Introduction

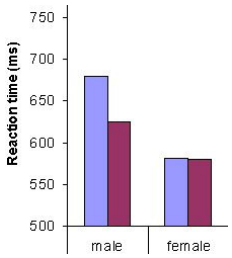
Functional MRI is being increasingly used in both pre-surgical and pre-radiotherapy planning as a non-invasive means of assessing normal functional anatomy [1]. As part of our on-going work investigating the role of fMRI as a possible replacement for the WADA test, we investigated possible gender differences in language processing and cognition in a cohort of normal volunteers.

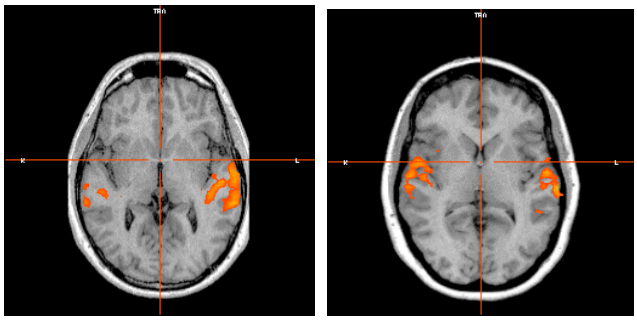
Methods

A total of 10 (5 male, 5 female) right-handed (Edinburgh Handedness Inventory) subjects were studied. Each subject was given an initial lateralised lexical decision test [2] on a PC using a stimulus programmed in E-prime (Psychology tools, Pittsburgh). Words, non-words and hash-symbols were randomly presented to the left or right visual fields (LVF or RVF). Subjects were asked to decide whether the presented target was a real English word or not. Response times and accuracy were recorded. Each subject was subsequently scanned using MRI on a 1.5 Tesla Philips Intera Scanner operating with a 150 mT/m/ms gradient slew rate. Initial localising images were followed by fMRI using the BOLD technique. Single-shot gradient-echo EPI images were acquired at 23 contiguous slice locations (4 mm thickness) using a TE of 40 ms and a TR of 3 s. A field-of-view of 24 cm was acquired with an imaging matrix of 64×64. Two functional tasks were performed: During the first, the subjects were asked to decide whether a visually presented 3 or 4-letter string was an English word or non-word (WNW). These were briefly presented every 3 s for a period of 120 ms with a cross hair shown in the remaining time. During the control phases, hash or asterisk symbols were presented at the same frequency to control for visual contrast. For the second task the subjects were asked to listen and comprehend an auditory story (AS) for periods of 30 s intervals with the scanner noise acting as a control for the intervening epochs. Following the fMRI studies, a high-resolution 3D T_1-weighted scan was acquired in the sagittal plane (TE/TR/flip = 4.6/9.8 ms/30°) with a near isotropic resolution of 1 mm for anatomical reference. All images were transferred to a PC and analysed using BrainVoyager2000™. Analysis included motion-correction and cross-correlation with the reference pattern modified by a haemodynamic response function. Activated maps were registered in the Talairach co-ordinate system and overlaid onto the 3D images for visualization. A lateralisation index (LI) was computed using the formula $100 \times (N_L-N_R)/(N_L+N_R)$ where N_L and N_R were the number of activated pixels in the left and right hemispheres respectively.

Results

Mean response times in the male subjects were significantly quicker ($P < 0.05$, Figure 1) for words presented to the RVF compared to LVF (625 ms and 679 ms respectively). Corresponding times in the female subjects were not significantly different (580 and 582 ms). Significant activation for the WNW task was only observed in two of the female subjects, this being in the superior frontal gyrus, anterior cingulate and angular gyrus. Values for the LI in these subjects were 6.9 and 1.2 %. Results from the AS task provided consistent gender-specific temporal lobe lateralisation patterns for all subjects (superior temporal, anterior and posterior transverse temporal lobe, Brodmann areas 22,41 & 42), with males demonstrating significant lateralisation in the left hemisphere, while females were bilateral. Mean values for LI were 43 % in males and –6 % in females ($P < 0.01$). Figure 2 illustrates a typical male and female response to the auditory stimulus. Figure 3 demonstrates the activation pattern observed in the WNW task.





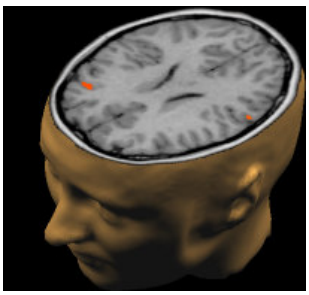


Figure 1: RVF & LVF reaction times. Figure 2: male (left) and female (right) response for AS. Figure 3: WNW task.

Conclusion

A clear right-visual field (left hemisphere) advantage was demonstrated in male subjects in the behavioural task. In the auditory test in the scanner, a clear difference in the lateralisation of temporal lobe activity was demonstrated which was gender-specific. This information will be important in the pre-surgical evaluation of patients with temporal lobe lesions.

References

1) Garcia-Alvarez R, Liney GP, Beavis AW. Use of functional magnetic resonance imaging in the treatment planning of intensity modulated radiotherapy. J. Radiotherapy in Practice 2003; 3:63-69.

2) Lavidor M, Hayes A, Bailey P. Handedness, measures of hemispheric asymmetry and lateralised lexical decision. Laterality 2003; 8:347-360.