Cortical activation in reduced during motor imagery in Amyotrophic Lateral Sclerosis

B. R. Stanton[1], V. C. Williams[1], P. N. Leigh[1], S. Williams[2], and A. Simmons[2]

[1]Department of Clinical Neuroscience and MRC Centre for Neurodegeneration Research, Institute of Psychiatry, King's College London, London, London, United Kingdom, [2]Department of Clinical Neuroscience and Centre for Neuroimaging Sciences, Institute of Psychiatry, King's College London, London, London, United Kingdom

Background

Amyotrophic Lateral Sclerosis (ALS) is a devastating neurodegenerative disorder, which principally targets the motor system. Previous functional imaging studies in ALS have demonstrated increased activation around the motor cortex during motor tasks[1-3], but it is unclear whether this represents cortical adaptation or the confounding effect of weakness. We therefore sought to study cortical activation during motor imagery, which activates motor networks[4] without the need for motor execution. We hypothesised that patients with ALS would show increased activation around the motor cortex during motor imagery, as seen in motor execution tasks.

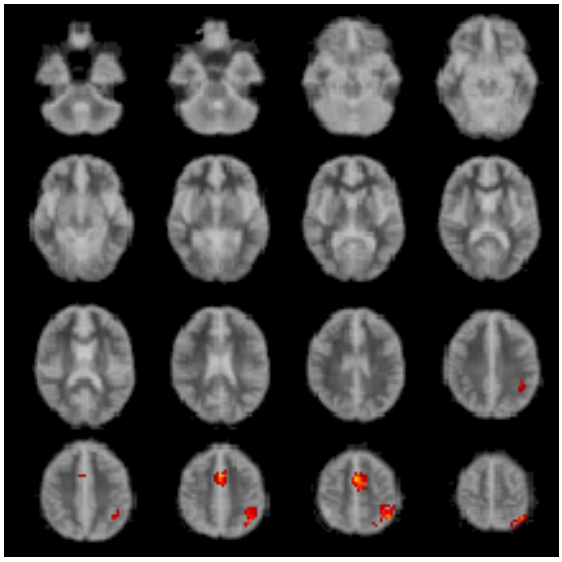
Methods

Data were acquired using a 1.5T GE NV/*i* MR system and a conventional transmit and receive birdcage head coil. 100 near axial T2* weighted images were acquired using a gradient echo EPI pulse sequence over a period of 5 minutes (TR =3s, TE=40ms, 20 slices, 5mm thickness/0.5mm slice gap, 24cm field of view, 64x64 matrix). A block design activation paradigm was used contrasting blocks of 30s of imagery of right hand movements against 30s of rest in sixteen patients with ALS and seventeen healthy controls. The groups were matched for age and gender. Subjects were observed during scanning to ensure that no overt movements were made. After correction for head movement and transformation to the space of Talairach and Tournoux, analysis used a non-parametric approach[5] to derive group activation maps and examine differences in activation between groups using an Analysis of Variance.

Results

During motor imagery, healthy volunteers showed 2 areas of activation, one large cluster around contralateral motor areas and one in the medial frontal cortex. ALS patients showed a less extensive cluster of activation around contralateral motor cortex with additional ipsilateral activation, but did not show any frontal activation. In the group comparison, ALS patients showed reduced activation during motor imagery compared to controls in the left inferior parietal lobule and medial frontal cortex (Figure 1).

Figure 1: Map of increased cortical activation in controls compared to patients with ALS



Discussion

In contrast to previous studies using motor execution paradigms, ALS patients showed reduced cortical activation during motor imagery. Motor imagery paradigms therefore do not offer a straightforward way of overcoming confounding by task difficulty in studies of motor cortical function in patients with weakness. One possible explanation for this discrepancy is that the motor execution findings are explained by increased task difficulty in weak patients, but findings from studies of patients with weakness from peripheral lesions argue against this[2]. Alternatively, it may be that patients with ALS fail to activate the motor imagery network normally. Motor imagery involves reactivating the representation of a specific motor action in working memory, and is known to involve pre-frontal regions. This result adds to the increasing body of evidence that ALS involves extra-motor regions[6,7], particularly the pre-frontal cortex. Our findings have significant implications for use of brain-computer communication aids in ALS.

References

1. Kew JJ et al. Cortical function in amyotrophic lateral sclerosis. A positron emission tomography study. *Brain* 1993;116 (Pt 3):655-80.
2. Kew JJ et al. Cortical function in progressive lower motor neuron disorders and amyotrophic lateral sclerosis: a comparative PET study. *Neurology* 1994;44:1101-10.
4. Lacourse MG et al. Brain activation during execution and motor imagery of novel and skilled sequential hand movements. *Neuroimage* 2005;27: 505-519.
5. Brammer MJ et al. Generic brain activation mapping in functional magnetic resonance imaging: a nonparametric approach. *Magn Reson.Imaging* 1997;15:763-70.
6. Abrahams S et al. Word retrieval in amyotrophic lateral sclerosis: a functional magnetic resonance imaging study. *Brain* 2004;127:1507-17.
7. Maekawa S et al. Cortical selective vulnerability in motor neuron disease: a morphometric study. *Brain* 2004; 127: 1237-1251