An fMRI study on motor activation and brain connectivity in a healthy subject

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INTRODUCTION

The human brain is a network made up of different regions, each region has its own specific task and function. Those regions are continuously sharing information with each other.
Different brain regions could be affected due to stroke, trauma, or degenerative disease. Imaging the brain using functional MRI at different states of activity and analysing the results provides information about functional connections and regions that could be affected or even damaged.

OBJECTIVES

- Analyse results from images pertained while the subject was performing a simple motor activity.
- Analyse results from the images pertained in a resting-state fMRI.
- Discuss the procedure and benefit of understanding the relationship between brain regions and their activation patterns.

METHODOLOGY

- Two separate fMRI sessions were conducted on two different occasions for brain connectivity and motor activation.
- The motor activation scan was done using a blocked periodic AB design (A = motor task, B = rest). TE = 50ms and TR = 3s.
- The resting-state scan, was done while the subject was lying with his eyes closed.
- Analysis was done using t-test formula : $T(i) = \frac{X_{task} - X_{control}}{se}$ for the motor activation and correlation function for the brain connectivity.

RESULTS

Figure 1 shows a set of 30 images acquired using EPI covering the whole brain. A large ROI (as shown in image #13) was selected covering most of the slice excluding the orbits and analysed. A pixel seed at random and its correlation coefficient (CC) was generated with all other pixels in the ROI. Figure 2 shows a typical plot. Activated pixels are shown in Table 1 for cc values above the chosen threshold.

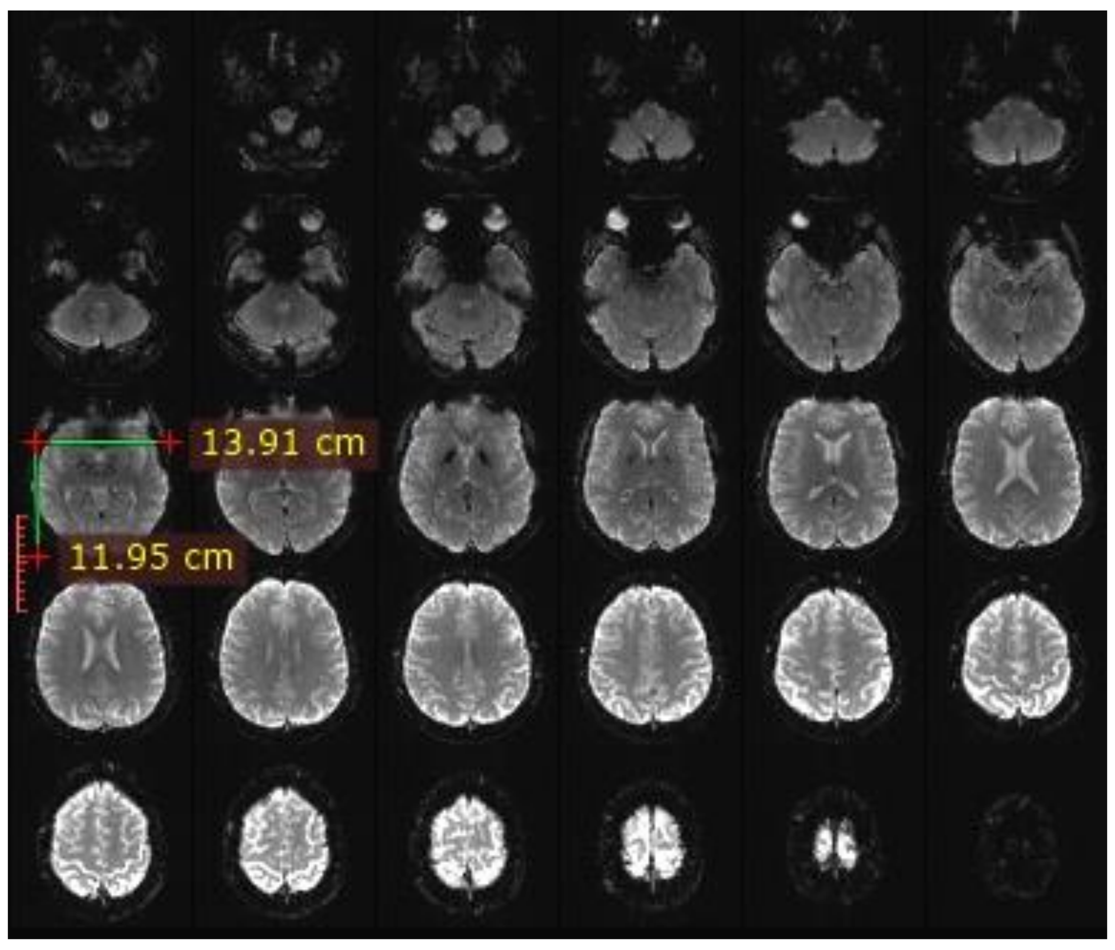

Figure 1: the chosen ROI for the connectivity experiment.

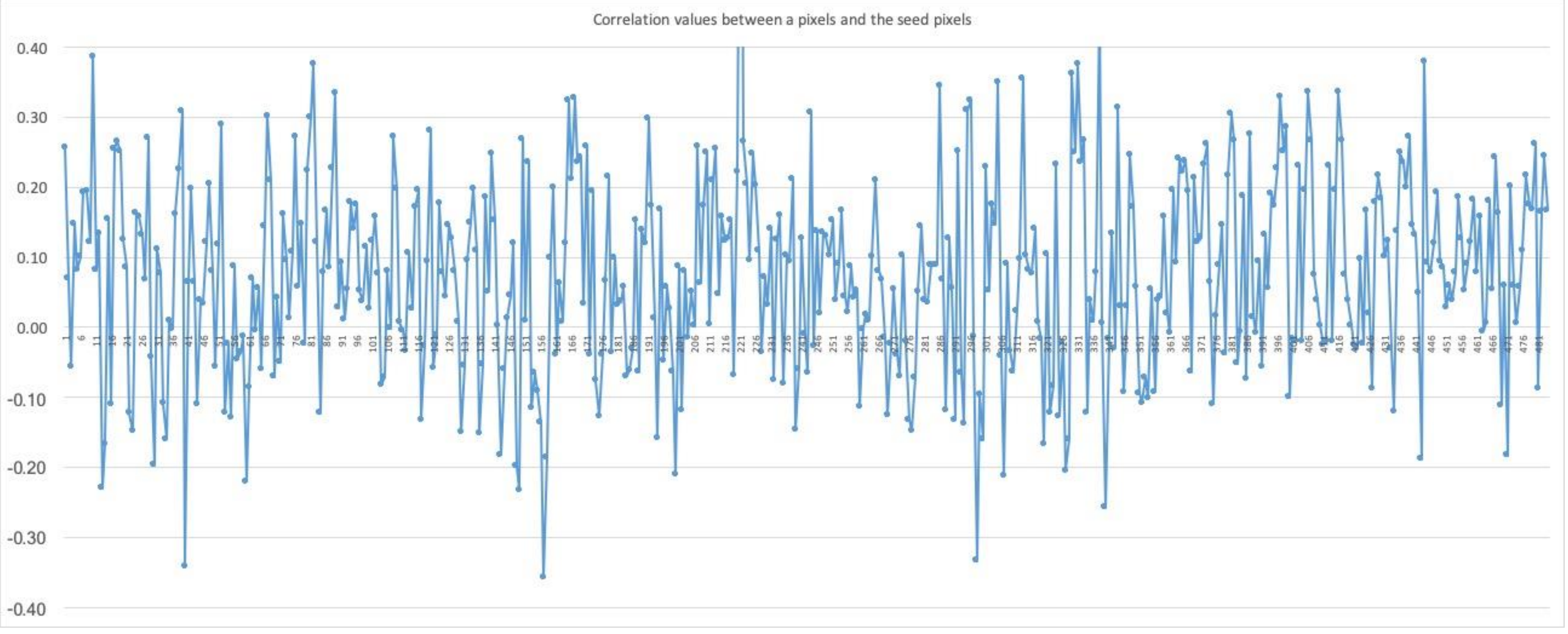

Figure 2:Correlation values between a pixel and the seed pixel.

	1	2	3	4	5	6	7	8
1								
2		2				1		
3								
4								
5								
6								
7								1

	1	2	3	4	5	6	7	8
1	3	2	1		1			
2	1	2				2		
3								
4								
5								
6								1
7								

Table 1: activated pixel at a threshold = 0.3 on two contiguous slices.

Combining 5 x 5 pixels and then choosing a threshold of 0.3, shows the correlation of the pixels to the seed pixel for two contiguous slices. The number of activated pixels within each region of 25 pixels is indicated in the maps as seen in table 1.

Motor activation experiment was performed by contracting and releasing the right hand fingers. The paradigm included three blocks of rest (R) and two blocks of activation (A). Each block consisted of 10 images.
Figure 3 shows pixel intensity values for two pixels in the selected ROI within the motor cortex. It is clear that noise can significantly obscure the identification of the activation pattern. Therefore, statistical inference methods such as t-test is used to identify the activation maps.

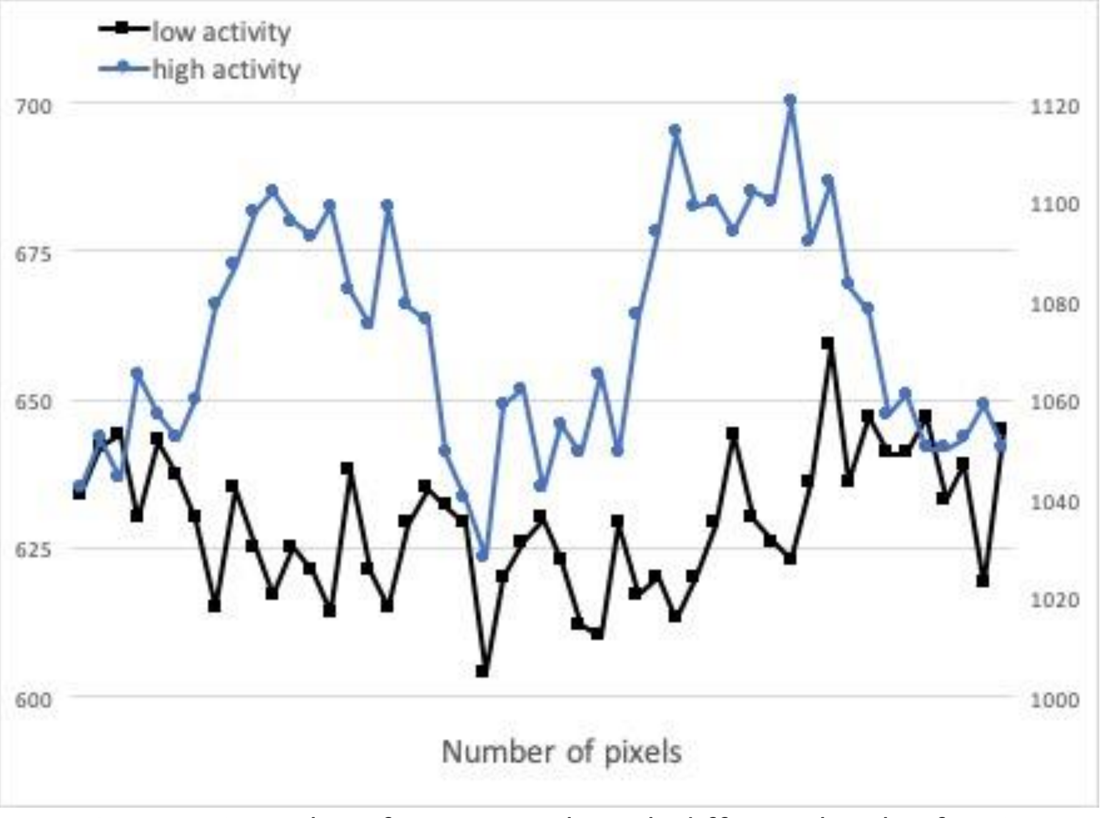

Figure 3: intensity values for two pixels with different levels of activation.

	33	34	35	36	37	38	39	40	41	42	43
0											
41											
42											
43											
44											
45											
46											
47											
48											
49											
50											

Table 2: Active pixels for threshold = 2 (light blue), and threshold = 5 (navy).

Shift (pixels)	t value
No	1.26
1	0.53
2	0.52

Table 3: : Average of t-values for various time shifts.

The motor activation maps for two threshold values are shown in Table 2. For higher threshold values a smaller number of pixels is activated. To test the onset of activation t-test values were recalculated for different time shifts and plotted in Figure 4. The results for averaging these values over the entire ROI (11x11) are shown in Table 3. It is clear that the activation signal began immediately after the task.

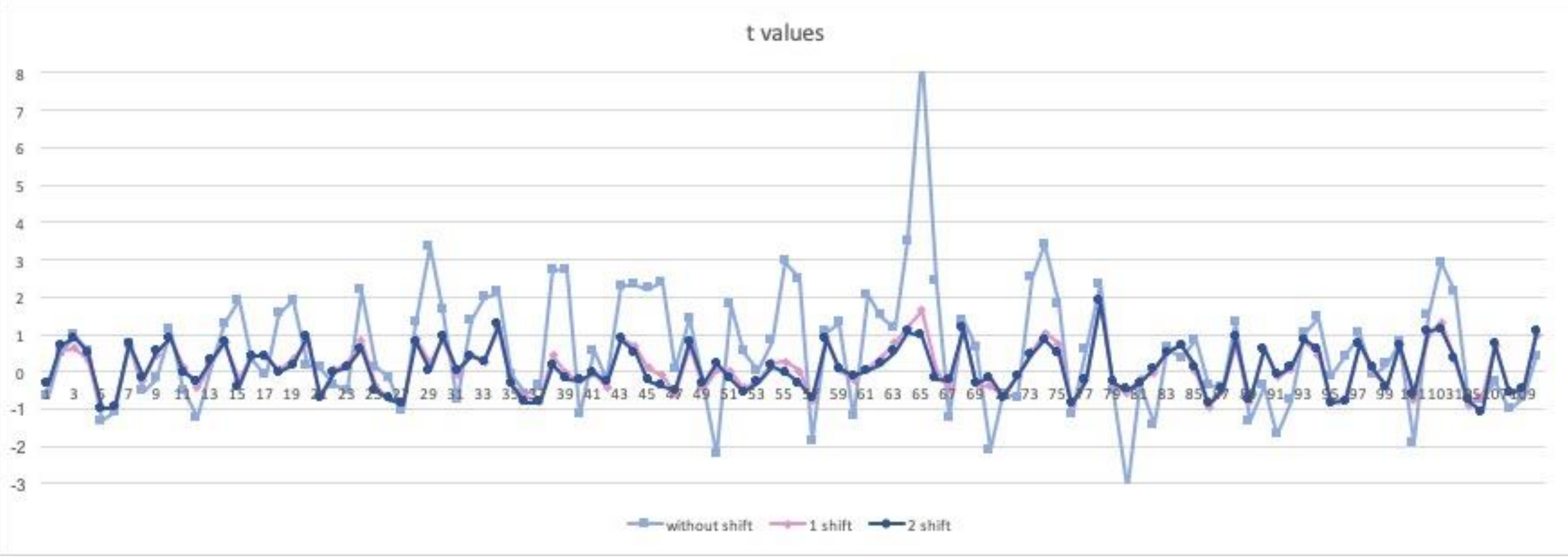

Figure 4: t-value for the various time shifts

CONCULSION

- The brain connectivity analysis showed increased correlation between the seed pixel which was chosen in the frontal lobe and other pixels within two contiguous slices. The frontal lobe is responsible for many high-level functions and tasks such as planning, emotion and motor control.
- Noise levels are high and can mask activation signals. Therefore, statistical methods are essential such as averaging and t-test. We used both in this work. Averaging improves detection power but reduces spatial resolution.
- The results of the motor activation has concluded that since the brain is always active, increasing the threshold detects regions in the brain that have higher activity.
- For the study shown above the subject relied on verbal instruction to time the motor activity, we performed a simple shift analysis to test the onset of neural activation. The conclusion is that there was no time delay between activation and brain response.
- FMRI is useful for measuring the intrinsic, steady-state hemodynamic fluctuations within a single subject, or even a group of subjects.

SELECTED REFRENCE

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