Behavioural and functional magnetic resonance imaging (fMRI) correlates of ocular motility: a preliminary study

MONASH University Biomedical Imaging

Newcastle University

Lina Juzokaite, Sharna Jamadar, Beth P Johnson, Joanne Fielding, Gary F Egan; Monash Biomedical Imaging, Monash University

Abstract

This study aims to answer three main questions:

- how saccadic eye movements are operated in the brain?
- how and where intense training affects saccadic performance?

In this project ocular motor tasks were applied in MRI scanner following two weeks training between scans. Results suggest that functional organisation differs and training positively influences saccadic performance.

Introduction

Rapid eye movement to the visual target is called saccade. Reflexive saccades (pro-saccades) rapidly respond to a suddenly appeared visual object whereas intentional saccades voluntarily shift gaze toward the target. Anti-saccade is more complex eye movement and has to be made in the opposite direction to visual stimulus.

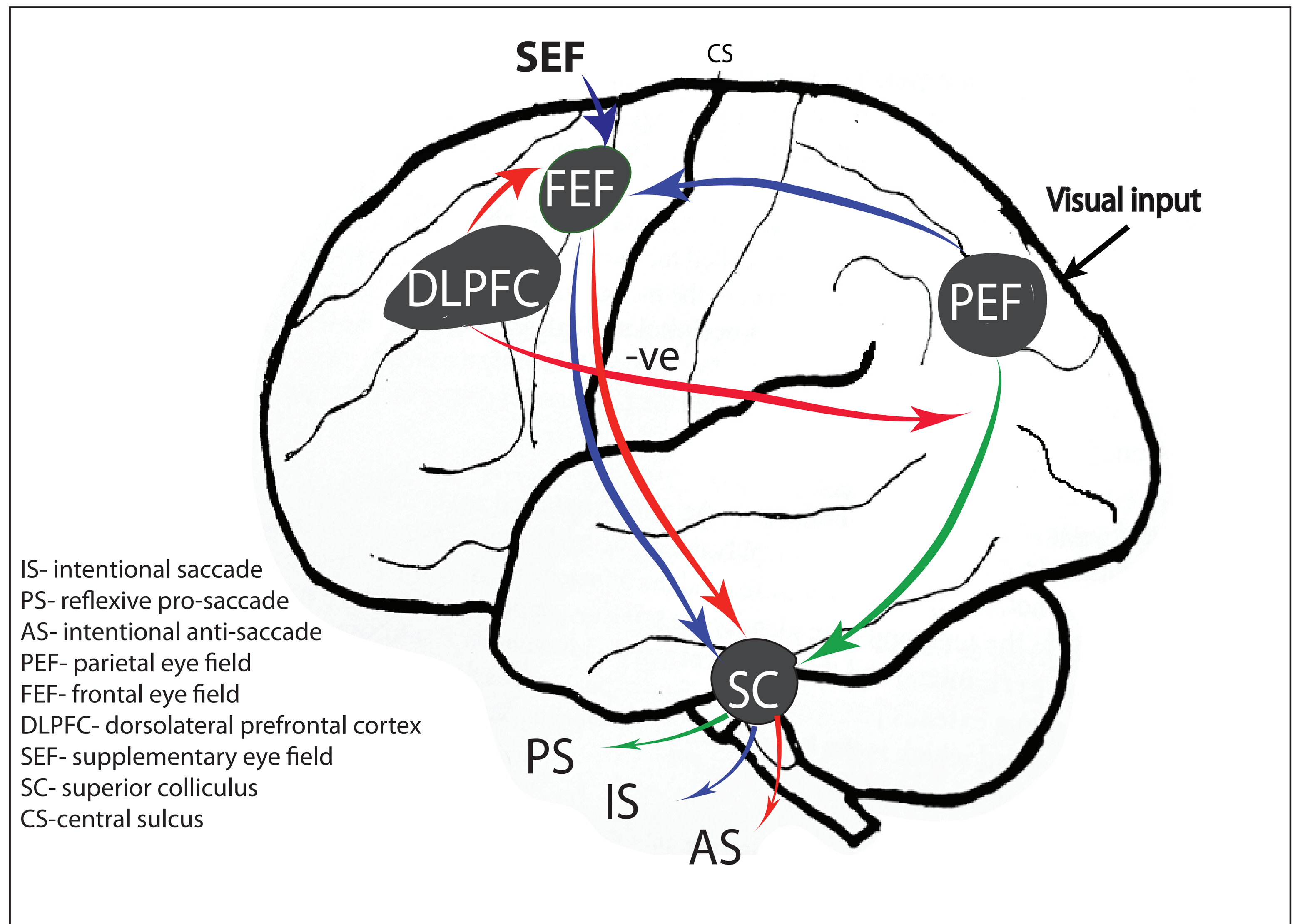

Figure 1: Cortical control of saccadic eye movements

All saccades are generated in the brainstem reticular formation and then triggered by the cortex to perform eye movement via SC. PS task directly triggers SC when impulse reaches PEF. Intentional saccade task involves FEF activation from PEF under SEF motor control. FEF is also involved in complex AS organisation. DLPFC inhibits PS pathway first and then stimulates FEF to perform a correct AS in opposite direction to visual target. Misdirected AS is an important indicator of inhibitory DLPF control in cortex. (Deseiligny et al.2004).

Methods

A group of healthy participants (n=13; mean 25 yrs; 8 females; 5 men) attended two fMRI scans with a two week interval and had been training an ocular motor task for 15 min daily. Analysis was comprised of two stages (1) analysis of eye movement trace with customised MATLAB software (ZoomTool), (2) functional and structural fMRI scans to identify activated brain areas (images were preprocessed using SPM5).

Results

1) Data below represents eye tack results from first visit (V1) and second visit (V2).

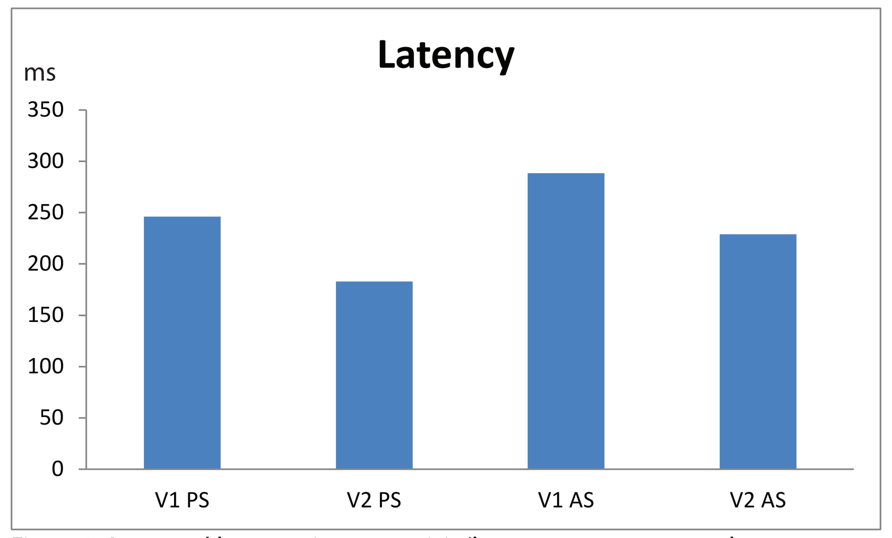

Figure 2. Averaged latency times per visit (latency represents ocular response time from visual target onset)

Latency of PS decreased by 62ms (F=20.89, p<0.001) and of AS by 60ms (F=18.3,p<0.001).

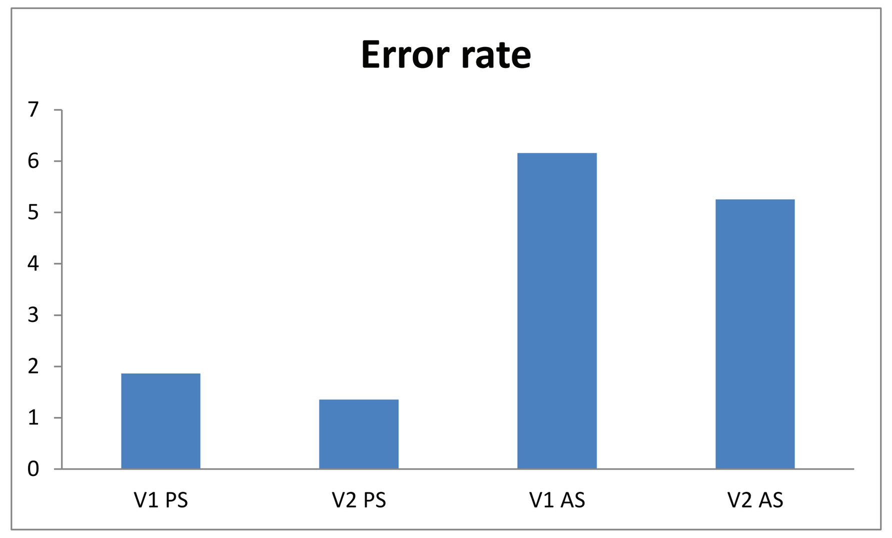

Figure 3. Averaged misdirected error count per visit.

After training there was a trend towards error rate improvement that did not reach significance within groups.

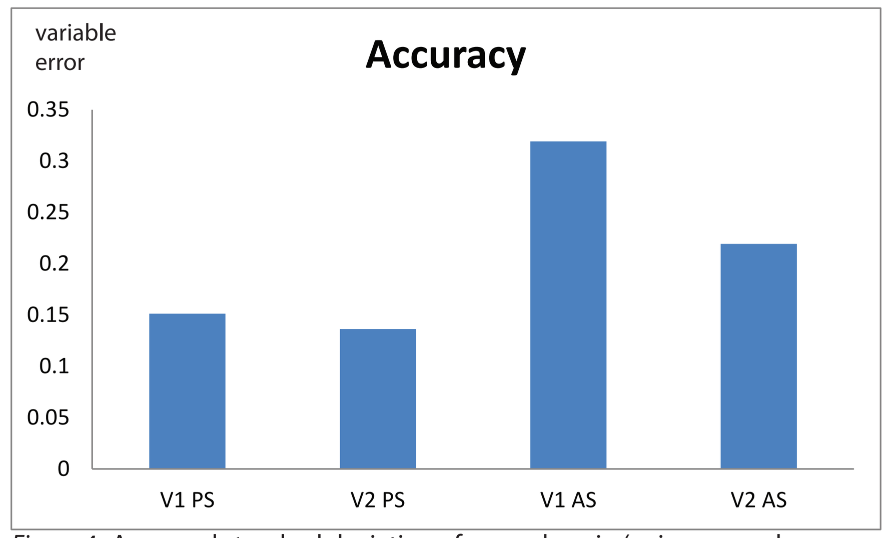

Figure 4. Averaged standard deviation of saccade gain (gain = saccade amplitude/target amplitude).

The accuracy of AS was significantly improved (F=9.179, p<0.01) after training to compare with PS.

2) FMRI data acquired from first visit of two participants.

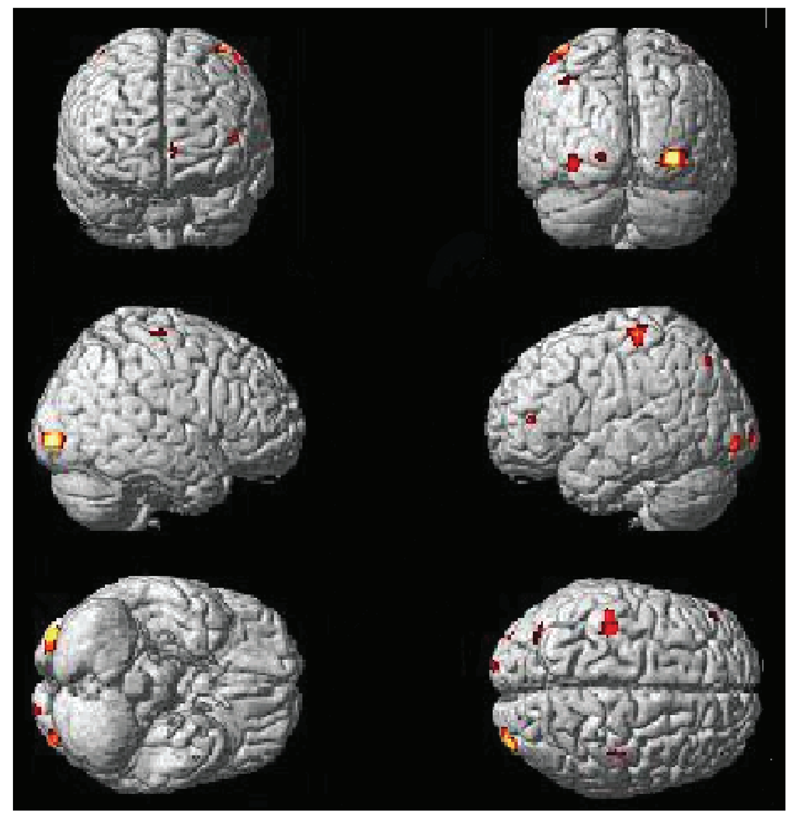

Figure 4. Group statistical parametric map (SPM). PS>AS . (p<0.001, κ=5 voxels)

Anatomical region (BA)	T value
R Inf Occipital(18)	5.56
L Postcentral (3/4)	4.26
L Angular (7/39)	3.96
L Mid Occipital 19	3.92
L Calcarine (18)	3.86
L Tir Inf Frontal (46)	3.67
R Precentral (6)	3.58
L Ant Cingulum (32)	3.37

Table 1. T-scores for brain regions revealing significant activation to the execution of pro-saccades compared with antisaccades

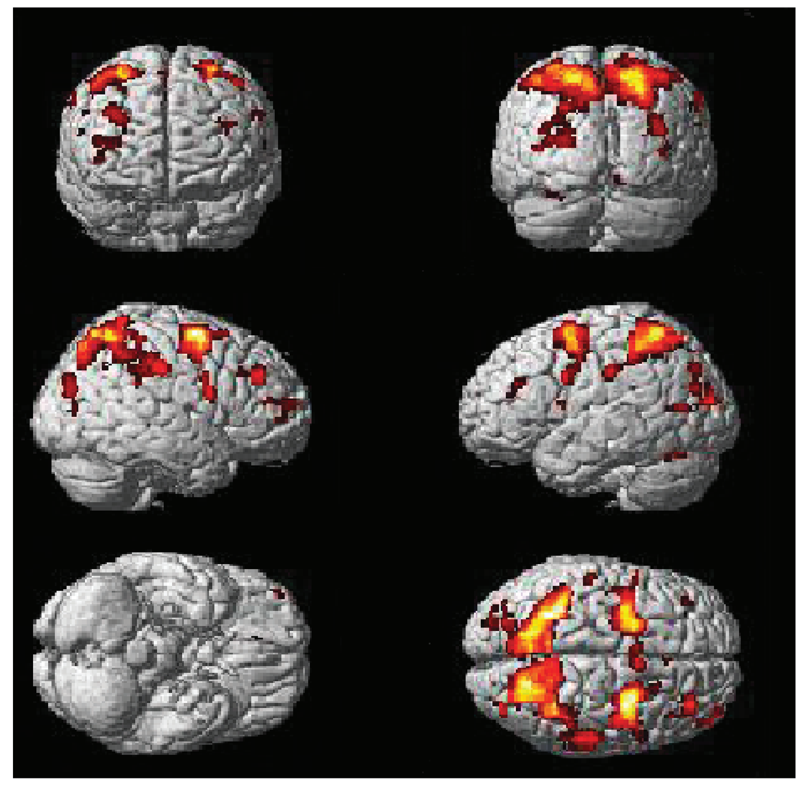

Figure 5. Group statistical parametric map (SPM). AS>PS (p<0.001, κ=5 voxels)

Anatomical region (BA)	T value
L R Sup Parietal (7)	8.77
R L Sup Frontal (6)	8.58
R Mid Frontal (6/9/10)	5.11
R L Precentral (6/9)	7.09
R Supramarginal 40	5.47
R Oper Inf Frontal (44)	4.57
R Mid Occipit (19)	4.23
R Sup Occipit (19)	3.48

Table 2. T-scores for brain regions revealing significant activation to the execution of antisaccades compared with prosaccades.

Conclusions

- The eye track study suggests that (1) intensive training impacts quicker respond to stimulus and that (2) motor learning stabilises final eye position opposite to the target during AS task.
- FMRI results is consistent with PS being controlled by PEF and FEF where AS task incorporates DLPFC inhibition of PEF and rearranged activation of FEF to implement correct saccade. It is expected to observe more activation in fMRI scans in frontal lobe after training because SEF is known to be responsible for motor learning.

Future directions:
fMRI results also appeared to show a trend towards functional lateralisation, which is consistent with Petit et al.'s findings (right FEF activation; saccadic motor asymmetry due to dominance of the left motor cortex in right-handers).

This preliminary study was part of the project which aims to reveal correlation between different neuronal organisation in individual brains and his/her success in ocular motor performance.

References

Ch. P. Deseilligny, D Milea, R.M. Muri. (2004) Eye movement control by the cerebral cortex. Current Opinion in Neurology ;17(1):17-25

D. Pélisson, N. Alahyane, M. Panouillères, C. Tilikete. (2010) Sensorimotor adaptation of saccadic eye movements. Neuroscience and Biobehavioral Reviews 34 (8) 1103–1120

L. Petit, L. Zago, M. Vigneau, F. Andersson, F. Crivello, B. Mazoyer, E. Mellet, N. Tzourio-Mazoyer. (2009) Functional asymmetries revealed in visually guided saccades: an FMRI study . J. Neurophysiol., 102 (5), pp. 2994–3003

Contacts

l.juzokaite@ncl.ac.uk