

Analysis of correlation between frequency and distance of transitions to improvement in performance

July 6, 2019

1 Introduction

Now we will be taking the distance of a transition into account in addition to the frequency. Our claim is that frequently practised movements will show a more significant improvement in performance regardless of the distance while the performance improvement of less frequently practised transitions will depend on the distance.

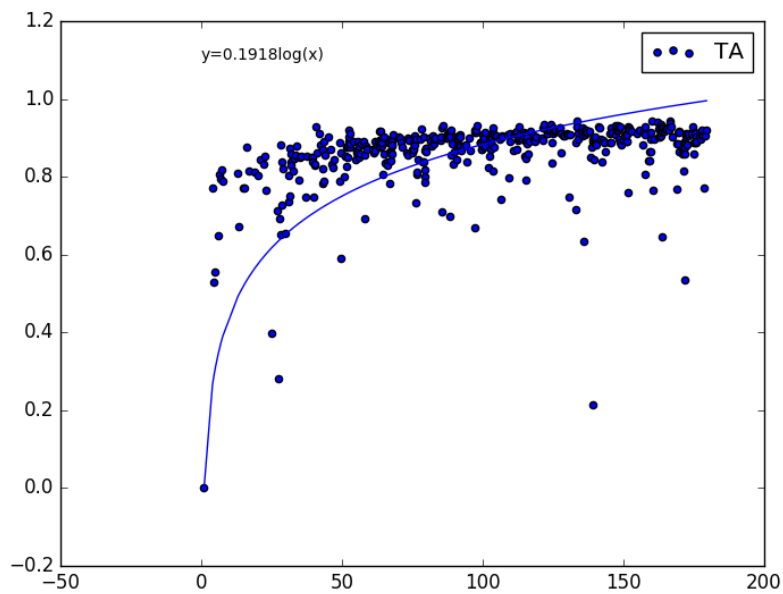
2 All Transitions

Out of 81 possible transitions, 69 exist in the dictionary set of words. The movement times of each transition was plotted for each subject without taking any average as well as by averaging across days and across blocks. So for each person there are 3 categories which are, all movement times, averaging across days and averaging across blocks. In each category there are 69 plots. Now each plot was fitted with an logarithmic function of the form

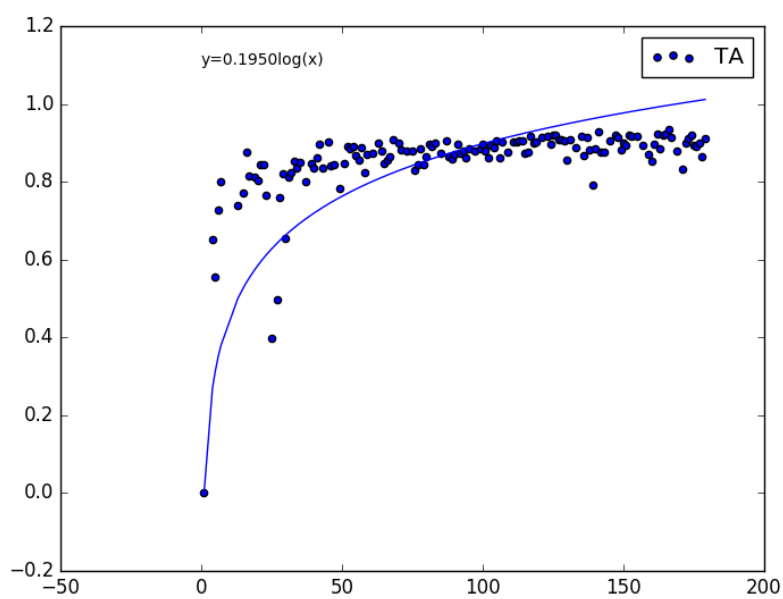
$$y = a * \log(x)$$

Below we see the transition T-A for Person 1 for all movement times, across blocks and across days.

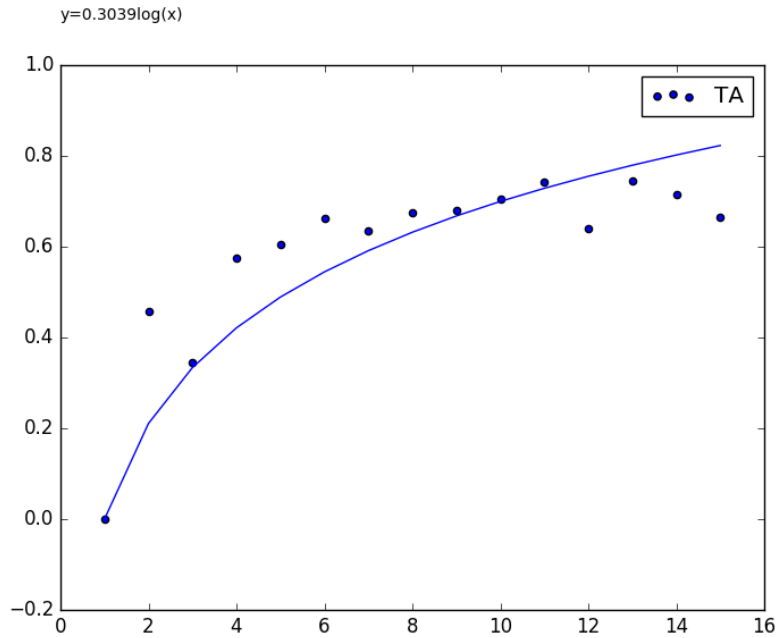
i)All Movement Times



ii) Across Blocks

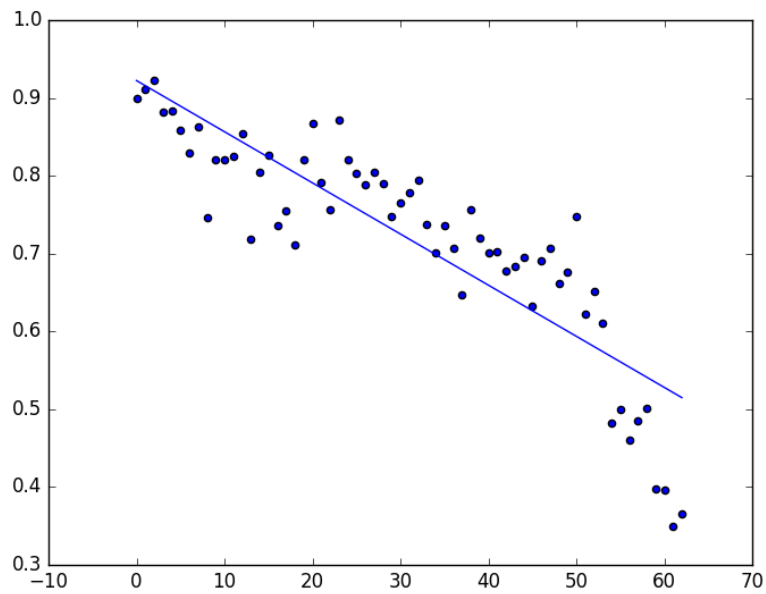


iii) Across Days

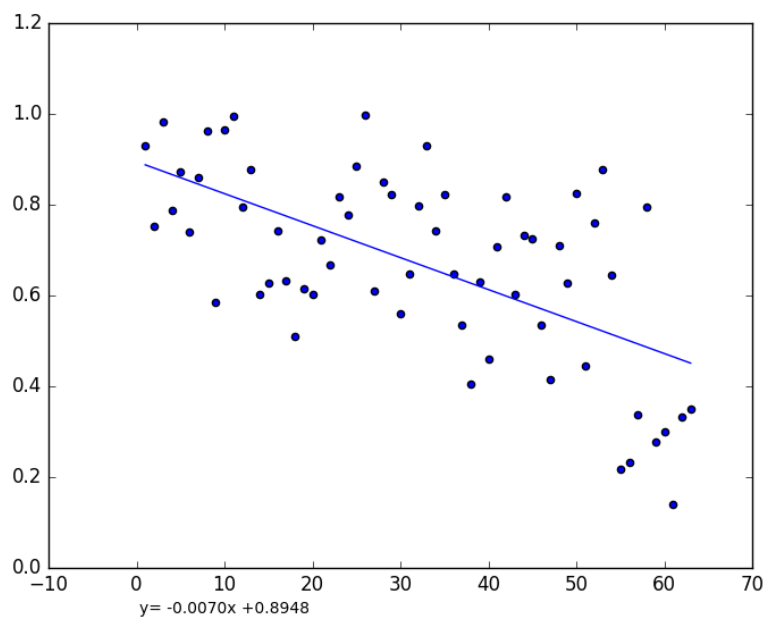


The performance improvement with practise was calculated by substituting the first and last instance of practise in the curve equation and then finding the percentage increase between these 2 values. This was found for each transition and then plotted. This was done for each subject in the 3 categories and then the average was taken across subjects. Each plot was then linearly fit inorder to observe the trend in the data points. In these plots the x-axis is the rank of the transition i.e the most frequent transition will have rank 1 and so on.

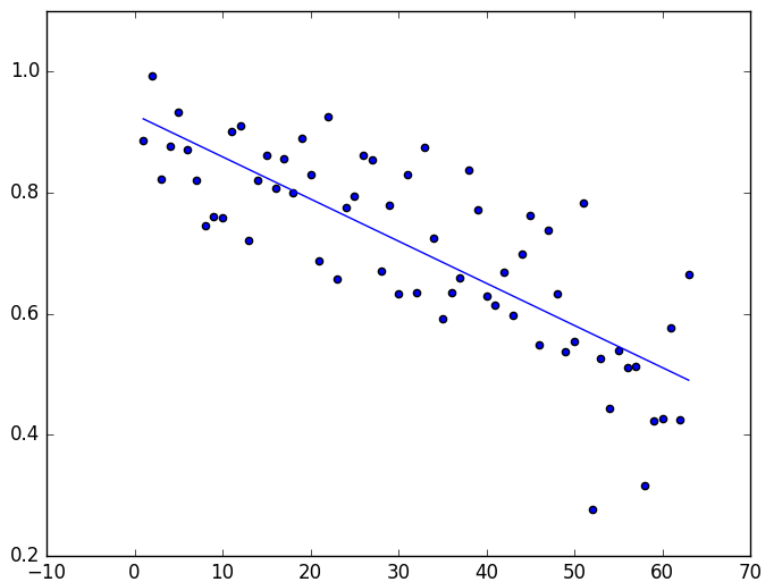
I)All Movement Times
i)Average across subjects



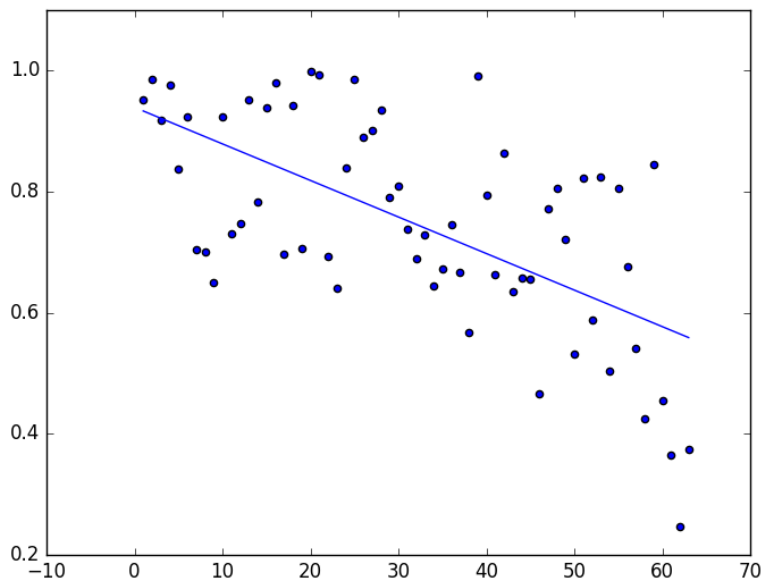
ii)Subject 1



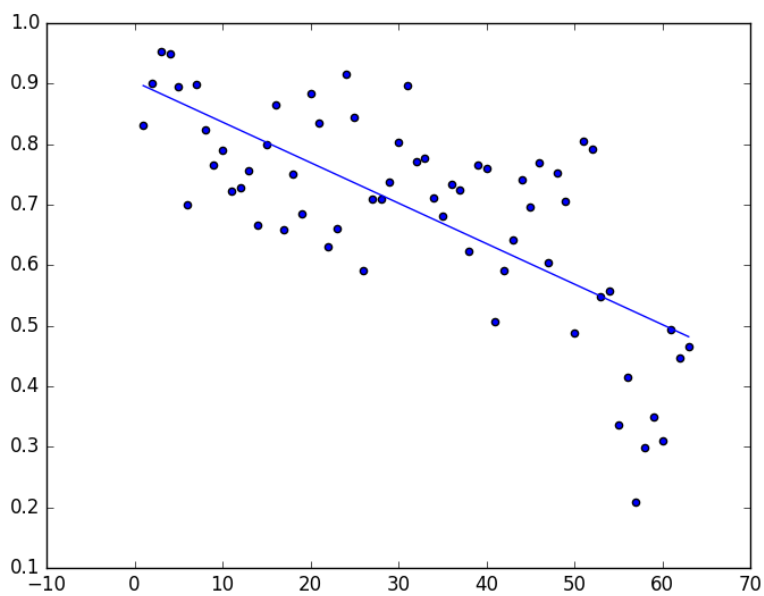
iii)Subject 2



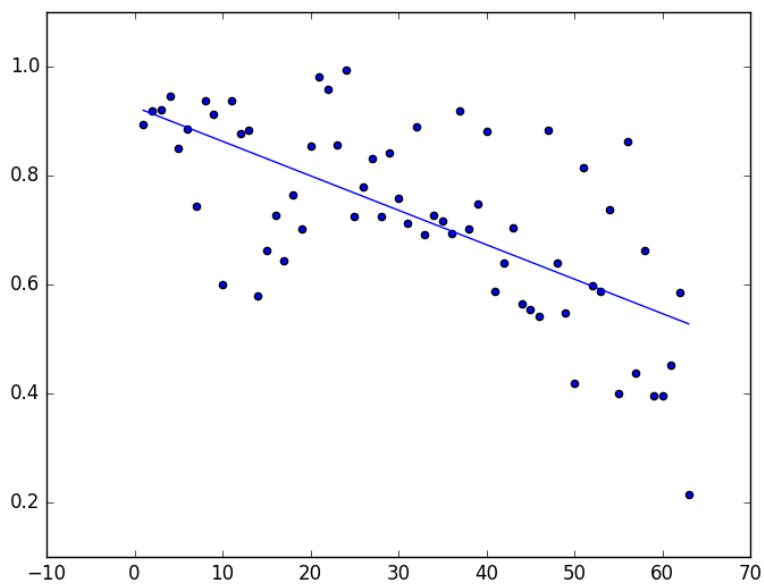
iv)Subject 3



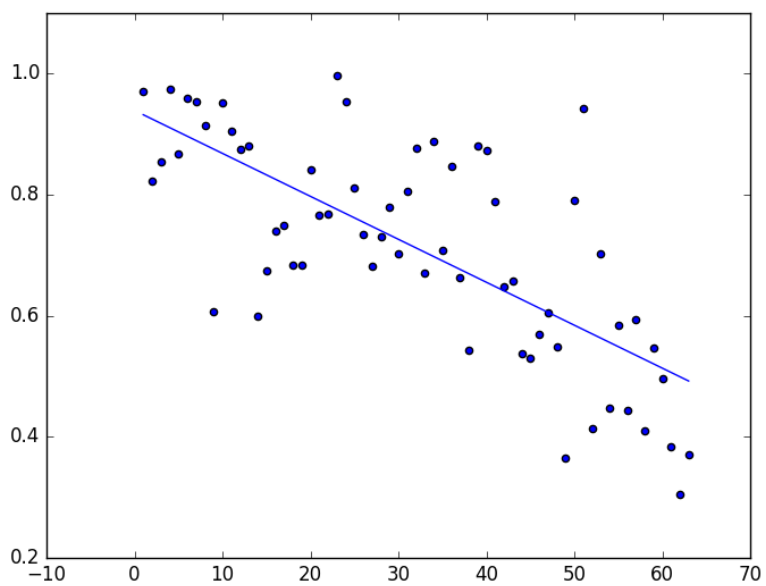
v)Subject 4



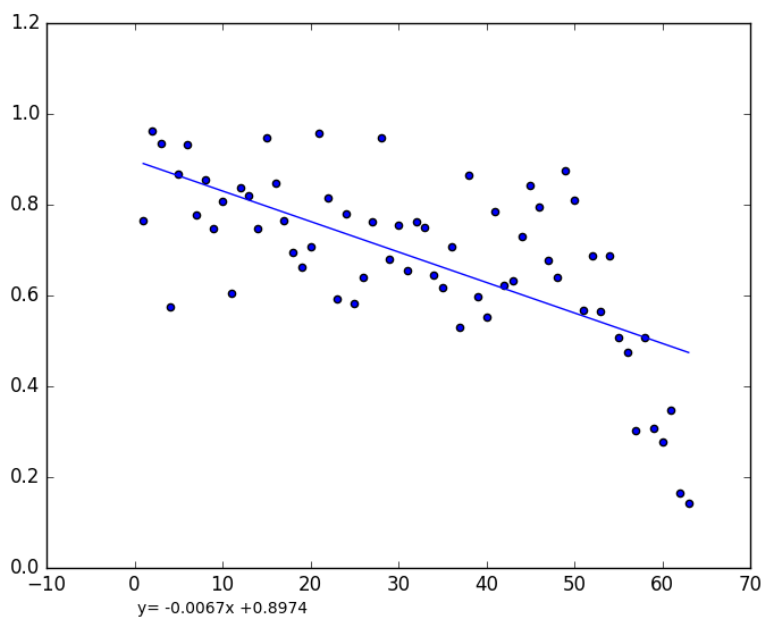
vi)Subject 5



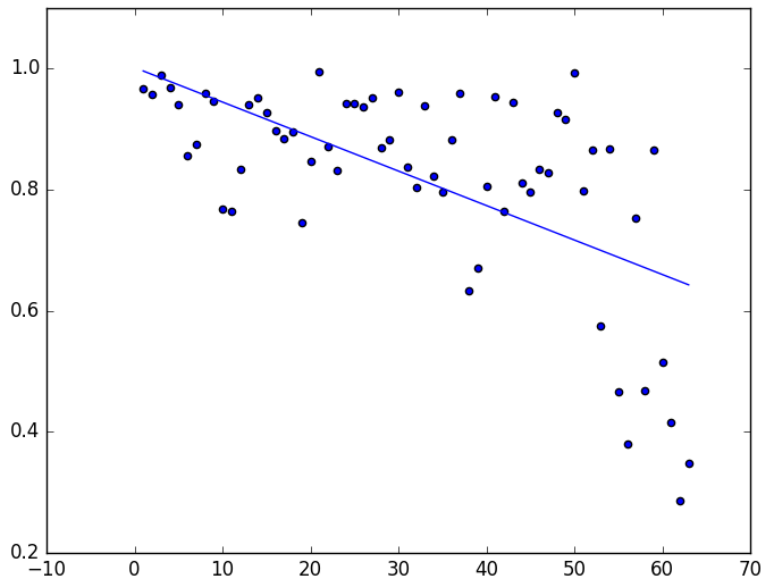
vii)Subject 6



viii)Subject 7



ix)Subject 8

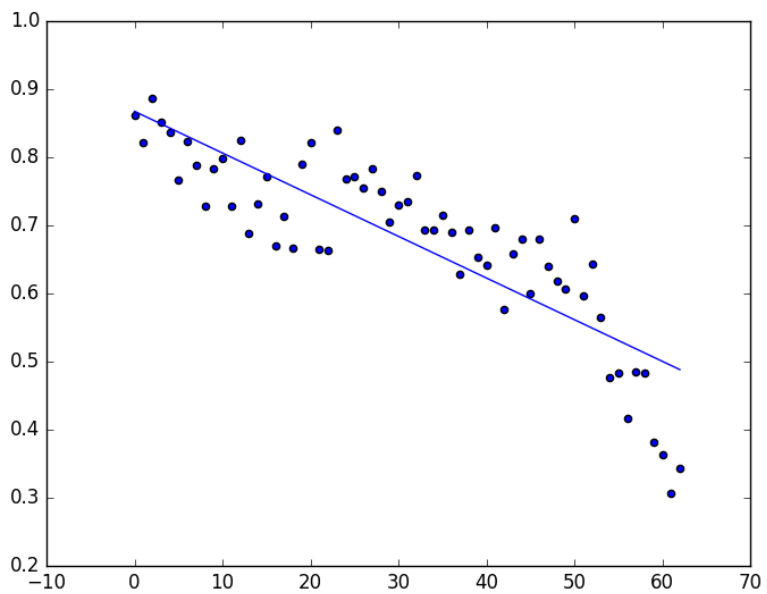


From these plots we can find the improvement of the most frequent transition compared to the least frequent transition. This is done by finding the difference between the 2 extremes of the fitted line and multiplying by 100.

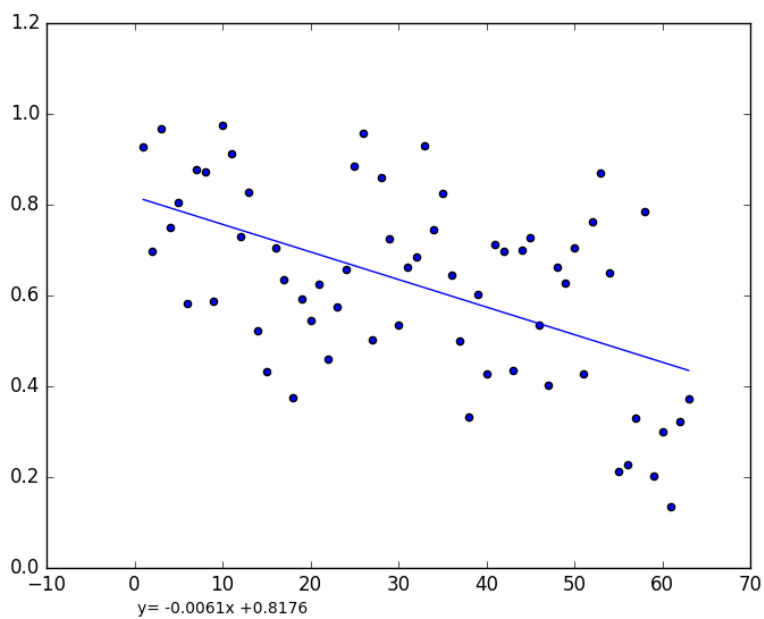
All Movement Times	
Plot	Difference between Most Frequent and Least Frequent Improvement
Average Plot	44.16
Subject 1	49.19
Subject 2	46.82
Subject 3	40.1
Subject 4	46.25
Subject 5	42.62
Subject 6	47.19
Subject 7	46.73
Subject 8	35.46

II)Across Blocks

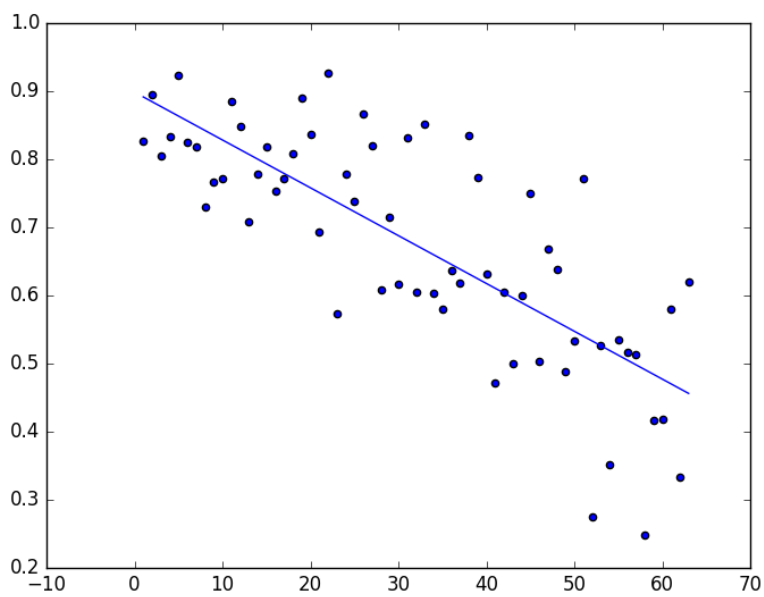
i)Average across subjects



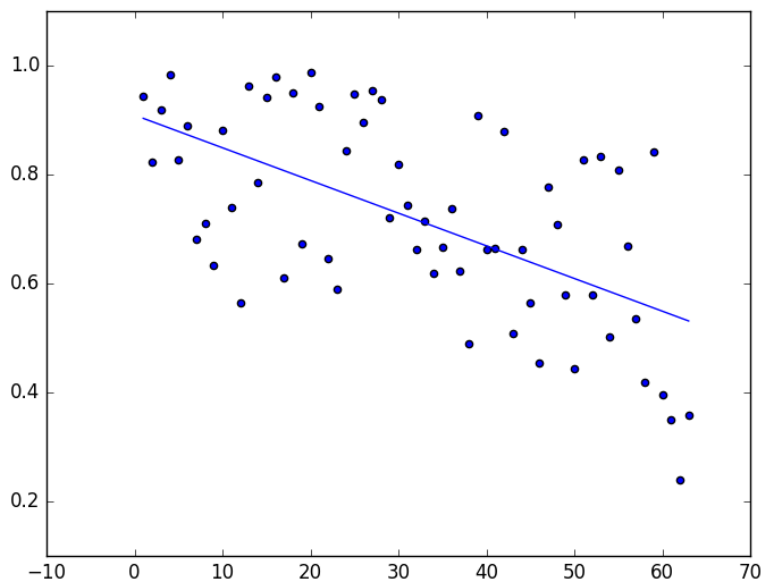
ii)Subject 1



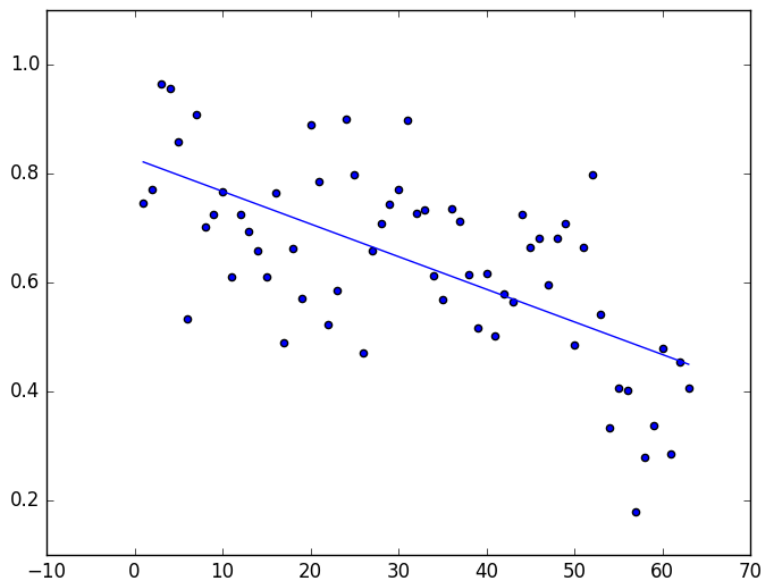
iii)Subject 2



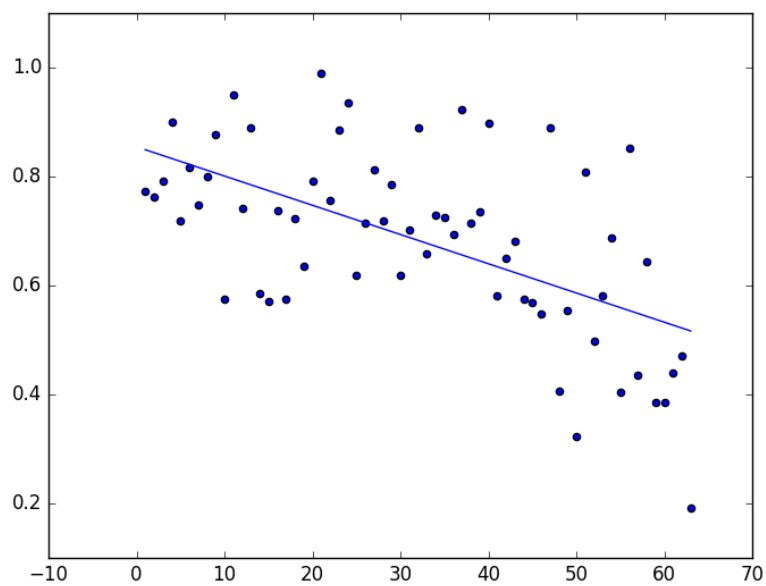
iv)Subject 3



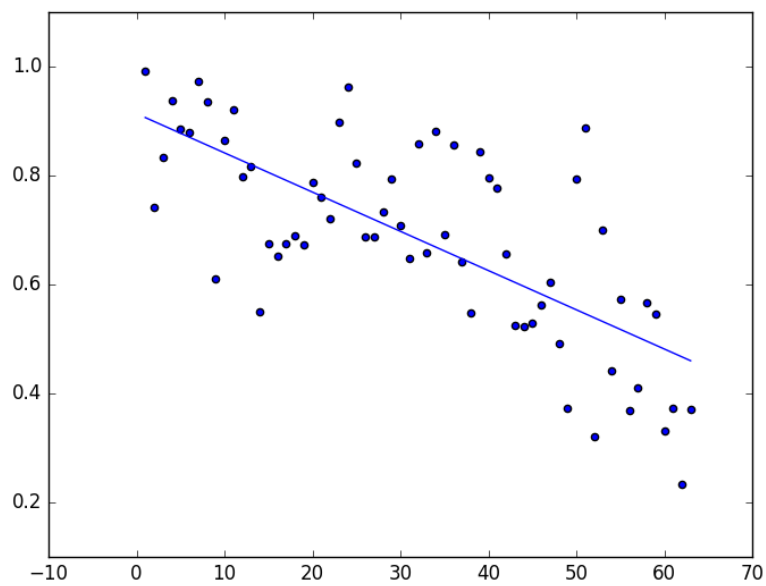
v)Subject 4



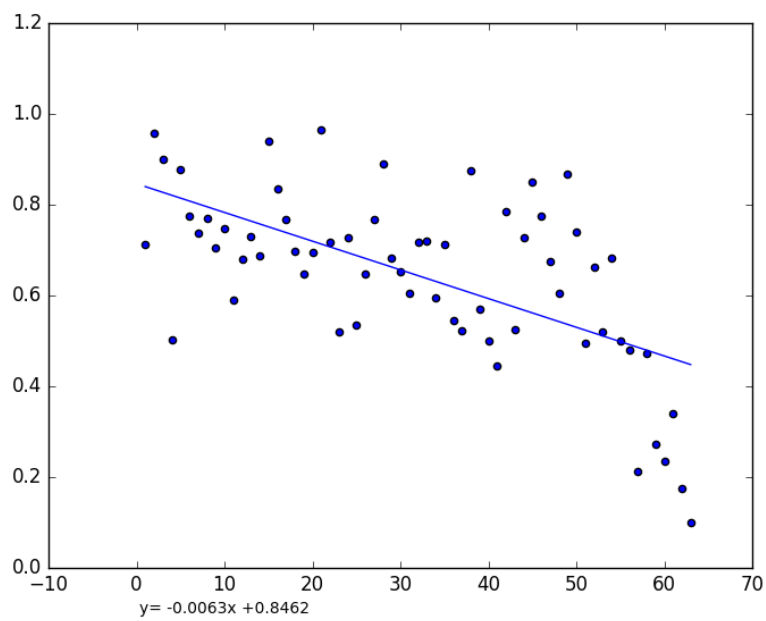
vi)Subject 5



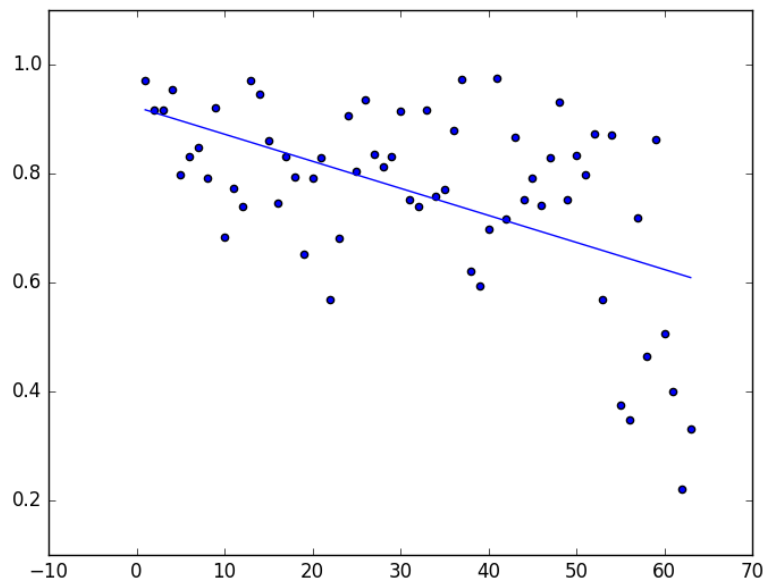
vii)Subject 6



viii)Subject 7



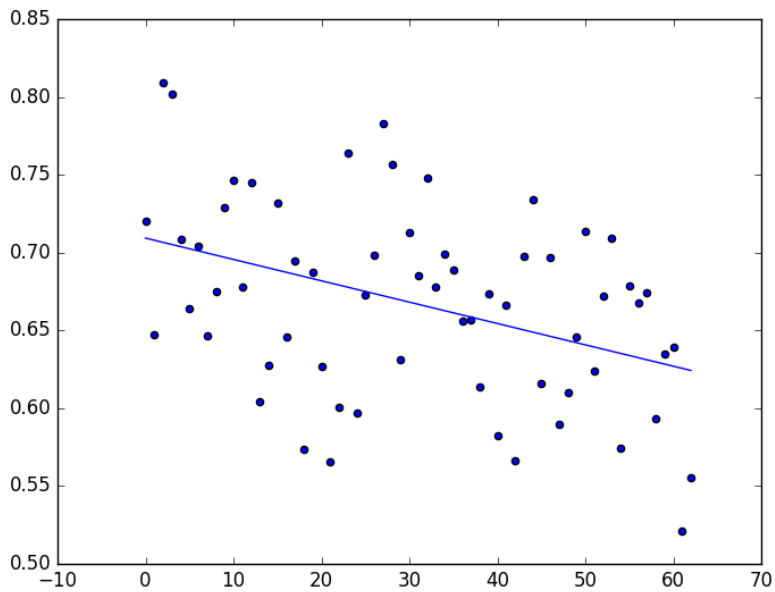
ix)Subject 8



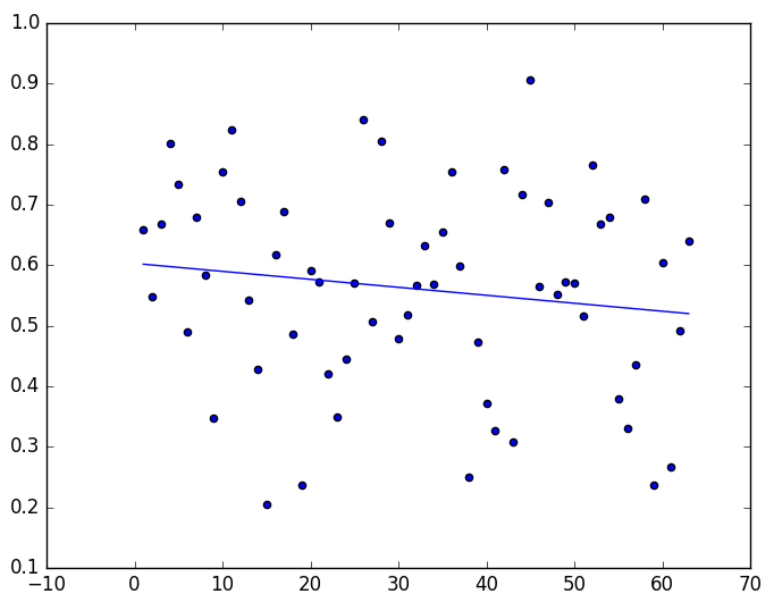
Across Blocks	
Plot	Difference between Most Frequent and Least Frequent Improvement
Average Plot	43.72
Subject 1	46.4
Subject 2	48.83
Subject 3	41.17
Subject 4	45.21
Subject 5	39.17
Subject 6	49.24
Subject 7	46.67
Subject 8	33.58

III) Across Days

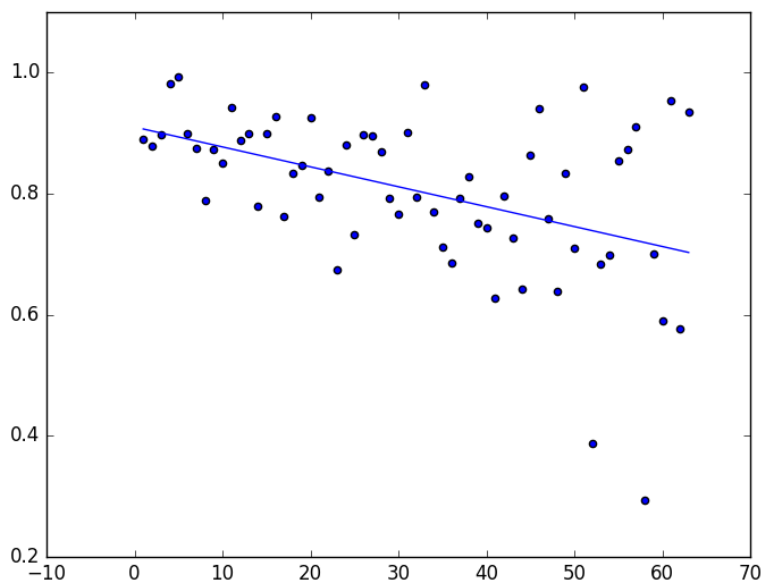
i) Average across subjects



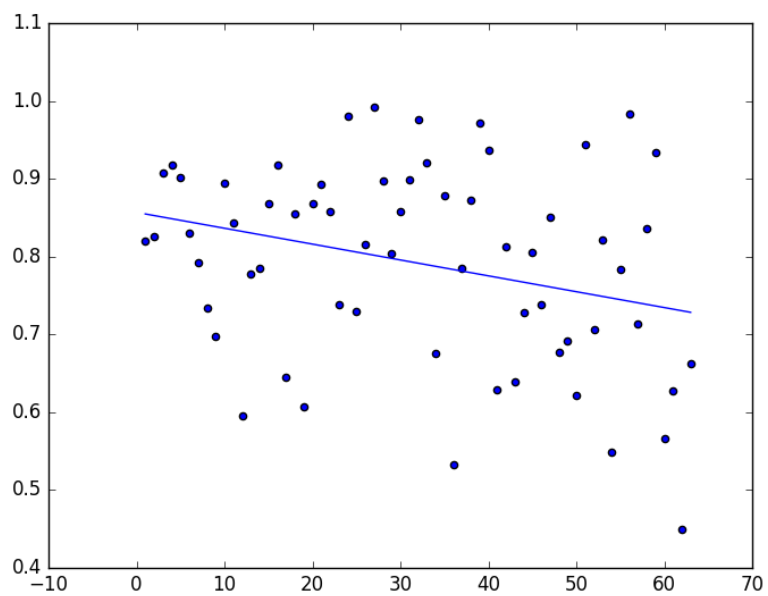
ii)Subject 1



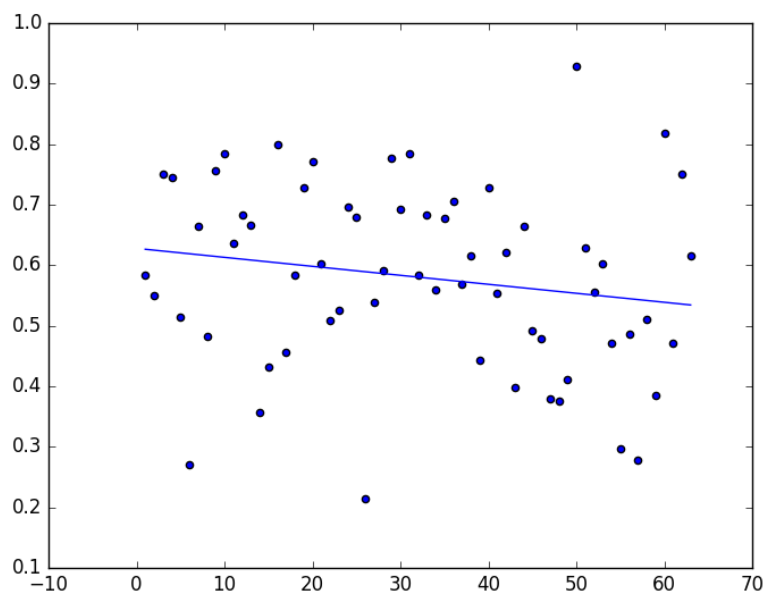
iii)Subject 2



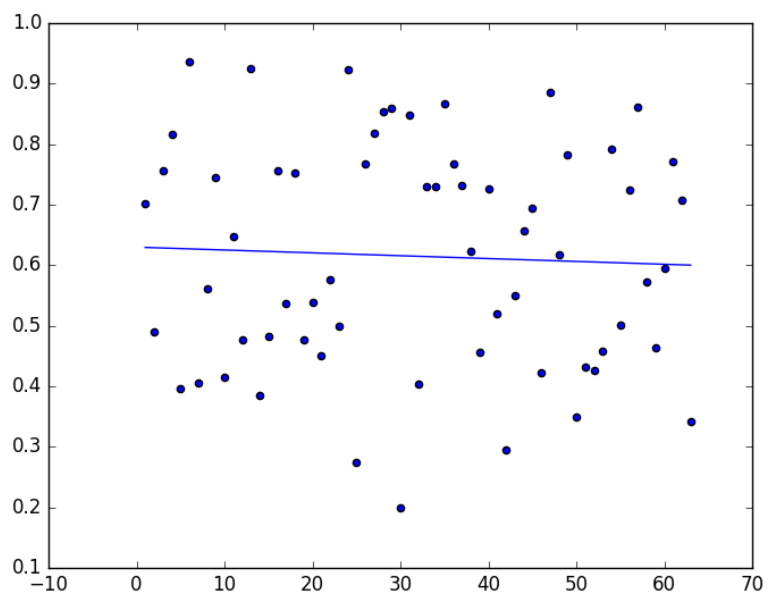
iv)Subject 3



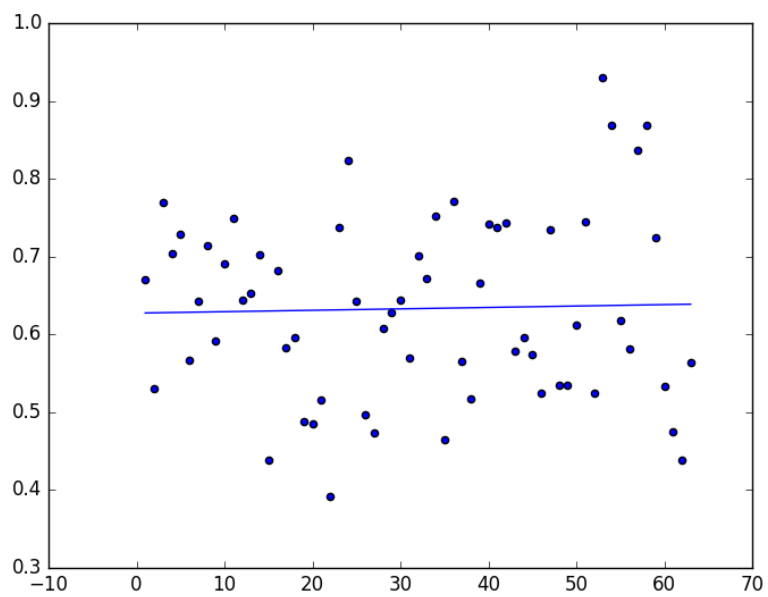
v)Subject 4



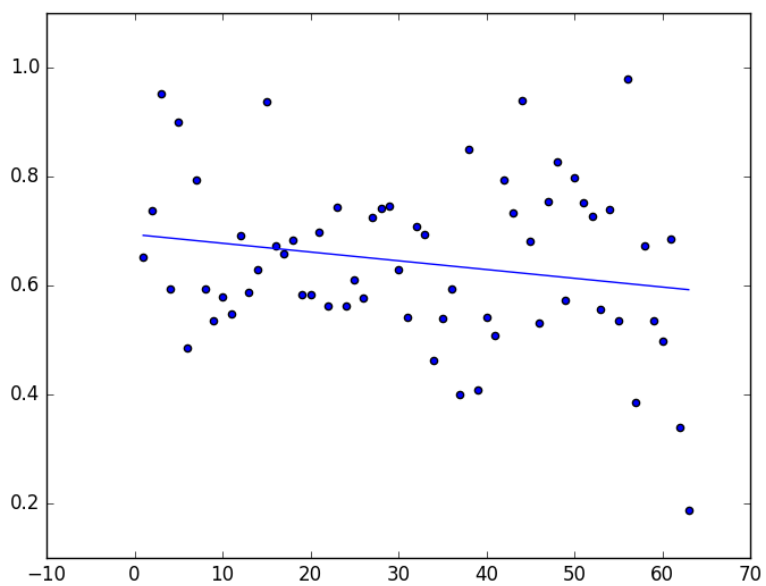
vi)Subject 5



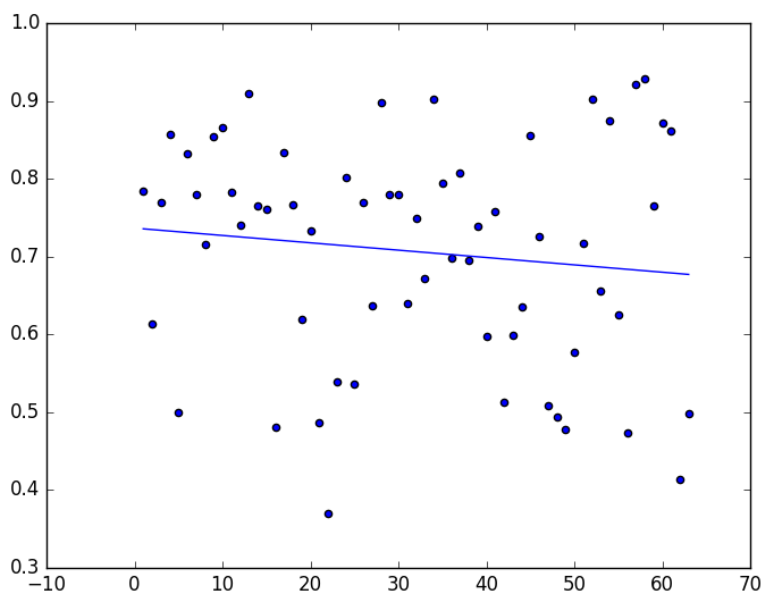
vii)Subject 6



viii)Subject 7



ix)Subject 8



Across Days	
Plot	Difference between Most Frequent and Least Frequent Improvement
Average Plot	11.98
Subject 1	13.56
Subject 2	22.49
Subject 3	14.78
Subject 4	14.69
Subject 5	46.44
Subject 6	-1.79
Subject 7	14.4
Subject 8	7.96

Inference: From these plots we can see that as the rank increases there is a reduction in the drop time. This is a clear indication that frequently practised transitions show more improvement in movement time as compared to less frequently practised transitions. On average the percentage drop between the most frequent and least frequent transition is 44.16% for all movement times and 43.72% when averaging across blocks. We can see that when averaging across days, there is not a lot of difference between more frequently and less frequently practised transitions. This can be attributed to the loss of information when we take the average of one entire day. This percentage shows a significant difference between improvement in movement time for most frequently practised transitions and least frequently practised transitions.

3 Distance and Movement Time

Distance Metric: To find the distance between transitions, each letter was assigned an (x,y) coordinate.

(insert keymap image)

From the above image, the coordinates are:

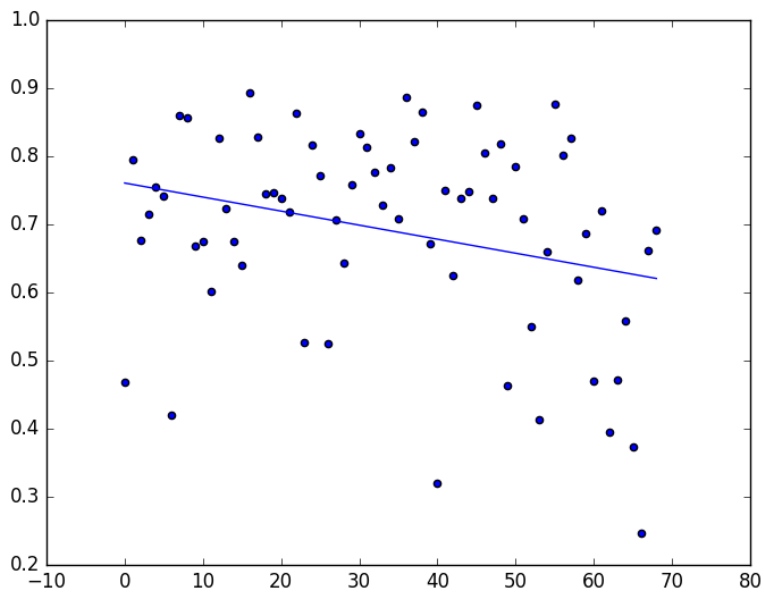
'E':(1,1), 'N':(2,1), 'T':(3,1), 'R':(4,1),

'S':(1,2), 'H':(4,2)

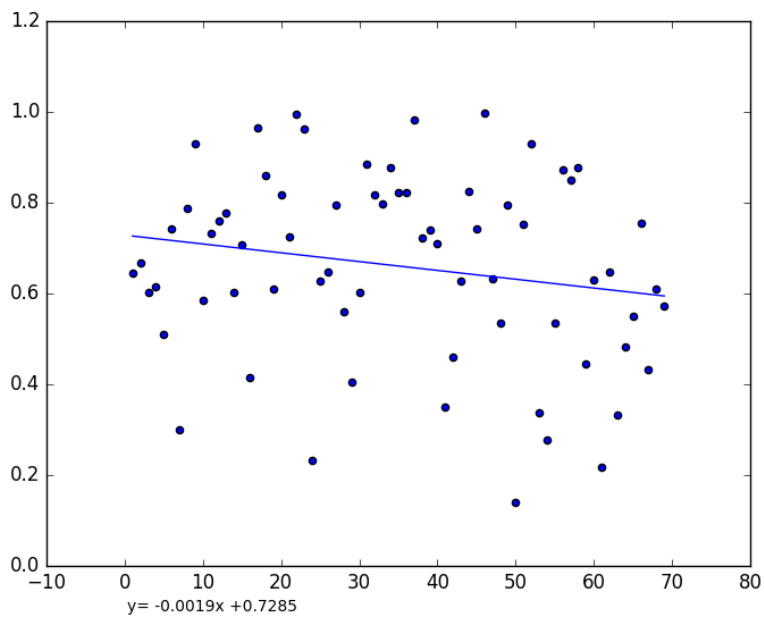
'O':(2,3), 'I':(3,3), 'A':(4,3)

Now the plots between distance and performance improvement were found to see if there was any correlation between distance and movement time alone.

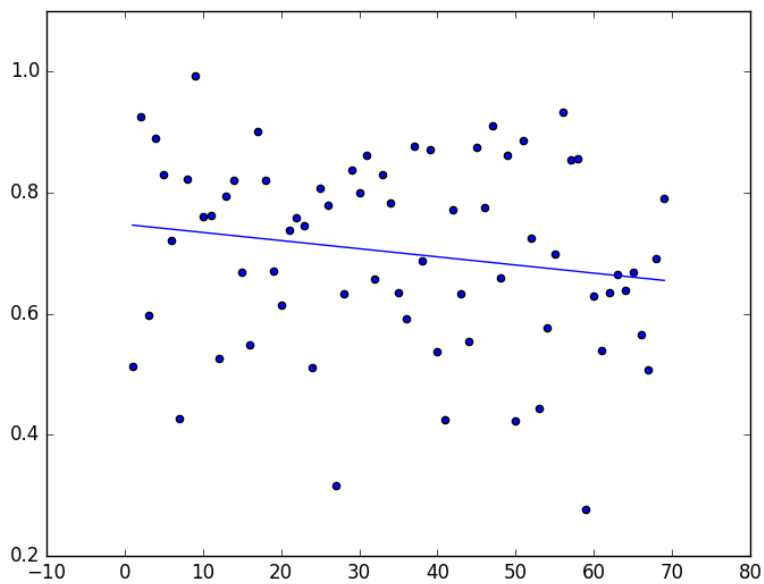
I)All Movement Times
i)Average across subjects



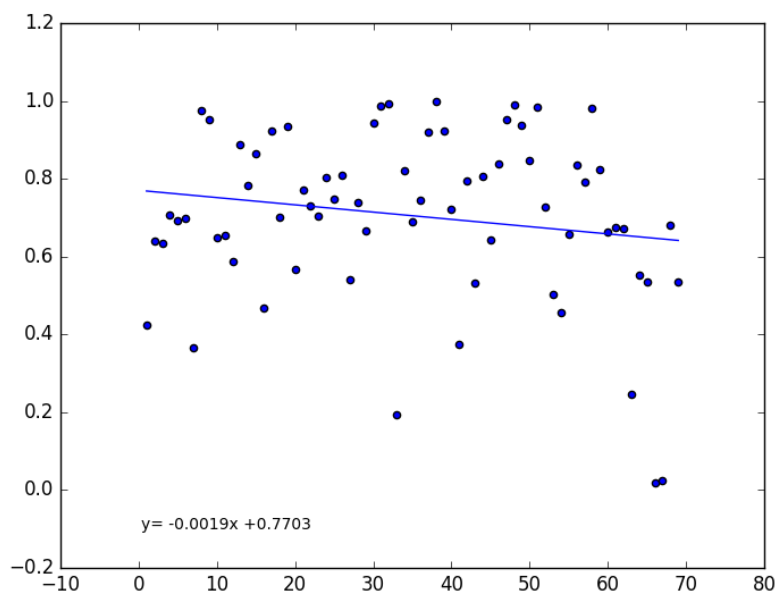
ii)Subject 1



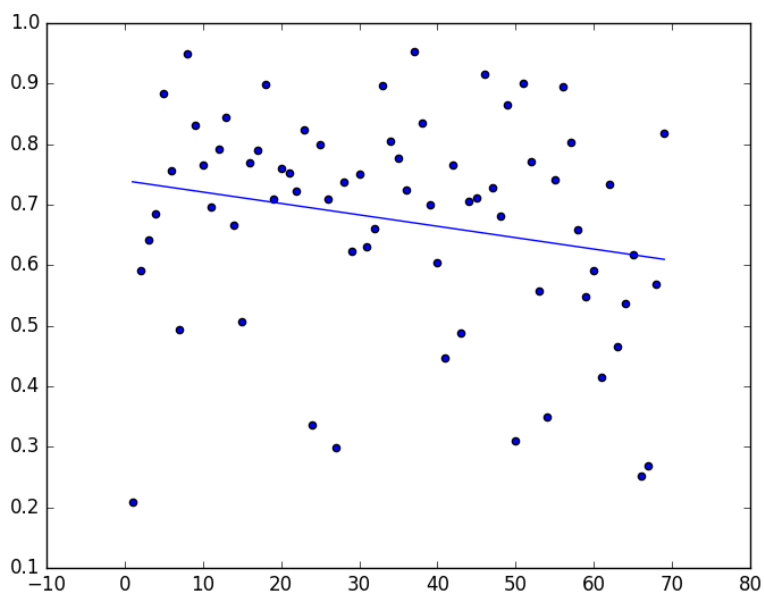
iii)Subject 2



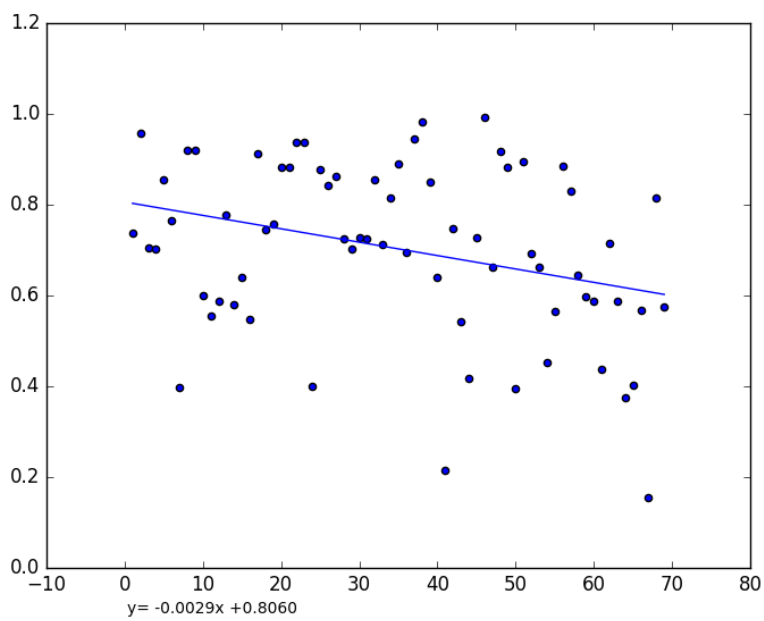
iv)Subject 3



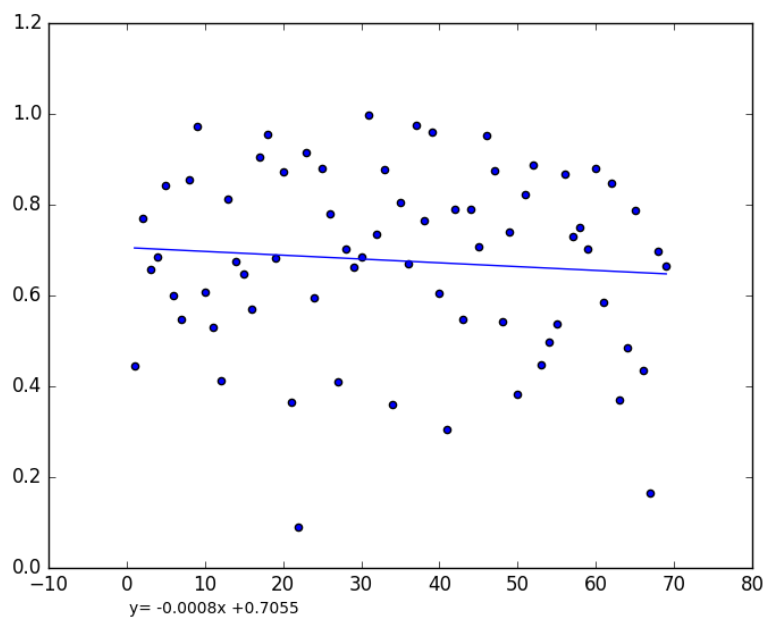
v)Subject 4



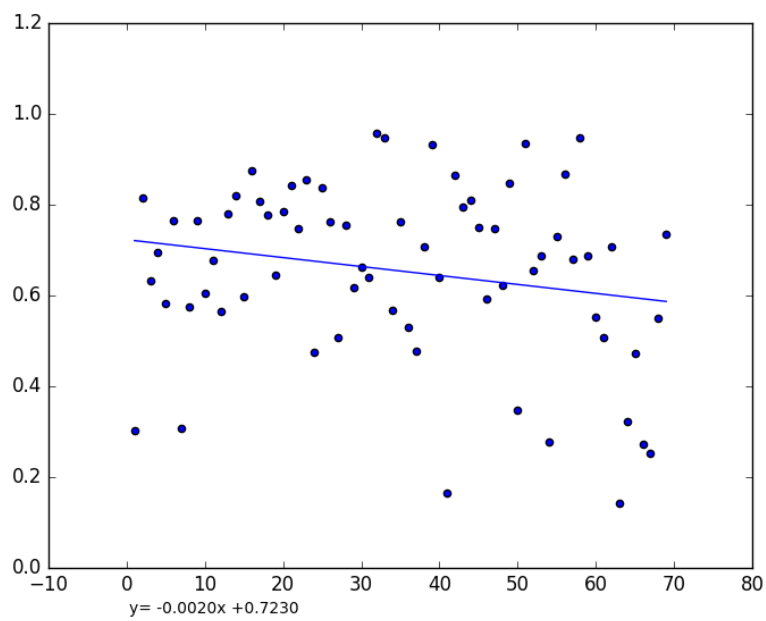
vi)Subject 5



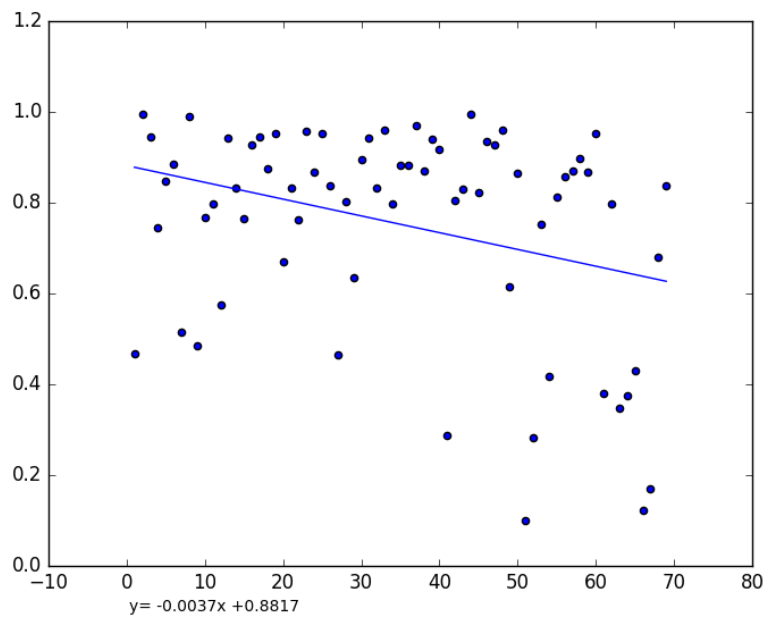
vii)Subject 6



viii)Subject 7

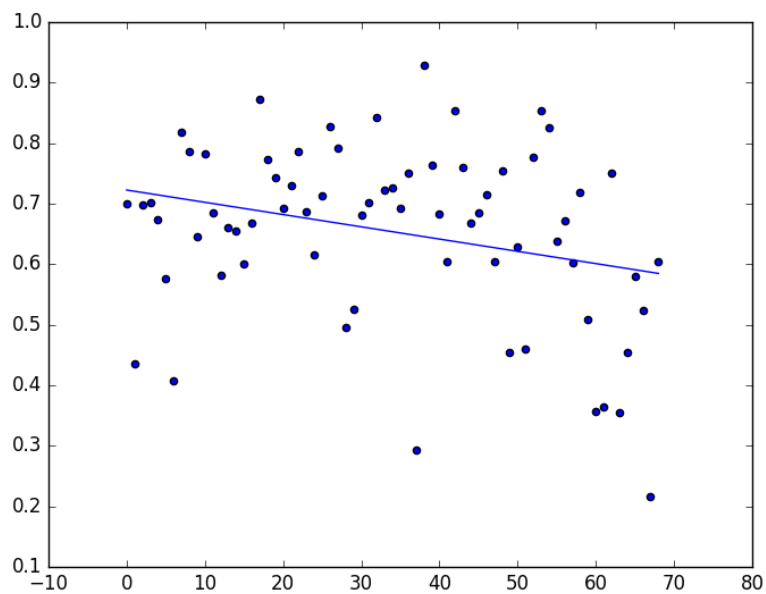


ix)Subject 8

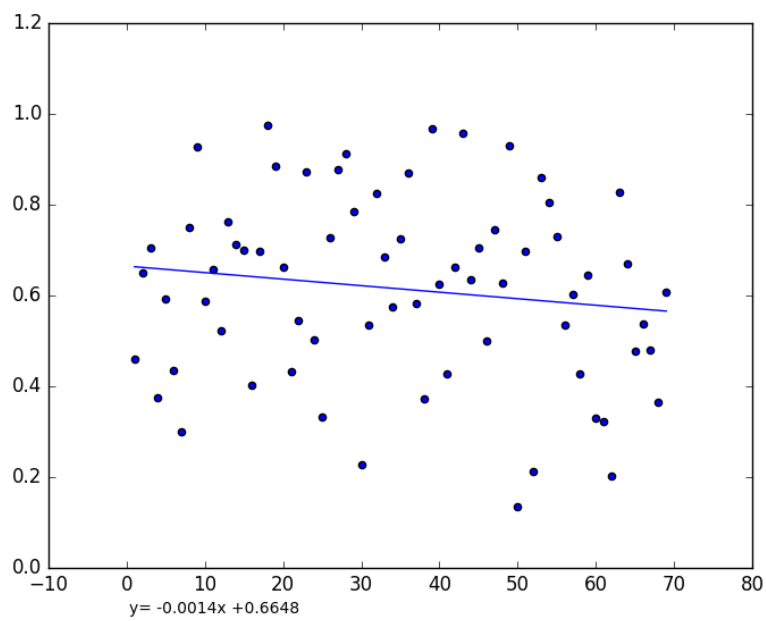


I)Across Blocks

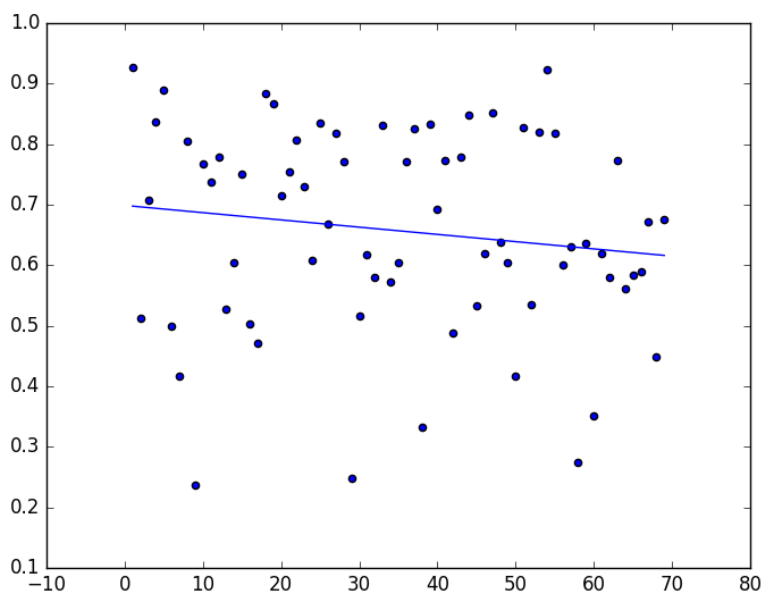
i)Average across subjects



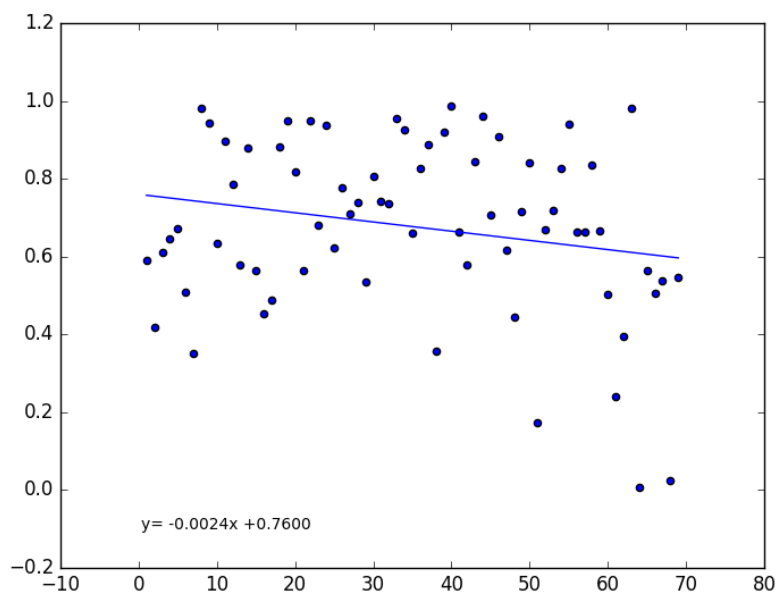
ii)Subject 1



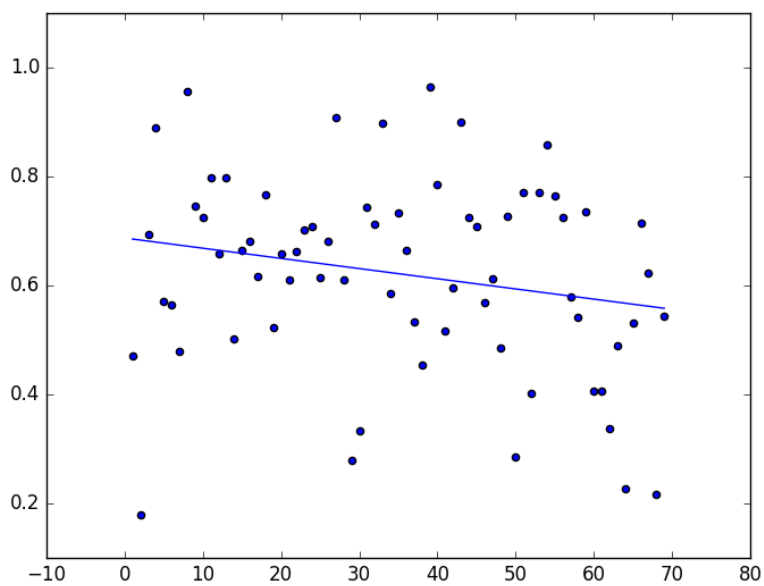
iii)Subject 2



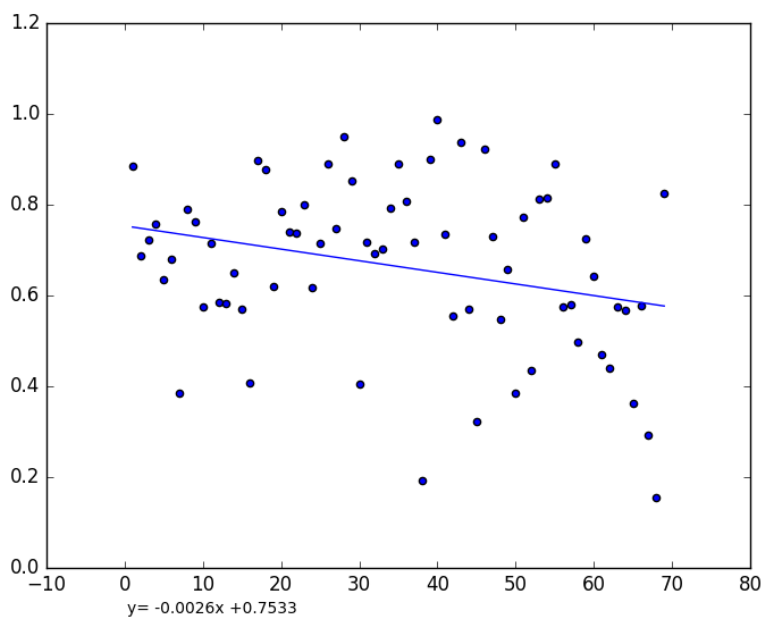
iv)Subject 3



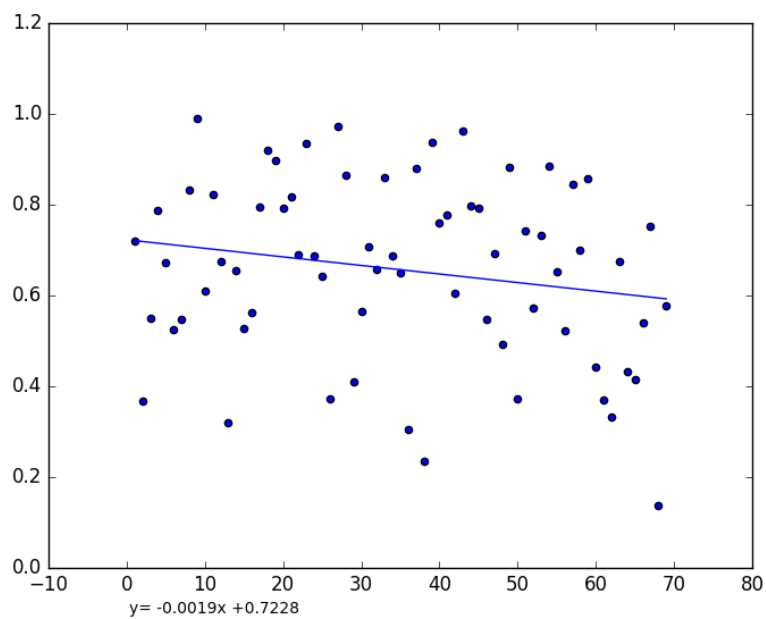
v)Subject 4



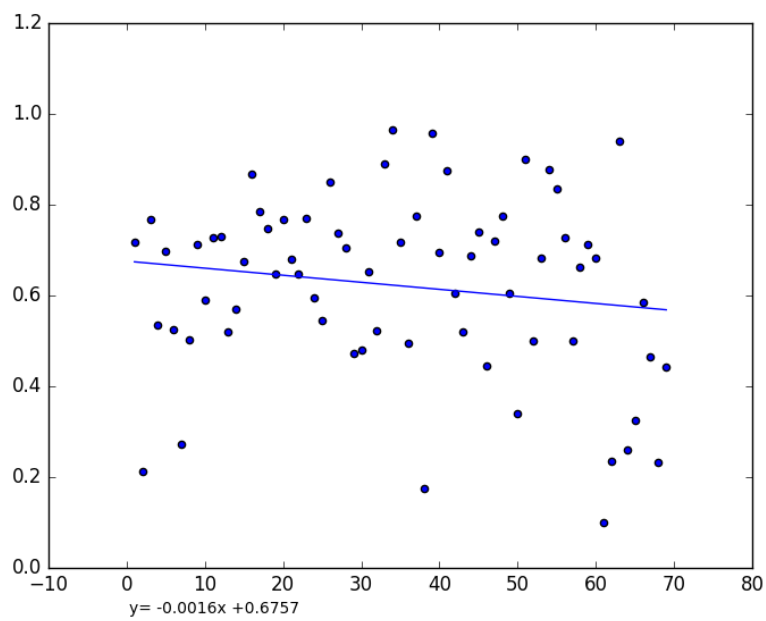
vi)Subject 5



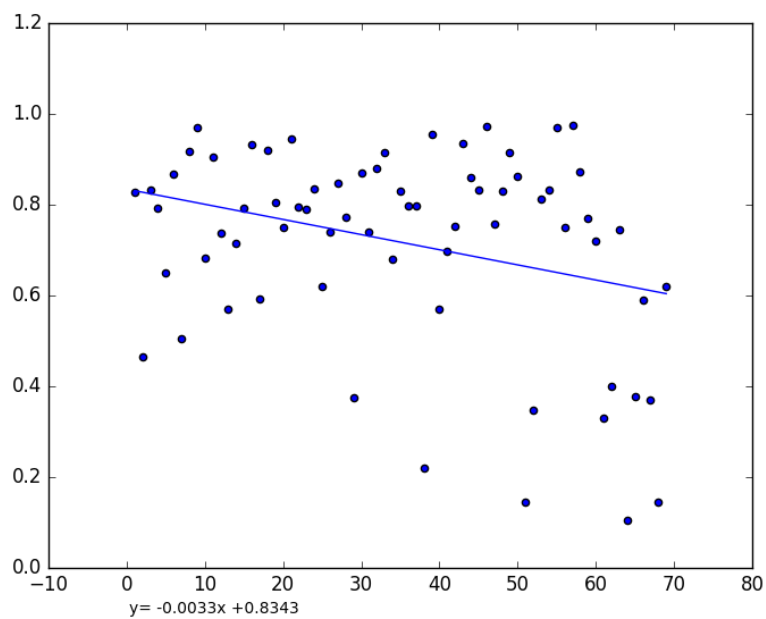
vii)Subject 6



viii)Subject 7

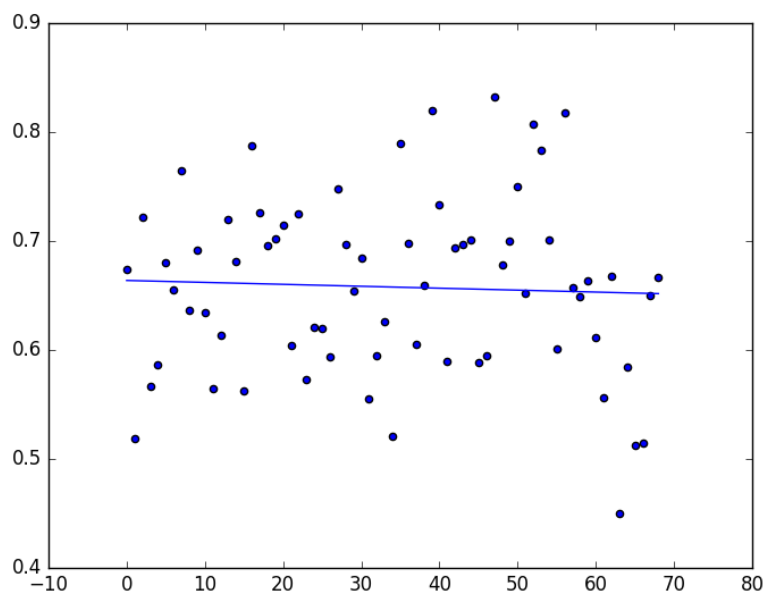


ix)Subject 8

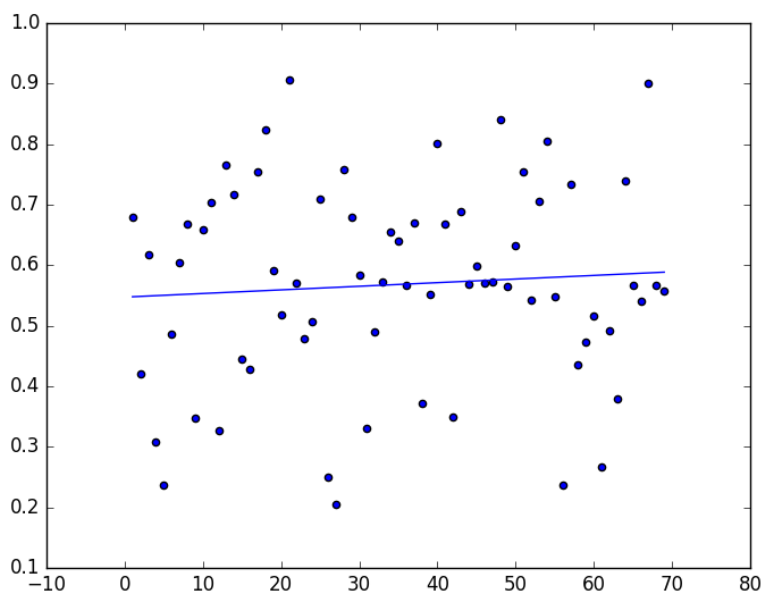


I)Across Days

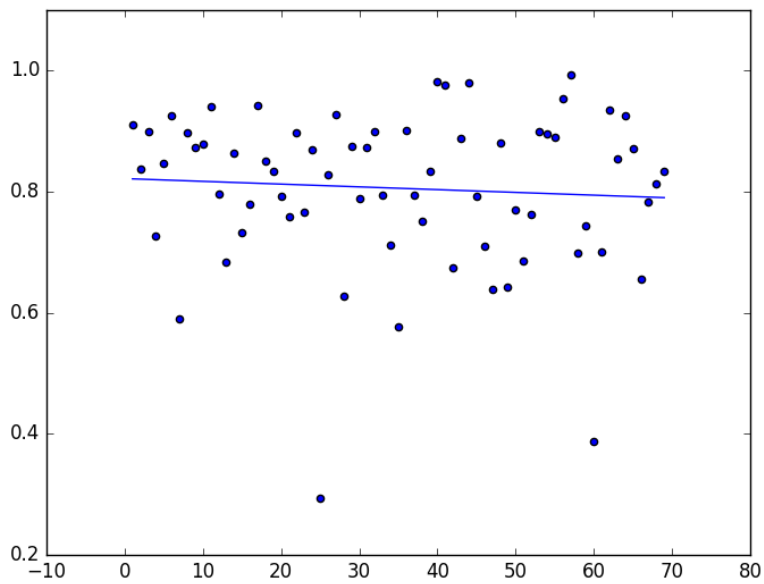
i)Average across subjects



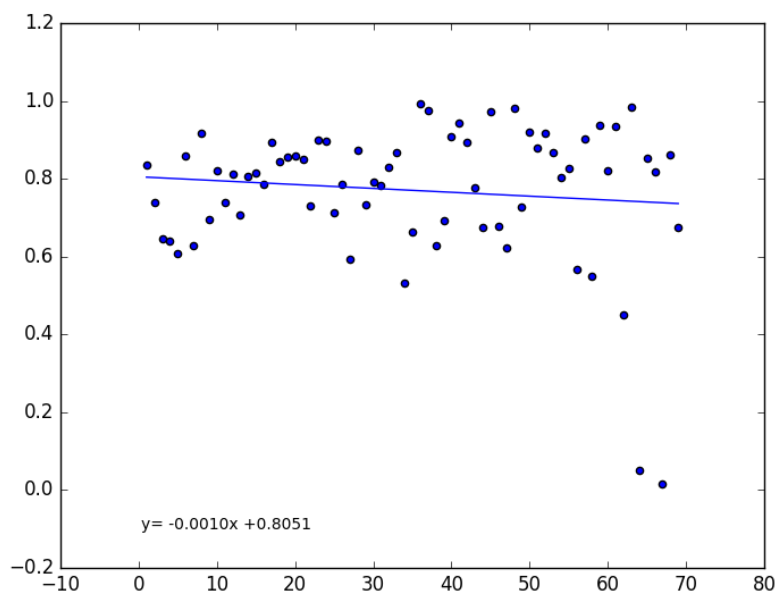
ii)Subject 1



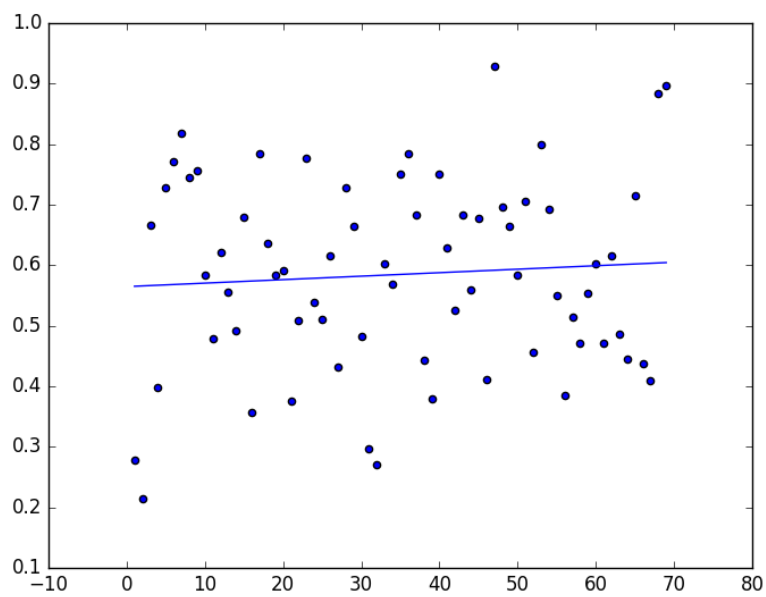
iii)Subject 2



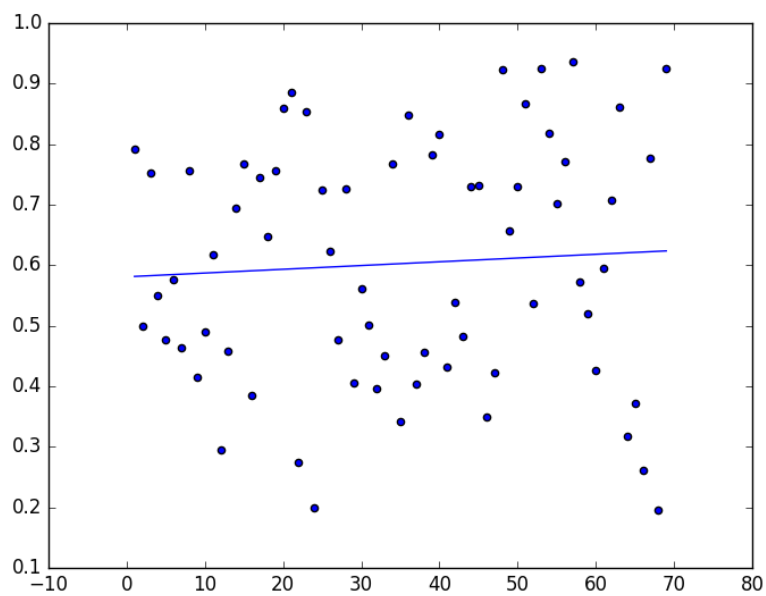
iv)Subject 3



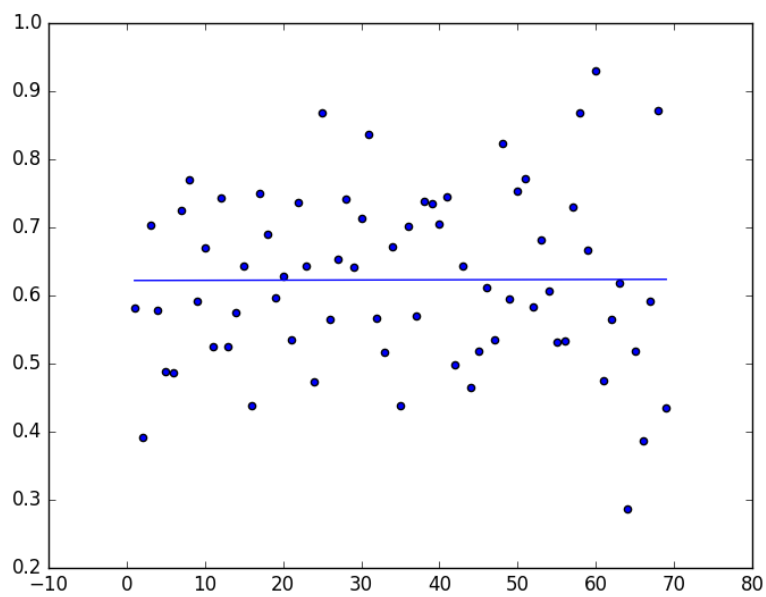
v)Subject 4



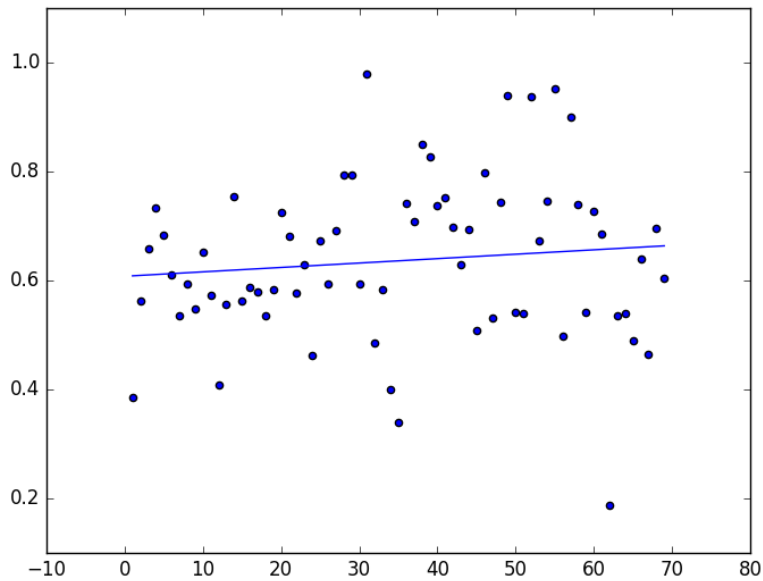
vi)Subject 5



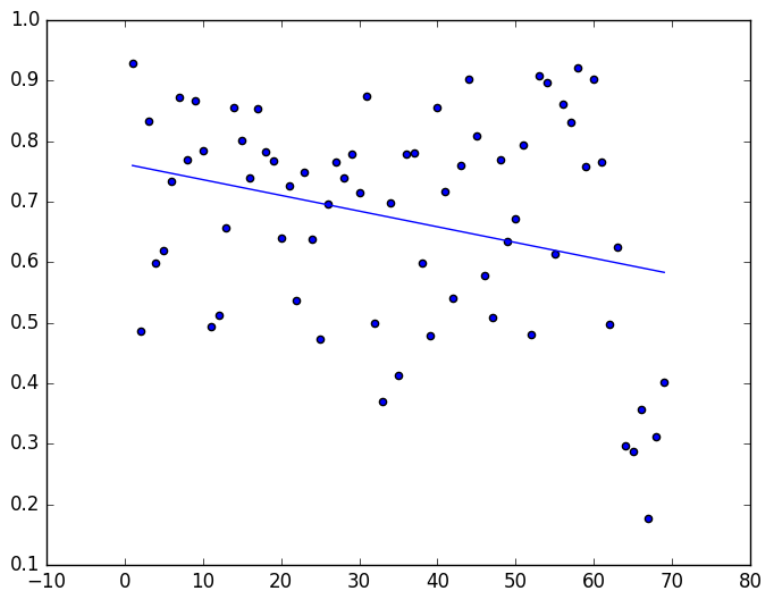
vii)Subject 6



viii)Subject 7



ix)Subject 8



Observations: From these plots we can see that there is no particular relation between distance and performance improvement alone. This suggests that we need to consider frequency in addition to distance.

4 Frequency and Distance

The distances were rounded off to the nearest integer and the performance was averaged across each distance for both highly frequent transitions and least frequent transitions. Transitions of zero distance were not considered. Highly frequent transitions were taken as all the transitions above the 90th percentile of the highest frequency of a subject. Least frequent transitions were taken as all the transitions below the 10th percentile of the highest frequency of a subject.

Highly Frequent Transitions:

Subject 1		
Distance	Improvement Mean	Improvement Standard Deviation
3	0.859255942	0.0715807512
2	0.9726968856	0.0109461663
1	0.5144847461	0.2375827369

Subject 2		
Distance	Improvement Mean	Improvement Standard Deviation
3	0.9084980455	0.0854522708
2	0.811183831	0.0647829376
1	0.7319433251	0.1548824842

Subject 3		
Distance	Improvement Mean	Improvement Standard Deviation
3	0.9641247207	0.0121559091
2	0.8114781718	0.10724657
1	0.7200300358	0.2648847213

Subject 4		
Distance	Improvement Mean	Improvement Standard Deviation
3	0.832069206	0
2	0.8885567436	0.0642101187
1	0.6252295741	0.2755736778

Subject 5		
Distance	Improvement Mean	Improvement Standard Deviation
3	0.9199734028	0.0008151213
2	0.941072866	0.004367887
1	0.6730712286	0.2211542368

Subject 6		
Distance	Improvement Mean	Improvement Standard Deviation
3	0.9129123643	0.0584104382
2	0.9439450304	0.0299312063
1	0.6596581995	0.1625256486

Subject 7		
Distance	Improvement Mean	Improvement Standard Deviation
3	0.7645647182	0
2	0.9090973822	0.0535248145
1	0.6061200867	0.329081193

Subject 8		
Distance	Improvement Mean	Improvement Standard Deviation
3	0.9785275557	0.0109850519
2	0.9639477433	0.0055102354
1	0.6871324941	0.270787554

Average across all subjects		
Distance	Improvement Mean	Improvement Standard Deviation
3	0.8924907444	0.0299249428
2	0.9052473317	0.042564992
1	0.6522087112	0.2395590316

Least Frequent Transitions:

Subject 1		
Distance	Improvement Mean	Improvement Standard Deviation
3	0.4716731672	0.172464349
2	0.5930533097	0.3132354212
1	0.3592053801	0.230074293

Subject 2		
Distance	Improvement Mean	Improvement Standard Deviation
3	0.4698638307	0.0426193466
2	0.5031844133	0.1630776567
1	0.5839256827	0.1458576068

Subject 3		
Distance	Improvement Mean	Improvement Standard Deviation
3	0.3950715104	0.0295896652
2	0.6123287582	0.168248859
1	0.5861504531	0.2070006758

Subject 4		
Distance	Improvement Mean	Improvement Standard Deviation
3	0.351509261	0.142600273
2	0.4506410661	0.1658469007
1	0.483277756	0.1637438226

Subject 5		
Distance	Improvement Mean	Improvement Standard Deviation
3	0.5670857078	0.1703047132
2	0.6031462592	0.304716638
1	0.5608333734	0.1519756035

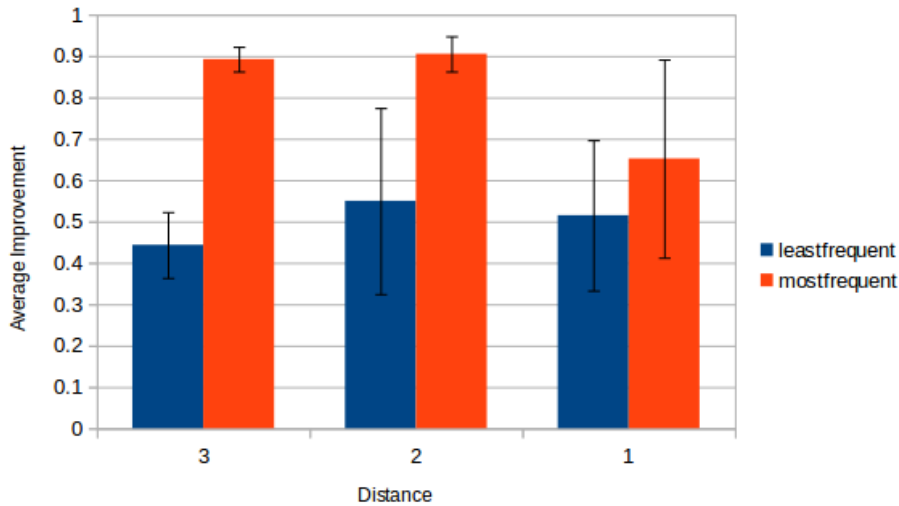
Subject 6		
Distance	Improvement Mean	Improvement Standard Deviation
3	0.4956577592	0.0518088187
2	0.5649028207	0.2457042297
1	0.5022251247	0.1248774498

Subject 7		
Distance	Improvement Mean	Improvement Standard Deviation
3	0.3047870171	0.0031079769
2	0.4735911169	0.20756104
1	0.4397013985	0.2026974479

Subject 8		
Distance	Improvement Mean	Improvement Standard Deviation
3	0.4915101144	0.024215521
2	0.5957305509	0.2312041673
1	0.605530613	0.2278617397

Average across all subjects		
Distance	Improvement Mean	Improvement Standard Deviation
3	0.443394796	0.079588833
2	0.5495722869	0.2249493641
1	0.5151062227	0.1817610799

If we look at the averages across subjects for most and least frequent as shown in the bar plot below, we can see that in the case of highly frequent transitions, for the distances 2 and 3 the improvement is almost the same i.e it is still high improvement irrespective of the distance. This can be seen by the means as well as by the standard deviations. While for least frequent transitions there is a difference based on distance and it can be seen that the subject will achieve higher improvement for distance 2 as compared to 1 or 3.



By checking at different frequency levels, it was found that for these subjects, 550 is a threshold i.e above 550 we will see that the improvement does not depend on distance while below 550 the improvement does depend on distance.