Bootstrap Test

June 26, 2018

1 This notebok is designed to test out our bootstrapping idea

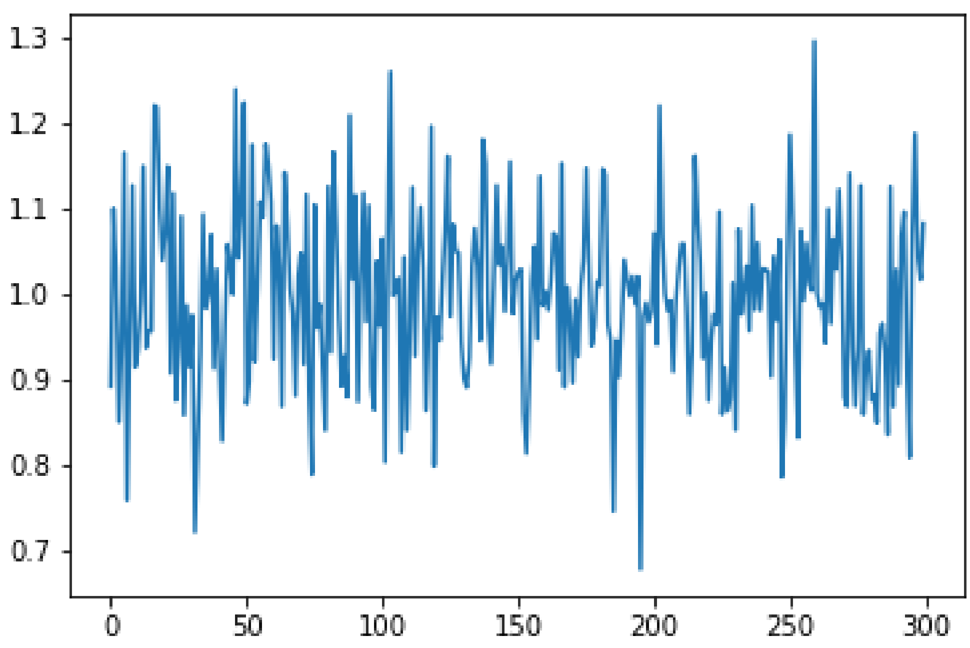
First I will generate data around at line at 1 and then give it a sigma of 0.1

```
In [2]: import numpy as np
        import matplotlib.pyplot as plt

        %matplotlib inline
```

```
In [3]: perfect_data = np.zeros(300) +1
        np.random.seed(123)
        noisy_data = np.random.randn(300)*0.1 + perfect_data
```

```
In [4]: print("Mean: {:0.4} Standard Dev: {:0.4}".format(np.mean(noisy_data),np.std(noisy_data))
        plt.plot(noisy_data)
        plt.show()
```

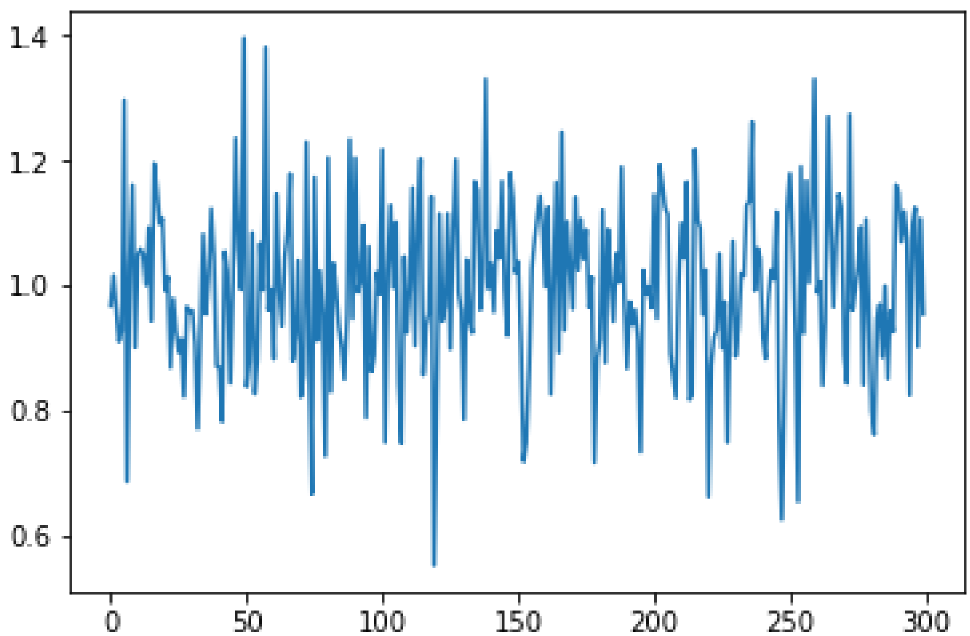
```
Mean: 0.9971 Standard Dev: 0.1027
```



Now I will create a new data set from the old one with a similar deviation

```
In [5]: new_noisy_data = noisy_data + np.random.randn(300)*0.1
        print("Mean: {:0.4} Standard Dev: {:0.4}".format(np.mean(new_noisy_data),np.std(new_nois
        plt.plot(new_noisy_data)
        plt.show()
```

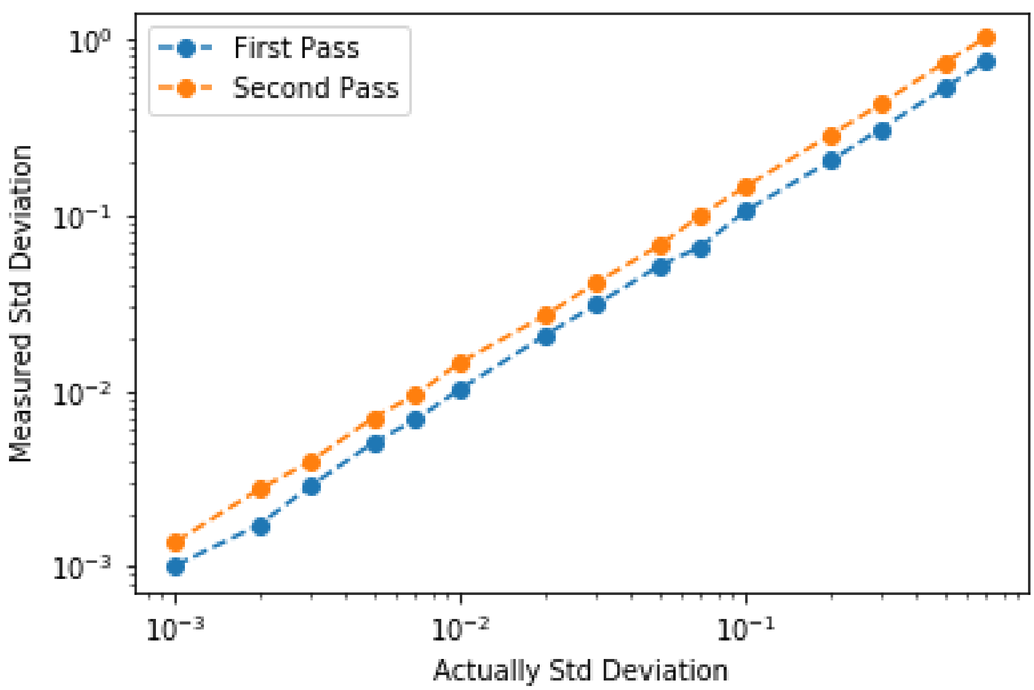
```
Mean: 0.9972 Standard Dev: 0.1351
```

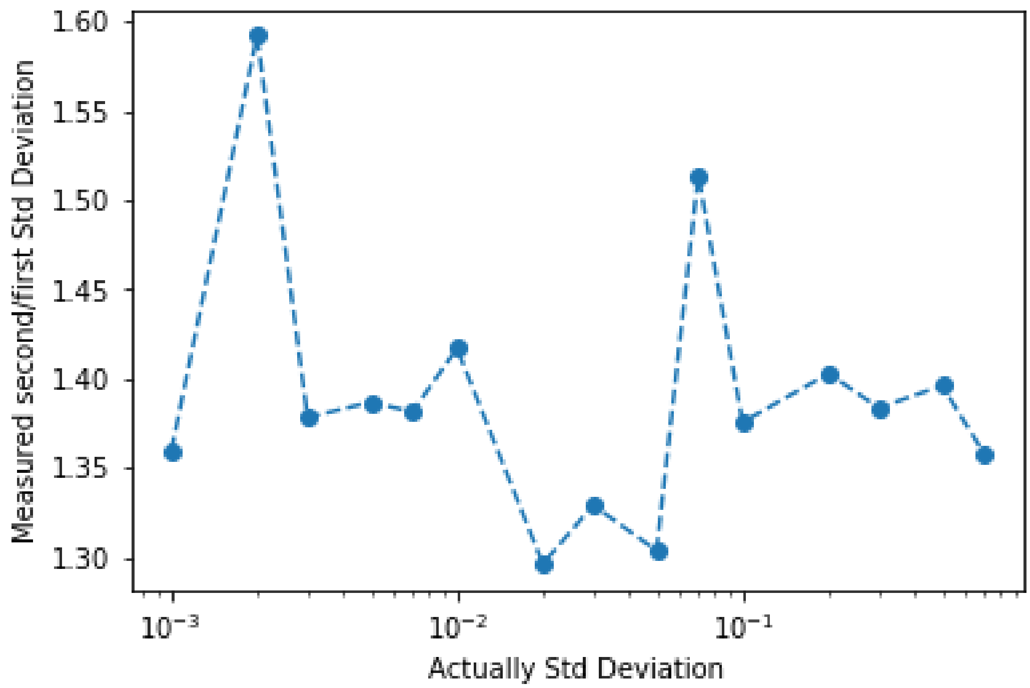


So we can see that the mean is still pretty good, but the Standard Deviation is about 30% worse. Let's see how this varies with the standard deviation.

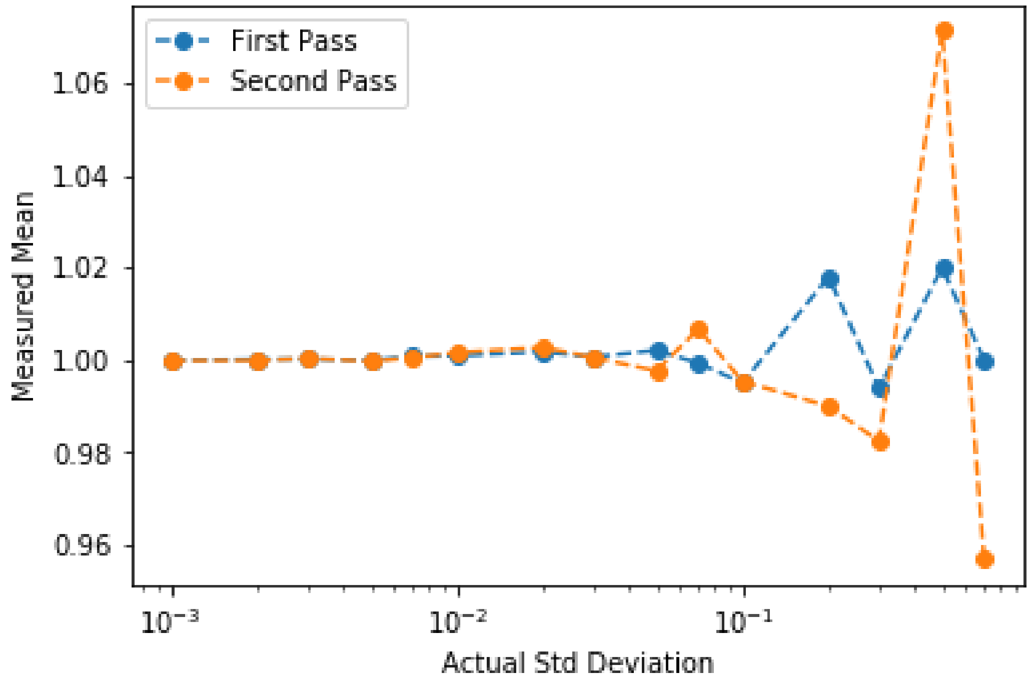
```
In [6]: test_std = [0.001,0.002,0.003,0.005,0.007,0.01,0.02,0.03,0.05,0.07,0.1,0.2,0.3,0.5,0.7]

        first_dev_list = list()
        first_mean_list = list()
        second_dev_list = list()
        second_mean_list = list()

        for i in range(len(test_std)):
            noisy_data = np.random.randn(300)*test_std[i] + perfect_data
            new_noisy_data = noisy_data + np.random.randn(300)*test_std[i]
            first_dev_list.append(np.std(noisy_data))
            first_mean_list.append(np.mean(noisy_data))
```

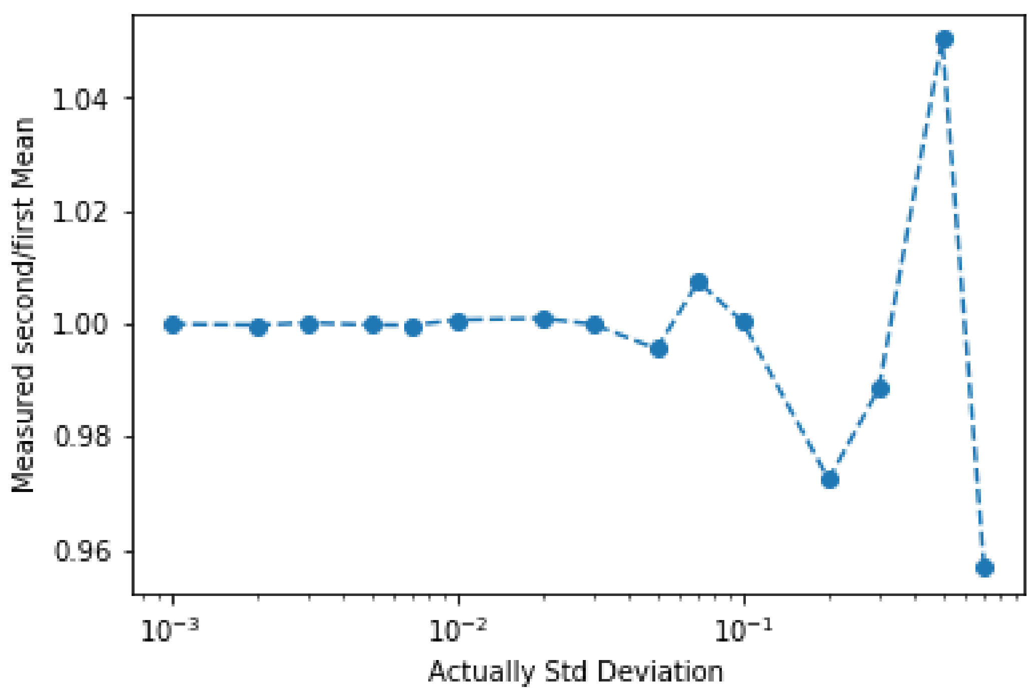
```
    second_dev_list.append(np.std(new_noisy_data))
    second_mean_list.append(np.mean(new_noisy_data))

first_dev_arr = np.array(first_dev_list)
first_mean_arr = np.array(first_mean_list)
second_dev_arr = np.array(second_dev_list)
second_mean_arr = np.array(second_mean_list)

plt.plot(test_std,first_dev_list,'o--',label='First Pass')
plt.plot(test_std,second_dev_list,'o--',label='Second Pass')
plt.xlabel('Actually Std Deviation')
plt.ylabel('Measured Std Deviation')
plt.legend()
plt.loglog()
plt.show()

plt.plot(test_std,second_dev_arr/first_dev_arr,'o--')
plt.xlabel('Actually Std Deviation')
plt.ylabel('Measured second/first Std Deviation')
plt.semilogx()
plt.show()
```






```
In [7]: plt.plot(test_std,first_mean_list,'o--',label='First Pass')
        plt.plot(test_std,second_mean_list,'o--',label='Second Pass')
        plt.xlabel('Actual Std Deviation')
        plt.ylabel('Measured Mean')
        plt.legend()
        plt.semilogx()
        plt.show()

        plt.plot(test_std,second_mean_arr/first_mean_arr,'o--')
        plt.xlabel('Actually Std Deviation')
        plt.ylabel('Measured second/first Mean')
        plt.semilogx()
        plt.show()
```


First Pass
Second Pass
1.06
1.04
1.02
1.00
0.98
0.96
Measured Mean
10^{-3}
10^{-2}
10^{-1}
Actual Std Deviation


1.04
1.02
1.00
0.98
0.96
Measured second/first Mean
10^{-3}
10^{-2}
10^{-1}
Actually Std Deviation

1.1 Now let's try many trials

In [8]:
```
np.random.seed(123)
perfect_data = np.zeros(300) +1
noisy_data = np.random.randn(300)*0.1 + perfect_data
```

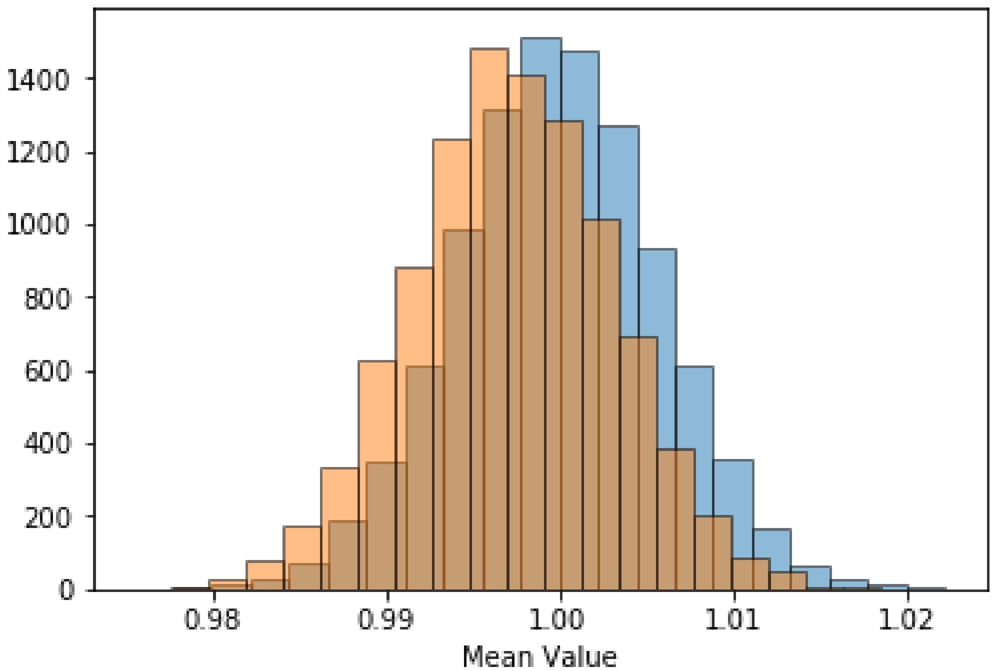
The idea here is to see if the mean on means and standard deviation of means is significantly different after 1000 trials. From the true distribution (perfect_data) and the starting point data that had noise (noisy_data).

In [9]:
```
def fit_data(perfect_data,noisy_data,num_trials,sigma):
    perfect_mean_list = list()
    noisy_mean_list = list()
    for i in range(num_trials):
        trialn = np.random.randn(300)*sigma + perfect_data
        perfect_mean_list.append(np.mean(trialn))
        trialn = np.random.randn(300)*sigma + noisy_data
        noisy_mean_list.append(np.mean(trialn))
    return((np.array(perfect_mean_list),np.array(noisy_mean_list)))
```

In [10]:
```
num_trials = 10000
(perfect_mean_arr,noisy_mean_arr) = fit_data(perfect_data,noisy_data,num_trials,0.1)
```

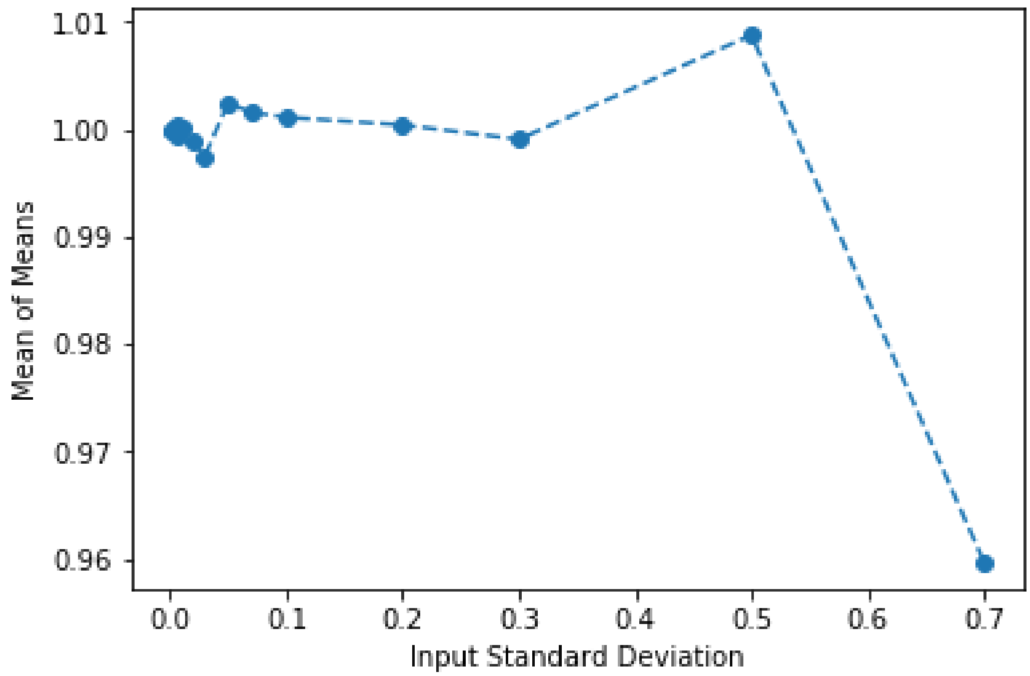
In [11]:
```
print("Perfect Mean: {:0.4} Standard Dev: {:0.4} Expected Std. Dev {:.04}".format(np.me
                                                                                 ,np.s
                                                                                 ,0.1/
print("Noisy Mean: {:0.4} Standard Dev: {:0.4}  Expected Std. Dev {:.04}".format(np.mea
                                                                                ,np.st
                                                                                ,0.1/n
plt.hist(perfect_mean_arr,bins=20,edgecolor='black',alpha=0.5)
plt.hist(noisy_mean_arr,bins=20,edgecolor='black',alpha=0.5)
plt.xlabel('Mean Value')
plt.show()
```

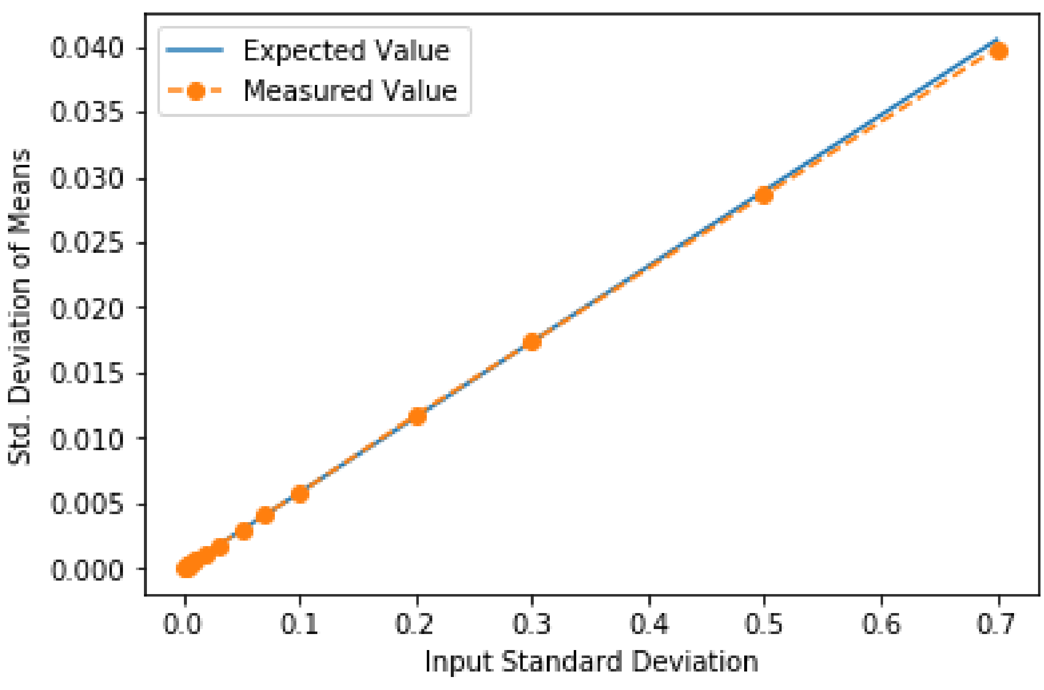
```
Perfect Mean: 0.9999 Standard Dev: 0.005857 Expected Std. Dev 0.005783
Noisy Mean: 0.9972 Standard Dev: 0.00582  Expected Std. Dev 0.005783
```




```
In [12]: all_sigma_means_list = list()
         all_sigma_stdev_list = list()
         test_std = [0.001,0.002,0.003,0.005,0.007,0.01,0.02,0.03,0.05,0.07,0.1,0.2,0.3,0.5,0.7]
         for i in range(len(test_std)):
             noisy_data = np.random.randn(300)*test_std[i] + perfect_data
             (perfect_mean_arr,noisy_mean_arr) = fit_data(perfect_data,noisy_data,num_trials,tes
             all_sigma_means_list.append(np.mean(noisy_mean_arr))
             all_sigma_stdev_list.append(np.std(noisy_mean_arr))
         all_sigma_means_arr = np.array(all_sigma_means_list)
         all_sigma_stdev_arr = np.array(all_sigma_stdev_list)
```

```
In [13]: plt.plot(test_std,all_sigma_means_arr,'o--')
         plt.ylabel("Mean of Means")
         plt.xlabel("Input Standard Deviation")
         plt.show()
         plt.plot(test_std,test_std/np.sqrt(299),label='Expected Value')
         plt.plot(test_std,all_sigma_stdev_arr,'o--',label='Measured Value')
         plt.ylabel("Std. Deviation of Means")
         plt.xlabel("Input Standard Deviation")
         #plt.loglog()
         plt.legend()
         plt.show()
```





In [14]:
```
plt.errorbar(test_std,all_sigma_means_arr,yerr=all_sigma_stdev_arr,marker='o',linestyle
plt.ylabel("Mean of Means")
```

```
plt.xlabel("Input Standard Deviation")
plt.axhline(1.0,linestyle='--',color='black')
plt.show()
```