Problem 2

b)

In [15]:

```
import numpy as np
from scipy.io import loadmat
import matplotlib.pyplot as plt
from sklearn.svm import LinearSVC

def countIncorrectClass(X, y, w):
    error = 0
    for i in range(len(y)):
        xiT = X[[i], :]
        yi = y[i]
        if (yi * xiT @ w < 0):
            error+=1
    return error


X = np.array([[2, 1], [1.5, 1], [.5, 1], [-.5, 1]]);
y = np.array([1, 1, -1, -1]);
w_LS = np.linalg.inv(X.T @ X) @ X.T @ y
print("w = ", w_LS)
print("error count is ", countIncorrectClass(X, y, w_LS));
```

```
w =  [ 0.94915254 -0.83050847]
error count is  0
```

d)

In [16]:

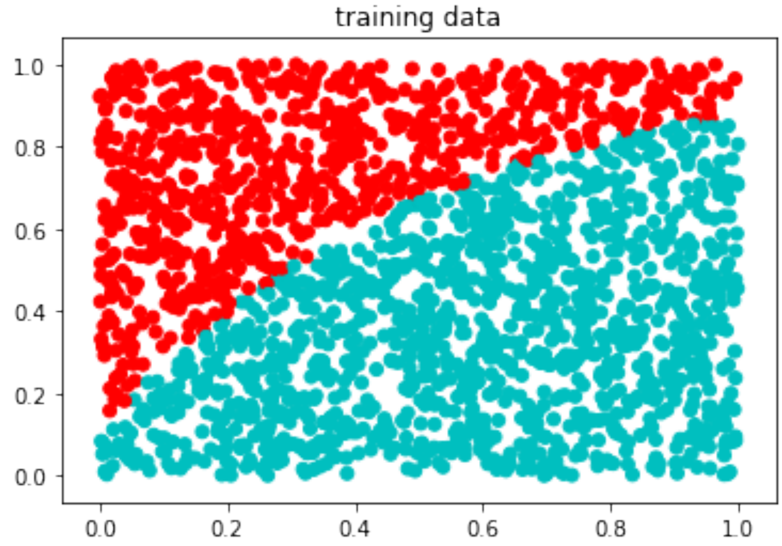
```
X = np.array([[2, 1], [1.5, 1], [.5, 1], [-5, 1]]);
y = np.array([1, 1, -1, -1]);
w_LS = np.linalg.inv(X.T @ X) @ X.T @ y
print("w = ", w_LS)
print("error count is ", countIncorrectClass(X, y, w_LS));
```

```
w =  [0.256 0.064]
error count is  1
```

Problem 3

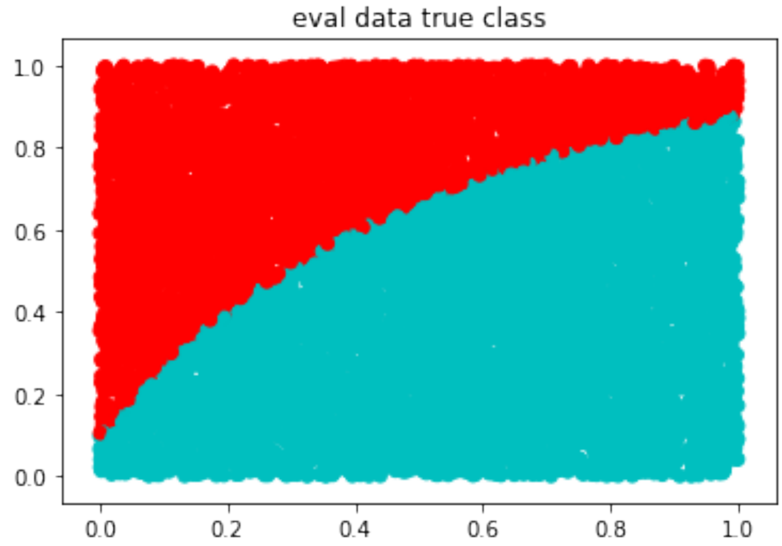
a)

In [17]:
```
in_data = loadmat('classifier_data.mat')

x_train = in_data['x_train']
x_eval = in_data['x_eval']
y_train = in_data['y_train']
y_eval = in_data['y_eval']

n_eval = np.size(y_eval)
n_train = np.size(y_train)

plt.scatter(x_train[:,0],x_train[:,1], color=['c' if i==-1 else 'r' fo
plt.title('training data')
plt.show()
```



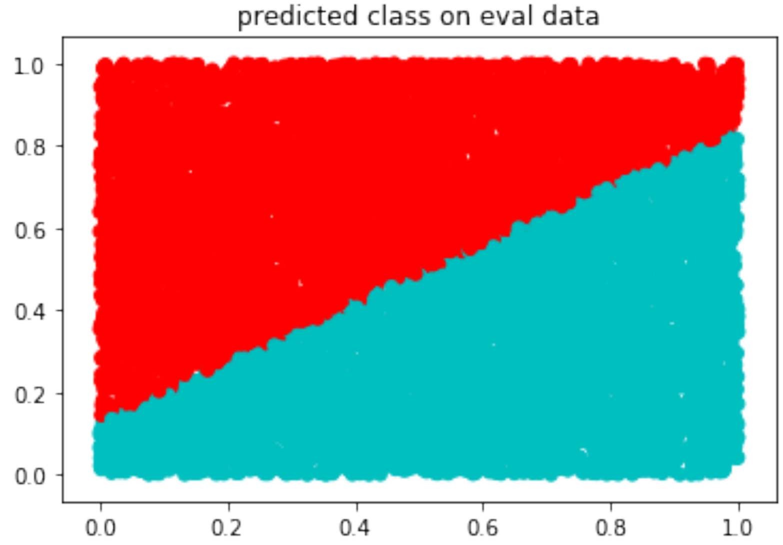
In [18]:

```
plt.scatter(x_eval[:,0],x_eval[:,1], color=['c' if i==-1 else 'r' for
plt.title('eval data true class')
plt.show()
```



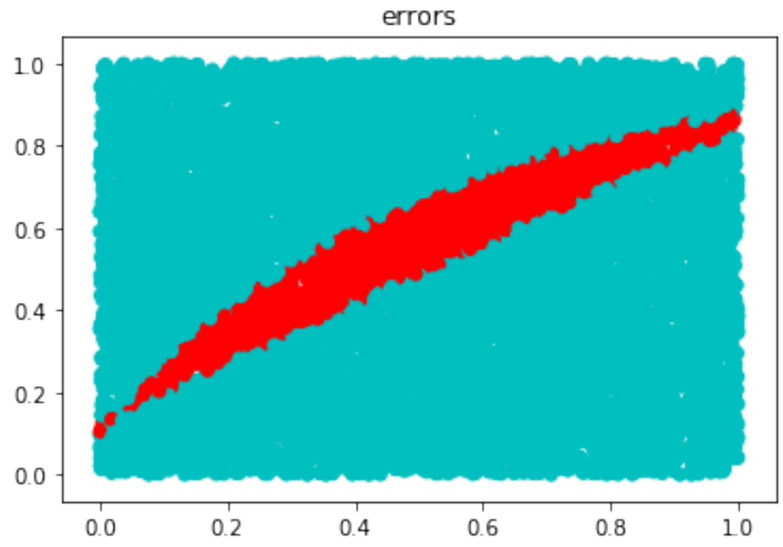
In [19]:

```
## Classifier 1
x_train_1 = np.hstack(( x_train, np.ones((n_train,1)) ))
x_eval_1 = np.hstack(( x_eval, np.ones((n_eval,1)) ))

# Train classifier using linear SVM from SK Learn library
clf = LinearSVC(random_state=0, tol=1e-8)
clf.fit(x_train_1, np.squeeze(y_train))
w_opt = clf.coef_.transpose()

#uncomment this line to use least squares classifier
#w_opt = np.linalg.inv(x_train_1.T@x_train_1)@x_train_1.T@y_train

y_hat_outlier = np.sign(x_eval_1@w_opt)
plt.scatter(x_eval[:,0],x_eval[:,1], color=['c' if i==-1 else 'r' for
plt.title('predicted class on eval data')
plt.show()
```



In [20]:

```
error_vec = [0 if i[0]==i[1] else 1 for i in np.hstack((y_hat_outlier,
plt.scatter(x_eval[:,0],x_eval[:,1], color=['c' if i==0 else 'r' for i
plt.title('errors')
plt.show()

print('Errors: '+ str(sum(error_vec)))
```

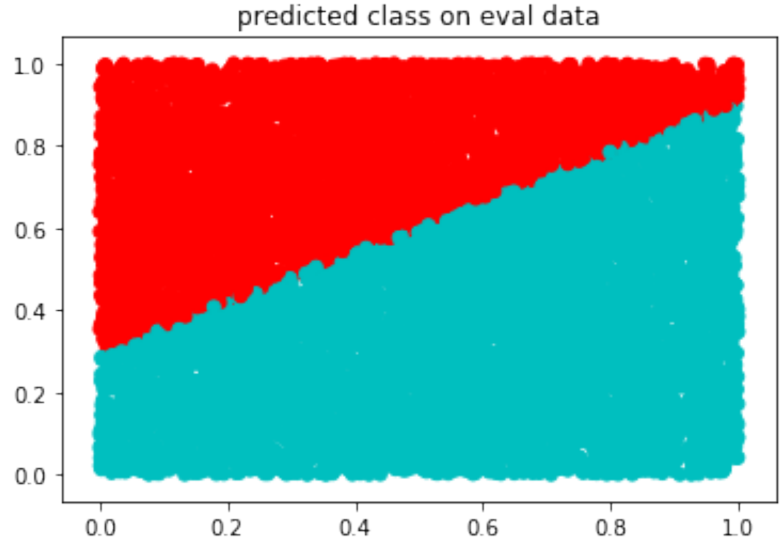


```
Errors: 1213
```

b)

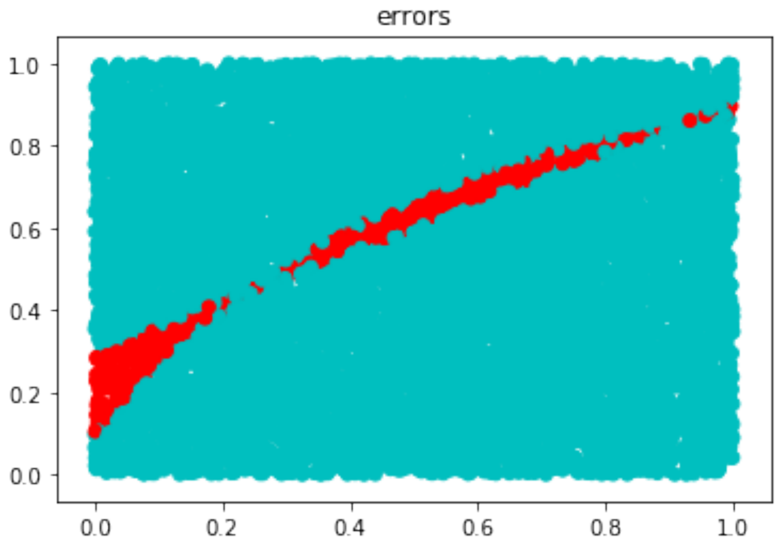
In [26]:

```
## Classifier 1
x_train_1 = np.hstack(( x_train, np.ones((n_train,1)) ))
x_eval_1 = np.hstack(( x_eval, np.ones((n_eval,1)) ))

# Train classifier using linear SVM from SK Learn library
clf = LinearSVC(random_state=0, tol=1e-8)
clf.fit(x_train_1, np.squeeze(y_train))
w_opt = clf.coef_.transpose()

#uncomment this line to use least squares classifier
w_opt = np.linalg.inv(x_train_1.T@x_train_1)@x_train_1.T@y_train

y_hat_outlier = np.sign(x_eval_1@w_opt)
plt.scatter(x_eval[:,0],x_eval[:,1], color=['c' if i==-1 else 'r' for
plt.title('predicted class on eval data')
plt.show()
```



In [27]:

```
error_vec = [0 if i[0]==i[1] else 1 for i in np.hstack((y_hat_outlier,
plt.scatter(x_eval[:,0],x_eval[:,1], color=['c' if i==0 else 'r' for i
plt.title('errors')
plt.show()

print('Errors: '+ str(sum(error_vec)))
```

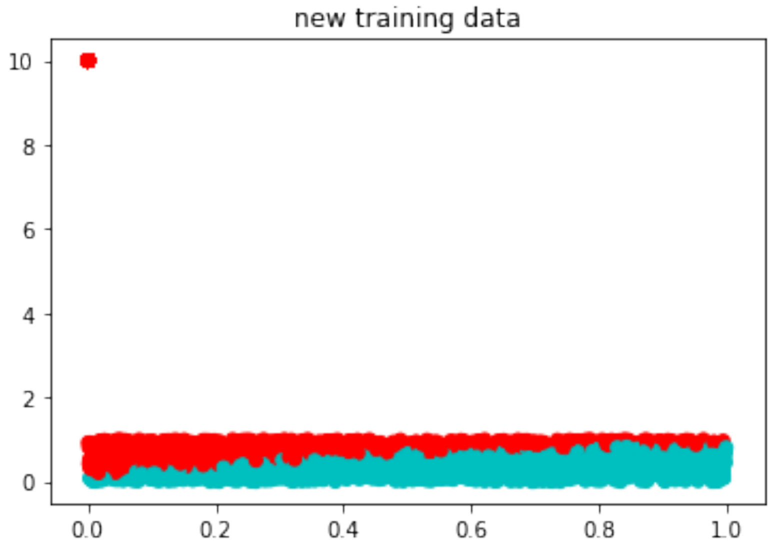


```
Errors: 495
```

Add correct points far from boundary

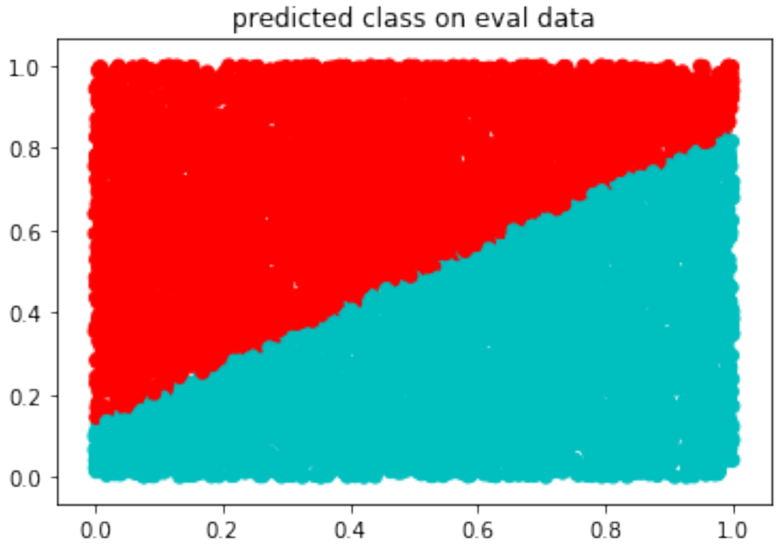
In [23]:

```
## create new, correctly labeled points
n_new = 1000 #number of new datapoints
x_train_new = np.hstack((np.zeros((n_new,1)), 10*np.ones((n_new,1))))
y_train_new = np.ones((n_new,1))

## add these to the training data
x_train_outlier = np.vstack((x_train,x_train_new))
y_train_outlier = np.vstack((y_train,y_train_new))
plt.scatter(x_train_outlier[:,0],x_train_outlier[:,1], color=['c' if
plt.title('new training data')
plt.show()
```



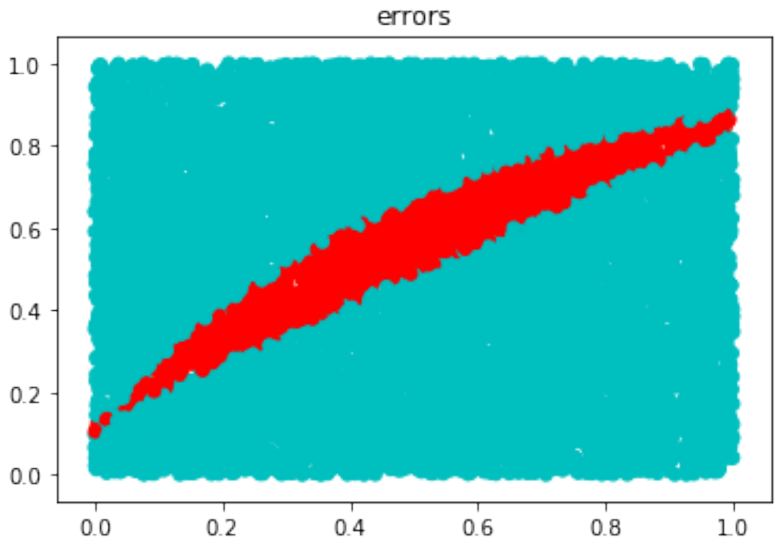
In [30]:

```
x_train_outlier_1 = np.hstack((x_train_outlier, np.ones((n_train+n_new
x_eval_1 = np.hstack((x_eval, np.ones((n_eval,1)) ))

#Train classifier using off the shelf SVM from sklearn
clf = LinearSVC(random_state=0, tol=1e-5)
clf.fit(x_train_outlier_1, np.squeeze(y_train_outlier))
w_opt_outlier = clf.coef_.transpose()

#uncomment this line to use least squares classifier
#w_opt_outlier = np.linalg.inv(x_train_outlier_1.T@x_train_outlier_1)@

y_hat_outlier = np.sign(x_eval_1@w_opt_outlier)
plt.scatter(x_eval[:,0],x_eval[:,1], color=['c' if i==-1 else 'r' for
plt.title('predicted class on eval data')
plt.show()
```



In [31]:

```
error_vec = [0 if i[0]==i[1] else 1 for i in np.hstack((y_hat_outlier,
plt.scatter(x_eval[:,0],x_eval[:,1], color=['c' if i==0 else 'r' for i
plt.title('errors')
plt.show()

print('Errors: '+ str(sum(error_vec)))
```

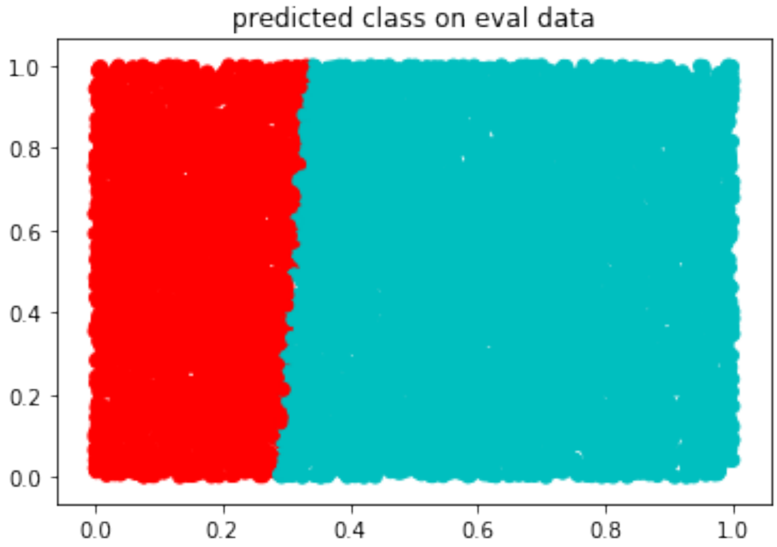


```
Errors: 1213
```

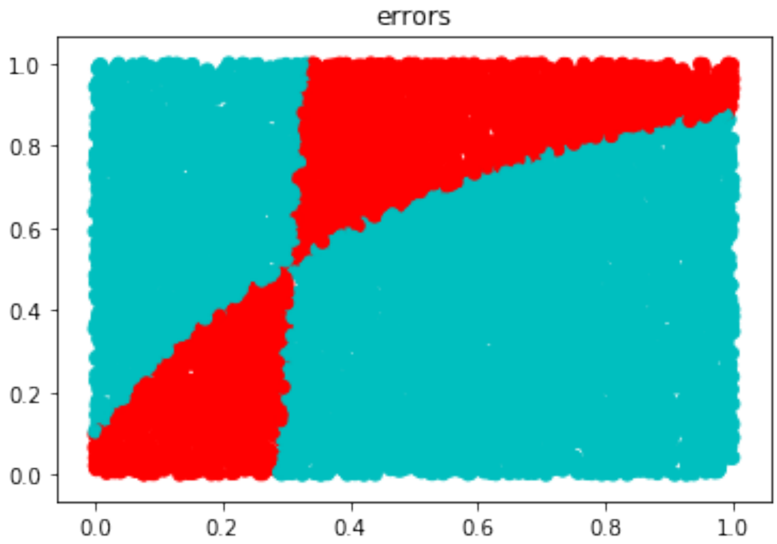
d)

In [33]:

```
x_train_outlier_1 = np.hstack((x_train_outlier, np.ones((n_train+n_nev
x_eval_1 = np.hstack((x_eval, np.ones((n_eval,1)) ))

#Train classifier using off the shelf SVM from sklearn
clf = LinearSVC(random_state=0, tol=1e-5)
clf.fit(x_train_outlier_1, np.squeeze(y_train_outlier))
w_opt_outlier = clf.coef_.transpose()

#uncomment this line to use least squares classifier
w_opt_outlier = np.linalg.inv(x_train_outlier_1.T@x_train_outlier_1)@x

y_hat_outlier = np.sign(x_eval_1@w_opt_outlier)
plt.scatter(x_eval[:,0],x_eval[:,1], color=['c' if i==-1 else 'r' for
plt.title('predicted class on eval data')
plt.show()
```



In [34]:
```
error_vec = [0 if i[0]==i[1] else 1 for i in np.hstack((y_hat_outlier,
plt.scatter(x_eval[:,0],x_eval[:,1], color=['c' if i==0 else 'r' for i
plt.title('errors')
plt.show()

print('Errors: '+ str(sum(error_vec)))
```



```
Errors: 2668
```

In [ ]: