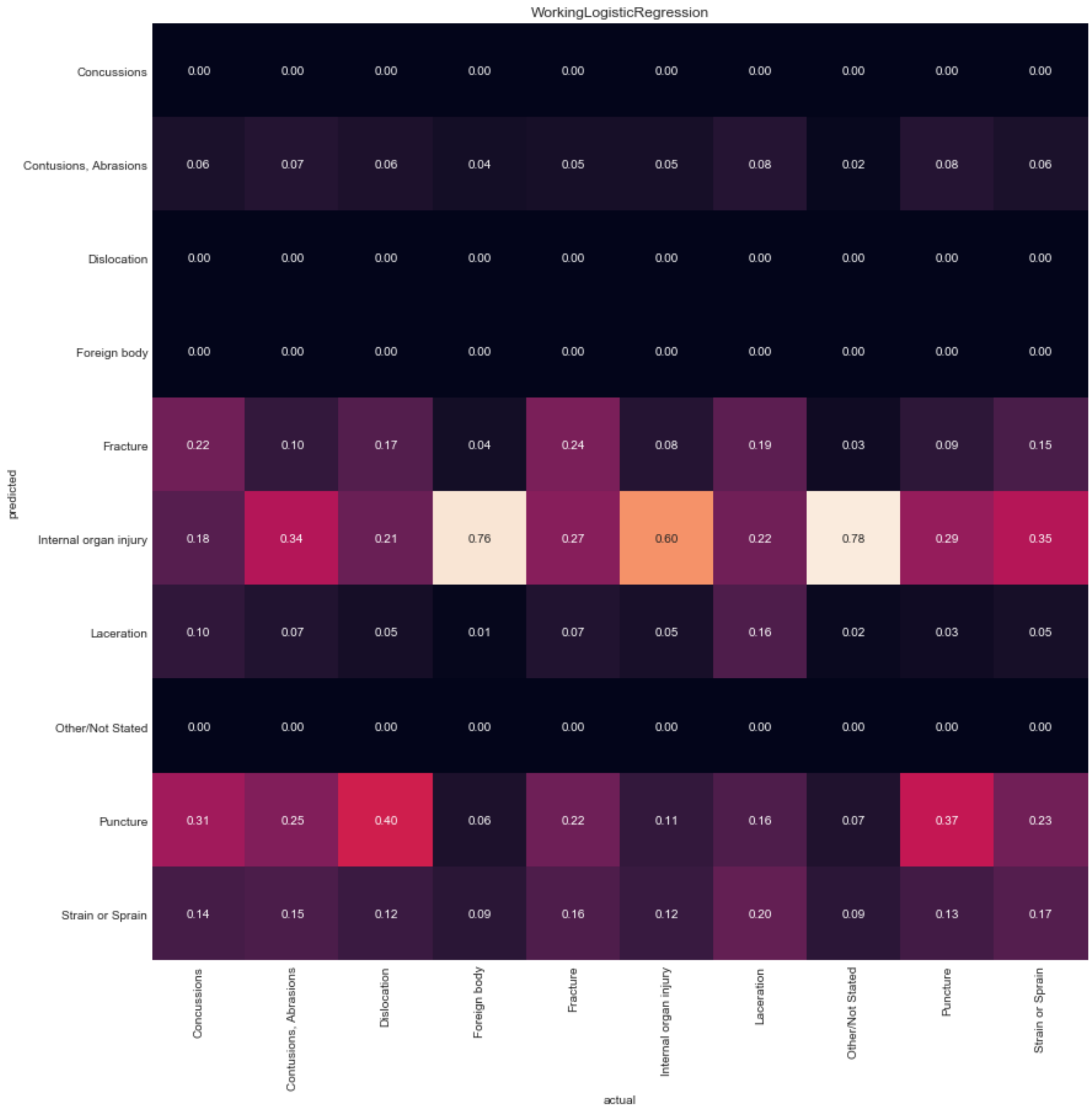
In [36]:

```
if True == Includes.LogisticRegression:
    logisticRegression = WorkingLogisticRegression(
        output_choice,
        neissSubset.getCategories(),
        neissSubset.getIdToCodeDataframe(),    # neissSubset.getIdToCode
Dataframe()[0:1500]
        neissSubset.getCodeIdTranslator(),
        max_iter=100)
```

```
/Users/mcorbett/anaconda3/lib/python3.6/site-packages/scipy/optimize/li
nesearch.py:314: LineSearchWarning: The line search algorithm did not c
onverge
  warn('The line search algorithm did not converge', LineSearchWarning)
/Users/mcorbett/anaconda3/lib/python3.6/site-packages/sklearn/utils/opt
imize.py:195: UserWarning: Line Search failed
  warnings.warn('Line Search failed')

test_score = 0.26411541530750815
```

In [37]:
```
if True == Includes.LogisticRegression:
    logisticRegression.showMissclassifiedSamples()
    logisticRegression.showAccuracy()
    logisticRegression.showConfusionMatrix()
    dfPredictedVersusActual = logisticRegression.getPredictedVersusActua
lDataframe()
    display(dfPredictedVersusActual)
```

```
Misclassified samples: 105127 out of 142858
Accuracy: 0.26
```



	target_class	predicted_class	Other/Not Stated	Fracture	Contusions, Abrasions	Foreign body	Laceration	Inte or in
0	Fracture	Strain or Sprain	0.0141	0.1824	0.0289	0.0043	0.1487	0.1
1	Laceration	Laceration	0.0127	0.1608	0.0023	0.1164	0.1158	0.2
2	Internal organ injury	Laceration	0.0128	0.1769	0.0158	0.0130	0.1332	0.1
3	Fracture	Strain or Sprain	0.0158	0.1908	0.0353	0.0023	0.1622	0.0
4	Contusions, Abrasions	Strain or Sprain	0.0291	0.1867	0.0424	0.0021	0.1974	0.0
...	...	...	...	...	...	...	...	
142853	Fracture	Strain or Sprain	0.0214	0.1948	0.0253	0.0030	0.1690	0.0
142854	Strain or Sprain	Strain or Sprain	0.0446	0.1323	0.0304	0.0021	0.1646	0.0
142855	Laceration	Contusions, Abrasions	0.0243	0.1844	0.0098	0.0184	0.1687	0.1
142856	Strain or Sprain	Contusions, Abrasions	0.0176	0.1925	0.0093	0.0203	0.1636	0.1
142857	Other/Not Stated	Fracture	0.0135	0.0778	0.0191	0.0048	0.3560	0.0

142858 rows × 12 columns

- Analysis: The data does not follow a logistic regression model

Gaussian Naive Bayes (GaussianNB) - dataframe subset used

Can perform online updates to model parameters via partial_fit method.

For details on algorithm used to update feature means and variance online,

see Stanford CS tech report STAN-CS-79-773 by Chan, Golub, and LeVeque:

[http://i.stanford.edu/pub/cstr/reports/cs/tr/79/773/CS-TR-79-773.pdf (http://i.stanford.edu/pub/cstr/reports/cs/tr/79/773/CS-TR-79-773.pdf)](http://i.stanford.edu/pub/cstr/reports/cs/tr/79/773/CS-TR-79-773.pdf)

In [38]:
```
if True == Includes.GaussianNB:
    class WorkingGaussianNB():
        def __init__(self, outputFeature, categories, dfIdToCode, codeId
Translator, verbose=False):
            self.outputFeature = outputFeature
            self.categories = categories.copy()
            self.df = dfIdToCode.copy()
            self.codeIdTranslator = codeIdTranslator

            self.categories.remove(outputFeature)
            # print('categories=', self.categories)

            # Build the Label encoder
            self.le = {}
            for col in self.df.columns:
                self.le[col] = preprocessing.LabelEncoder()
                self.le[col].fit(self.df[col].unique())

                if True == verbose:
                    print('{0:12s} => {1}'.format(col, self.le[col].clas
ses_))

            self.y_test = self.df[self.outputFeature]
            self.y_labels = self.columnOutputValueIdToString(self.y_test
.unique(), self.outputFeature)

        def columnOutputValueIdToString(self, y_values, column_name):
            target_dict = column_dictionary[column_name]

            dfValues = pd.DataFrame(y_values, columns=[column_name])
            self.codeIdTranslator._transform(dfValues, 'idToCode', colum
n_name)
            return [target_dict[x] for x in dfValues[column_name]]

        def showPredicted(self):
            print("Number of mislabeled points out of a total {} points
 : {}, performance {:05.2f}%"
                  .format(
                      self.df.shape[0],
                      (self.y_test != self.y_pred).sum(),
                      100*(1-(self.y_test != self.y_pred).sum()/self.df.
shape[0])
            ))

        def showConfusionMatrix(self):
            fig, ax = plt.subplots(figsize=(14, 14))

            heatmap = WorkingHeatmap(title='WorkingGaussianNB',
                x_label='true label', y_label='predicted label',
                y_bottom_adjust=0.5, y_top_adjust=-0.5,
                normalize_columns=True)

            # This sets the yticks "upright" with 0, as opposed to sidew
ays with 90.
            #plt.yticks(rotation=0)  # does not appear to be working...
```

```
            heatmap.plot(
                self.confusion_matrix.T, square=True, annot=True, fmt='.
2f', cbar=False,
                ax=ax, xticklabels=self.y_labels, yticklabels=self.y_lab
els)

            plt.show()


        def trainClassifier(self, show_predicted_versus_actual=True, sho
w_confusion_matrices=True):
            # Drop categories with low scores
            categories = self.categories
            df = self.df

            # Train classifier
            gnb = GaussianNB()
            gnb.fit(
                df[categories].values,
                df[self.outputFeature])

            y_pred = gnb.predict(self.df[categories])
            self.y_pred = y_pred

            self.confusion_matrix = metrics.confusion_matrix(self.y_test
, self.y_pred,)
```

In [39]:

```
if True == Includes.GaussianNB:
    gaussianNB = WorkingGaussianNB(
        output_choice,
        neissSubset.getCategories(),
        neissSubset.getIdToCodeDataframe(),
        neissSubset.getCodeIdTranslator())
```

In [40]:

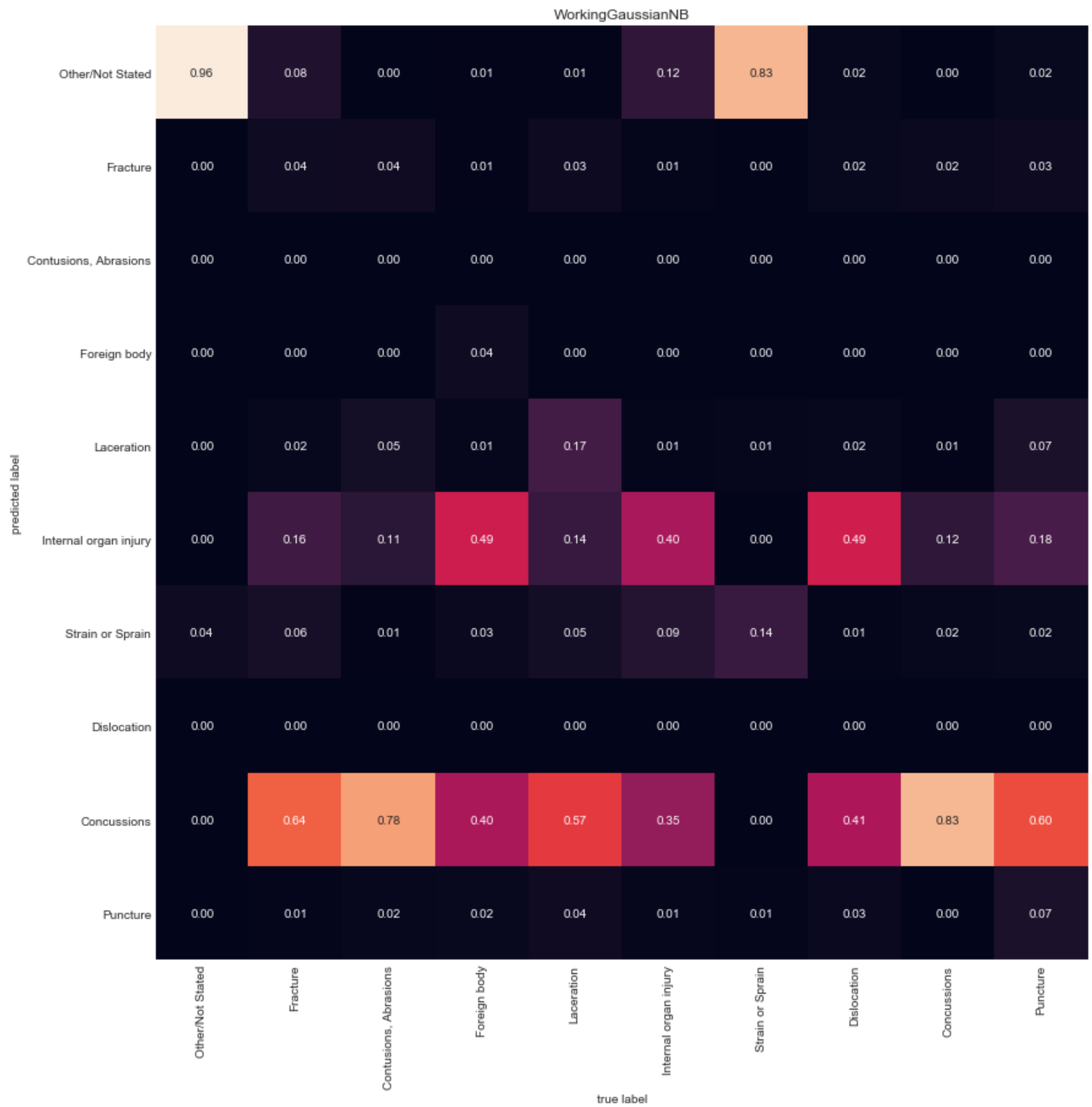
```
if True == Includes.GaussianNB:
    gaussianNB.trainClassifier()
```

In [41]:

```
if True == Includes.GaussianNB:
    gaussianNB.showPredicted()
```

```
Number of mislabeled points out of a total 1000000 points : 719923, per
formance 28.01%
```

In [42]:
```
if True == Includes.GaussianNB:
    gaussianNB.showConfusionMatrix()
```



In [ ]:

Decision Tree - dataframe subset used

[http://benalexkeen.com/decision-tree-classifier-in-python-using-scikit-learn/ (http://benalexkeen.com/decision-tree-classifier-in-python-using-scikit-learn/)](http://benalexkeen.com/decision-tree-classifier-in-python-using-scikit-learn/)

DecisionTreeClassifier(

```
class_weight=None, criterion='gini', max_depth=None,

max_features=None, max_leaf_nodes=None,

min_impurity_split=1e-07, min_samples_leaf=1,

min_samples_split=2, min_weight_fraction_leaf=0.0,

presort=False, random_state=None, splitter='best')
```

- Analysis: The GausianNB works better then either the Linear or Logistic Regressions.

In [43]:
```
if True == Includes.DecisionTree:
    class WorkingDecisionTree():
        def __init__(self, df, output_choice, dataframe_pruner=None):
            self.df = df.copy()
            self.output_choice = output_choice

            if None != dataframe_pruner:
                self.df = dataframe_pruner.prune(self.df)

            # Remove columns containing NaN or columns where the number
 of unique items is greater than
            toBeDropped = []
            for col in self.df.columns:
                if self.df[col].isnull().values.any():
                    toBeDropped.append(col)


            # Also remove the case number and the narrative
            toBeDropped.extend(['CPSC_Case_Number', 'Narrative_1'])

            # The following dates (1999 ... 2013) contain codes that do
 not match the column_codes table.
            self.df = self.df[~self.df['Treatment_Date'].dt.year.isin(li
st(range(1999, 2013)))]

            self.df.drop(toBeDropped, axis=1, inplace=True)

            # Remove values from dates (2014 ... 2018) that do not have
 column codes for them
            self.df = self.df[~self.df['Product_1'].isin([1841, 1903])]
            self.df = self.df[~self.df['Product_2'].isin([1841, 1903])]

            self.df['mDate'] = mdates.date2num(self.df['Treatment_Date'
])
            self.df.drop(['Treatment_Date'], axis=1, inplace=True)

            self.dfDecisionTree = Neiss.translateCodesToIds(self.df)

            self.replaceValueWithStringInColumn('Product_1', 0, 'Zero')
# Keep the zero.
            self.replaceValueWithStringInColumn('Product_2', 0, 'Zero')
# Especially for Product_2.
            self.replaceValueWithStringInColumn('Fire_Involvement', 4,
'InvalidCode')


            #self.checkForNumericValueInColumn('Disposition')
            self.checkForNumericValueInColumn('Fire_Involvement')
            self.checkForNumericValueInColumn('Product_1')
            self.checkForNumericValueInColumn('Product_2')

            self.dfOneHot = WorkingDecisionTree.transformToOneHotEncoded
Dataframe(self.dfDecisionTree)
            #print('dfOneHot.shape =', self.dfOneHot.shape)
            #print('dfOneHot.columns =', self.dfOneHot.columns)
```

```
            self.y_labels_org = self.columnOutputValueCodeToString(
                self.df[self.output_choice].unique(),
                self.output_choice)

            self.y_labels = []
            for col_value in self.dfOneHot.columns:
                if col_value[0] == self.output_choice:
                    self.y_labels.append(col_value)

            self.x_labels = [value for value in self.dfOneHot.columns if
value not in self.y_labels]
            self.x = self.dfOneHot[self.x_labels]
            self.y = self.dfOneHot[self.y_labels]
            #print('x_labels =', self.x_labels)
            #print('x.shape =', self.x.shape)
            #print('y.shape =', self.y.shape)

            #print()
            #for col in self.dfDecisionTree.columns:
            #    print('{:20s}\tnunique={}\tnum_nulls={}\ttype={}'.forma
t(
            #        col,
            #        self.dfDecisionTree[col].nunique(),
            #        self.dfDecisionTree[col].isnull().sum(),
            #        self.dfDecisionTree[col].dtype))

            print('Done')

        def testNull(obj, name):
            if pd.isnull(obj).any():
                raise Exception('Exception: {} is null'.format(name))

        def showConfusionMatrix(self):
            fig, ax = plt.subplots(figsize=(14, 14))

            heatmap = WorkingHeatmap(title='WorkingDecisionTree',
                x_label='true label', y_label='predicted label',
                y_bottom_adjust=0.5, y_top_adjust=-0.5,
                normalize_columns=True)

            # This sets the yticks "upright" with 0, as opposed to sidew
ays with 90.
            #plt.yticks(rotation=0)  # does not appear to be working...

            heatmap.plot(
                self.confusion_matrix.T, square=True, annot=True, fmt='.
2f', cbar=False,
                ax=ax, xticklabels=self.y_labels, yticklabels=self.y_lab
els)

            plt.show()

        def columnOutputValueCodeToString(self, y_values, column_name):
            target_dict = column_dictionary[column_name]

            dfValues = pd.DataFrame(y_values, columns=[column_name])
            return [target_dict[x] for x in dfValues[column_name]]
```

```
        def fullTestTrainAccuracy(self, criterion='gini', graph_viz=Fals
e, out_file=None, render_name=None):
             # gini is the default criterion

            clfDecisionTree = DecisionTreeClassifier(criterion=criterion
)
            clfDecisionTreeFit = clfDecisionTree.fit(self.x, self.y)
            y_pred = clfDecisionTreeFit.predict(self.x)
            self.y_labels = self.y_labels_org

            self.y_test = self.columnOutputValueCodeToString(
                self.df[self.output_choice], self.output_choice)

            dfPredY = pd.DataFrame(y_pred, columns=self.y.columns)
            dfPredY = WorkingDecisionTree.transformFromOneHotEncodedData
frame(dfPredY)
            self.y_pred = dfPredY[self.output_choice]

            WorkingDecisionTree.testNull(self.y_test, 'self.y_test')
            WorkingDecisionTree.testNull(self.y_pred, 'self.y_pred')

            self.confusion_matrix = metrics.confusion_matrix(self.y_test
, self.y_pred)

            # Model accuracy
            accuracy = metrics.accuracy_score(self.y, y_pred)
            print('Accuracy =', accuracy)

            # This code generates the following error for some reason:
            #    Error: neiss_2013_2018: syntax error in line 743 near
 ','
            if True == graph_viz:
                dot_data = export_graphviz(
                    clfDecisionTreeFit, out_file=out_file,
                    feature_names = self.x_labels,     # inputs
                    class_names   = self.y_labels,     # outputs
                    filled=True, rounded=True,
                    special_characters=True)

                graph = graphviz.Source(dot_data)
                if None != render_name:
                    graph.render(render_name)

        def _runClassifier(self, classifier, X_test, y_test):
            y_pred = classifier.predict(X_test)

            dfTestY = WorkingDecisionTree.transformFromOneHotEncodedData
frame(self.y_test)

            dfPredY = pd.DataFrame(y_pred, columns=self.y_test.columns)
            dfPredY = WorkingDecisionTree.transformFromOneHotEncodedData
frame(dfPredY)

            self.y_test = dfTestY[self.output_choice]
            self.y_pred = dfPredY[self.output_choice]
```

```
            self.confusion_matrix = metrics.confusion_matrix(self.y_test
, self.y_pred)
            self.y_labels = self.y_test.unique()

            #print('self.y_test')
            #display(self.y_test)
            #print('self.y_pred')
            #display(self.y_pred)

            # Model accuracy
            accuracy = metrics.accuracy_score(y_test, y_pred)
            print('Accuracy =', accuracy)

            # This code generates the following error for some reason:
            #    Error: neiss_2013_2018: syntax error in line 743 near
 ','
            if True == graph_viz:
                dot_data = export_graphviz(
                    clfDecisionTreeFit, out_file=out_file,
                    feature_names = self.x_labels,     # inputs
                    class_names   = self.y_labels,     # outputs
                    filled=True, rounded=True,
                    special_characters=True)

                graph = graphviz.Source(dot_data)
                if None != render_name:
                    graph.render(render_name)

        def splitTestTrainAccuracy(self,
            criterion='gini', random_state=1, test_size=0.3,
            graph_viz=False, out_file=None, render_name=None):

            X_train, X_test, y_train, y_test = train_test_split(
                self.x, self.y, test_size=0.3, random_state=bu_id)
            self.y_test = y_test

            clfDecisionTree = DecisionTreeClassifier(criterion=criterion
)
            clfDecisionTreeFit = clfDecisionTree.fit(X_train, y_train)
            print(clfDecisionTreeFit)

            self._runClassifier(clfDecisionTreeFit, X_test, y_test)

        def gridSearch(self, random_state=1, test_size=0.3,
            graph_viz=False, out_file=None, render_name=None):

            # http://benalexkeen.com/decision-tree-classifier-in-python-
using-scikit-learn/

            #DecisionTreeClassifier(class_weight=None, criterion='gini',
max_depth=None,
            #             max_features=None, max_leaf_nodes=None,
            #             min_impurity_split=1e-07, min_samples_leaf=1,
            #             min_samples_split=2, min_weight_fraction_leaf=
0.0,
            #             presort=False, random_state=None, splitter='bes
```

```
t')

            tree_parameters = {
                'criterion' : ['gini','entropy'],
                'min_samples_split' : [2, 4, 8, 16, 32, 64, 128],
                'max_depth' : [16, 32, 64, 128, 256]
            }

            X_train, X_test, y_train, y_test = train_test_split(
                self.x, self.y, test_size=0.3, random_state=bu_id)
            self.y_test = y_test

            #print('X_train')
            #display(X_train)
            #print('y_train')
            #display(y_train)

            clfDecisionTree = GridSearchCV(DecisionTreeClassifier(), tre
e_parameters, cv=5)
            clfDecisionTreeFit = clfDecisionTree.fit(X_train, y_train)
            print(clfDecisionTreeFit)

            self._runClassifier(clfDecisionTreeFit, X_test, y_test)
            # num_leafs = [1, 5, 10, 20, 50, 100]

        def replaceValueWithStringInColumn(self, column_name, replace_va
lue, with_string):
            self.dfDecisionTree[column_name] = [
                with_string if str(x) == '{}'.format(replace_value) else
x
                for x in self.dfDecisionTree[column_name]]  # Replace ze
ros in col='disposition' with 'Unknown'

        def checkForNumericValueInColumn(self, columnName):
            for index, value in enumerate(self.dfDecisionTree[columnName
]):
                if type(value) == int:
                    if 'Treatment_Date' in self.dfDecisionTree.columns:
                        print('{}: Found int={} at {} - {}'.format(
                            columnName, value, index, dfDecisionTree['Tr
eatment_Date'].iloc[index]))
                    else:
                        print('{}: Found int={} at {}'.format(columnName
, value, index))

        def transformFromOneHotEncodedDataframe(df):
            df1 = df.copy()

            columns = df.columns
            for col in df.columns:
                (column_name, value) = col

                if column_name not in df1.columns:
                    df1[column_name] = np.nan

                is_set = (1 == df[col])
                df1[column_name][is_set] = value
```

```
            df1.drop(columns, axis=1, inplace=True)

            return df1

        def transformToOneHotEncodedDataframe(df):
            '''
            Take columns that are objects and turn them into multiple on
e-hot columns.

            Args:
                df    (pd.DataFrame):  The dataframe to convert to a one
-hot dataframe

            Returns:
                dfOneHot (pd.DataFrame):  A dataframe with the original
 objects replaced with one-hot versions.


            Example dataframe:

                Cost(dollars)  Item
                2              'Baseball'
                5              'Baseball Glove'
                7              'Helmet'

            Will become a dataframe similar to:

                Cost(dollars)  ('Item', 'Baseball')    ('Item', 'Basebal
l Glove')  ('Item', 'Helmet)
                2              1                       0
0
                5              0                       1
0
                7              0                       0
1

            By making a tuple for the column header it is easy to determ
ine the variable that the one-hot
            column represents.
            '''
            dfOneHot = df.copy()

            updateFreq = 100
            print('Dots are printed every {} translations during one-hot
transformation'.format(updateFreq))

            for col in df.columns:
                if df[col].dtype == object:
                    print('One-hot transforming {:20s}'.format(col), end
='\t')

                    unique = pd.unique(df[col].sort_values(ascending=Tru
e))
                    nUnique = len(unique)
                    print('nUnique={}'.format(nUnique), end='\t')
```

```
                    updateIndex = updateFreq
                    updateNext = updateFreq

                    for index, value in enumerate(unique):
                        if index == updateIndex:
                            updateIndex += updateFreq
                            updateNext += updateFreq
                            print('.', end='')

                        dfOneHot[(col, value)] = (dfOneHot[col] == value
).astype(int)
                    dfOneHot.drop(columns=[col], inplace=True)
                    print('\tcomplete')
            return dfOneHot
```

In [44]:

```
if True == Includes.DecisionTree:
    df = neiss.getDataFrame()
    # max_output_rows = 1000000
    # max_output_rows = 20000
    # max_output_rows = 10000
    max_output_rows = 5000
    # max_output_rows = 100
    # max_output_rows = len(df) // 4
    pruner = DataFramePruner(dict_prune={output_choice : 10}, max_output
_rows=max_output_rows)

    decisionTree = WorkingDecisionTree(df, output_choice, pruner)
```

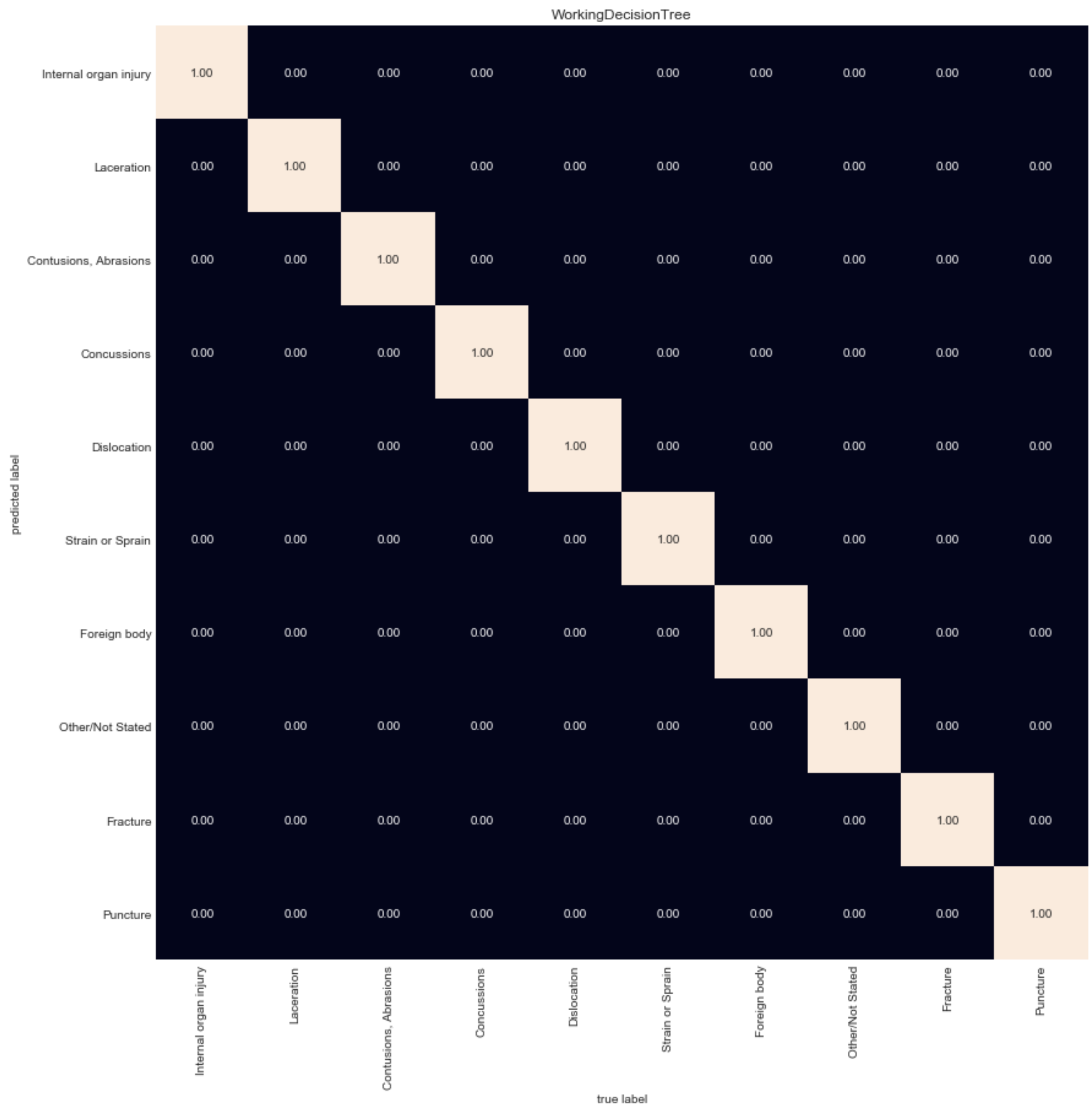
```
Dots are printed every 100 translations during one-hot transformation
One-hot transforming Sex                        nUnique=2
complete
One-hot transforming Race                       nUnique=7
complete
One-hot transforming Body_Part                  nUnique=24
complete
One-hot transforming Diagnosis                  nUnique=10
complete
One-hot transforming Disposition                nUnique=6
complete
One-hot transforming Location                   nUnique=8
complete
One-hot transforming Fire_Involvement           nUnique=3
complete
One-hot transforming Product_1                  nUnique=355     ...
complete
One-hot transforming Product_2                  nUnique=166     .
complete
One-hot transforming Stratum                    nUnique=5
complete
Done
```

- Full with 100% training set, 100% testing set

In [45]:
```
if True == Includes.DecisionTree:
    render_name='neiss_full'
    graph_viz=False
    decisionTree.fullTestTrainAccuracy(graph_viz=graph_viz, render_name=
render_name)
```

```
Accuracy = 1.0

/Users/mcorbett/anaconda3/lib/python3.6/site-packages/ipykernel_launche
r.py:249: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: http://pandas.pydata.org/pandas-d
ocs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
```

In [46]:
```
if True == Includes.DecisionTree:
    decisionTree.showConfusionMatrix()
```



In [47]:
```
if True == Includes.DecisionTree:
    if True == graph_viz:
        !open '{}.pdf'.format(render_name)
```

- Now with 70% training set, 30% testing set

In [48]:
```
if True == Includes.DecisionTree:
    bu_id = 7286
    render_name='neiss_70_30_split'
    graph_viz=False
    decisionTree.splitTestTrainAccuracy(
        criterion='gini', graph_viz=graph_viz, render_name=render_name,
        test_size=0.3, random_state=bu_id)
```

```
DecisionTreeClassifier(class_weight=None, criterion='gini', max_depth=N
one,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=No
ne,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=None, splitter='best')
Accuracy = 0.4706666666666667
```

```
/Users/mcorbett/anaconda3/lib/python3.6/site-packages/ipykernel_launche
r.py:249: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: http://pandas.pydata.org/pandas-d
ocs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
```

In [49]:
```
if True == Includes.DecisionTree:
    decisionTree.showConfusionMatrix()
```

In [50]:
```
if True == Includes.DecisionTree:
    if True == graph_viz:
        !open '{}.pdf'.format(render_name)
```

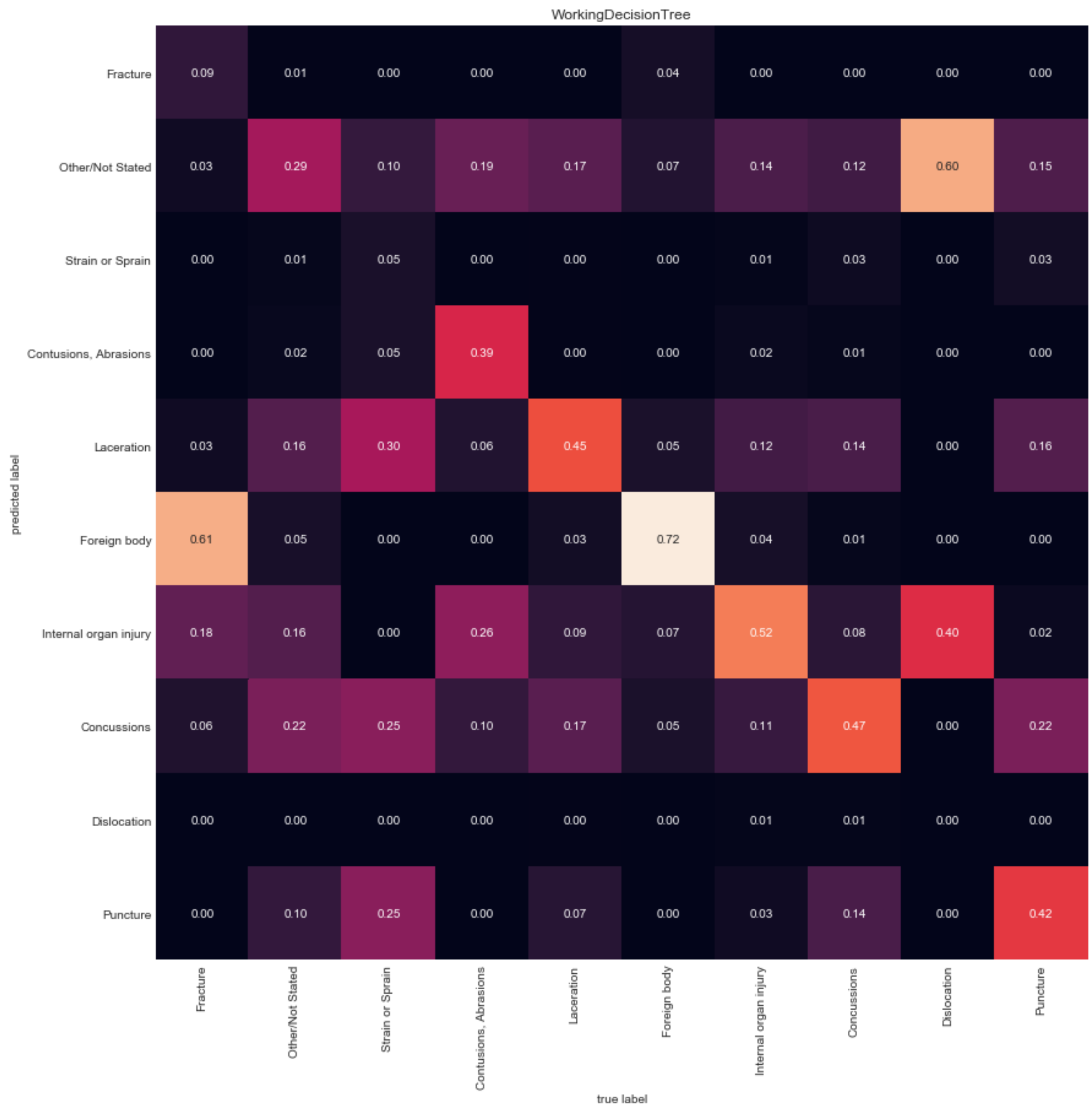
Now using GridSearchCV

In [51]:
```
if True == Includes.DecisionTree:
    bu_id = 7286
    render_name='neiss_grid_search_cv'
    graph_viz=False
    decisionTree.gridSearch(graph_viz=graph_viz, render_name=render_name
, test_size=0.3, random_state=bu_id)
```

```
GridSearchCV(cv=5, error_score='raise-deprecating',
             estimator=DecisionTreeClassifier(class_weight=None,
                                              criterion='gini', max_dep
th=None,
                                              max_features=None,
                                              max_leaf_nodes=None,
                                              min_impurity_decrease=0.
0,
                                              min_impurity_split=None,
                                              min_samples_leaf=1,
                                              min_samples_split=2,
                                              min_weight_fraction_leaf=
0.0,
                                              presort=False, random_sta
te=None,
                                              splitter='best'),
             iid='warn', n_jobs=None,
             param_grid={'criterion': ['gini', 'entropy'],
                         'max_depth': [16, 32, 64, 128, 256],
                         'min_samples_split': [2, 4, 8, 16, 32, 64, 12
8]},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=Fa
lse,
             scoring=None, verbose=0)
Accuracy = 0.4633333333333333
```

```
/Users/mcorbett/anaconda3/lib/python3.6/site-packages/ipykernel_launche
r.py:249: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: http://pandas.pydata.org/pandas-d
ocs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
```

In [52]:
```
if True == Includes.DecisionTree:
    decisionTree.showConfusionMatrix()
```



In [53]:
```
if True == Includes.DecisionTree:
    if True == graph_viz:
        !open '{}.pdf'.format(render_name)
```

- Analysis: The DecisionTree looks like it is taking shape. The accurracy is upto 50%. Unfortunately, feeding more rows into the dataframe causes a NaN error. Running out of memory?

LDA (fit based on class) / Support Vector Machines (SVM) / Pipeline

In [54]:
```
if True == Includes.LdaSvmPipeline:
    class WorkingLdaSvmPipeline:
        def __init__(self,
                     outputFeature, categories, dfIdToCode,
                     codeIdTranslator, max_iter=5000,
                     dataframe_pruner=None):
            self.outputFeature = outputFeature
            self.categories = categories.copy()
            self.df = dfIdToCode.copy()
            self.codeIdTranslator = codeIdTranslator

            self.categories.remove(self.outputFeature)

            if None != dataframe_pruner:
                self.df = dataframe_pruner.prune(self.df)

            self.inputs = self.df[self.categories]
            self.output = self.df[self.outputFeature]

            self.x_train, self.x_test, self.y_train, self.y_test = train
_test_split(
                self.inputs, self.output, test_size=1/7.0, random_state=
122)

            # Standardize the data
            self.scaler = StandardScaler()

            # --- --- ---

            n_components=self.y_test.nunique()
            print('n_components=', n_components)

            lda_tree_parameters = {
                'n_components' : [n_components],
            }
            self.clfLdaGridCV = GridSearchCV(LinearDiscriminantAnalysis
(), lda_tree_parameters, cv=5)

            # --- --- ---

            svc_tree_parameters = {
                'kernel'       : ['rbf'],
                'C'            : [1000, 1E6],
                'gamma'        : ['auto'],
                'class_weight' : ['balanced']

            }
            self.clfSvcGridCV = GridSearchCV(SVC(), svc_tree_parameters,
cv=5)

            # --- --- ---

            self.model = Pipeline([
                ('scaler', self.scaler),
                ('lda', self.clfLdaGridCV),
                ('svc', self.clfSvcGridCV)
```

```
            ])

        print('Model built')

    def columnOutputValueIdToString(self, y_values, column_name):
        target_dict = column_dictionary[column_name]

        dfValues = pd.DataFrame(y_values, columns=[column_name])
        self.codeIdTranslator._transform(dfValues, 'idToCode', colum
n_name)
        return [target_dict[x] for x in dfValues[column_name]]

    def compute(self):
        self.model.fit(self.x_train, self.y_train)
        self.y_pred = self.model.predict(self.x_test)

        self.confusion_matrix = metrics.confusion_matrix(self.y_test
, self.y_pred)
        self.y_labels = self.y_test.unique()

        self.y_labels = self.columnOutputValueIdToString(self.y_labe
ls, self.outputFeature)

        # Model accuracy
        accuracy = metrics.accuracy_score(self.y_test, self.y_pred)
        print('Accuracy =', accuracy)

    def testNull(obj, name):
        if pd.isnull(obj).any():
            raise Exception('Exception: {} is null'.format(name))

    def showConfusionMatrix(self):
        fig, ax = plt.subplots(figsize=(14, 14))

        heatmap = WorkingHeatmap(title='WorkingDecisionTree',
            x_label='true label', y_label='predicted label',
            y_bottom_adjust=0.5, y_top_adjust=-0.5,
            normalize_columns=True)

        # This sets the yticks "upright" with 0, as opposed to sidew
ays with 90.
        #plt.yticks(rotation=0)  # does not appear to be working...

        heatmap.plot(
            self.confusion_matrix.T, square=True, annot=True, fmt='.
2f', cbar=False,
            ax=ax, xticklabels=self.y_labels, yticklabels=self.y_lab
els)

        plt.show()
```

In [55]:
```
if True == Includes.LdaSvmPipeline:
    max_output_rows = 5000
    # max_output_rows = len(df) // 4

    pruner = DataFramePruner(
        dict_prune={output_choice : 10},
        max_output_rows=max_output_rows)

    ldaSvmPipeline = WorkingLdaSvmPipeline(
        output_choice,
        neissSubset.getCategories(),
        neissSubset.getIdToCodeDataframe(),
        neissSubset.getCodeIdTranslator(),
        max_iter=100,
        dataframe_pruner=pruner)
```

```
n_components= 10
Model built
```

In [56]:
```
if True == Includes.LdaSvmPipeline:
    ldaSvmPipeline.compute()
```

```
/Users/mcorbett/anaconda3/lib/python3.6/site-packages/sklearn/discrimin
ant_analysis.py:466: ChangedBehaviorWarning: n_components cannot be lar
ger than min(n_features, n_classes - 1). Using min(n_features, n_classe
s - 1) = min(10, 10 - 1) = 9 components.
  ChangedBehaviorWarning)
/Users/mcorbett/anaconda3/lib/python3.6/site-packages/sklearn/discrimin
ant_analysis.py:472: FutureWarning: In version 0.23, setting n_componen
ts > min(n_features, n_classes - 1) will raise a ValueError. You should
set n_components to None (default), or a value smaller or equal to min
(n_features, n_classes - 1).
  warnings.warn(future_msg, FutureWarning)
/Users/mcorbett/anaconda3/lib/python3.6/site-packages/sklearn/discrimin
ant_analysis.py:466: ChangedBehaviorWarning: n_components cannot be lar
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  ChangedBehaviorWarning)
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  warnings.warn(future_msg, FutureWarning)
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  ChangedBehaviorWarning)
/Users/mcorbett/anaconda3/lib/python3.6/site-packages/sklearn/discrimin
ant_analysis.py:472: FutureWarning: In version 0.23, setting n_componen
ts > min(n_features, n_classes - 1) will raise a ValueError. You should
set n_components to None (default), or a value smaller or equal to min
(n_features, n_classes - 1).
  warnings.warn(future_msg, FutureWarning)
/Users/mcorbett/anaconda3/lib/python3.6/site-packages/sklearn/discrimin
ant_analysis.py:466: ChangedBehaviorWarning: n_components cannot be lar
ger than min(n_features, n_classes - 1). Using min(n_features, n_classe
s - 1) = min(10, 10 - 1) = 9 components.
  ChangedBehaviorWarning)
/Users/mcorbett/anaconda3/lib/python3.6/site-packages/sklearn/discrimin
ant_analysis.py:472: FutureWarning: In version 0.23, setting n_componen
ts > min(n_features, n_classes - 1) will raise a ValueError. You should
set n_components to None (default), or a value smaller or equal to min
(n_features, n_classes - 1).
  warnings.warn(future_msg, FutureWarning)
/Users/mcorbett/anaconda3/lib/python3.6/site-packages/sklearn/discrimin
ant_analysis.py:466: ChangedBehaviorWarning: n_components cannot be lar
ger than min(n_features, n_classes - 1). Using min(n_features, n_classe
s - 1) = min(10, 10 - 1) = 9 components.
  ChangedBehaviorWarning)
/Users/mcorbett/anaconda3/lib/python3.6/site-packages/sklearn/discrimin
ant_analysis.py:472: FutureWarning: In version 0.23, setting n_componen
ts > min(n_features, n_classes - 1) will raise a ValueError. You should
set n_components to None (default), or a value smaller or equal to min
(n_features, n_classes - 1).
  warnings.warn(future_msg, FutureWarning)
/Users/mcorbett/anaconda3/lib/python3.6/site-packages/sklearn/discrimin
ant_analysis.py:466: ChangedBehaviorWarning: n_components cannot be lar
```

```
ger than min(n_features, n_classes - 1). Using min(n_features, n_classe
s - 1) = min(10, 10 - 1) = 9 components.
  ChangedBehaviorWarning)
/Users/mcorbett/anaconda3/lib/python3.6/site-packages/sklearn/discrimin
ant_analysis.py:472: FutureWarning: In version 0.23, setting n_componen
ts > min(n_features, n_classes - 1) will raise a ValueError. You should
set n_components to None (default), or a value smaller or equal to min
(n_features, n_classes - 1).
  warnings.warn(future_msg, FutureWarning)

Accuracy = 0.3734265734265734
```

In [57]:
```
if True == Includes.LdaSvmPipeline:
    ldaSvmPipeline.showConfusionMatrix()
```

- Analysis: For the same size dataset the DecisionTree appears to be faaster than the Scaler, LDA,SVM pipeline and provides better classification.