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PHYSIOLOGY

Neurovascular relationships in human sensorimotor cortex can be modulated by movement

O J Arthurs, T Donovan, T A Carpenter, J D Pickard, S J Boniface

Wolfson Brain Imaging Centre, Box 65, Addenbrooke's Hospital, Hills Road, Cambridge, CB2 2QQ. UK.

The interpretation of fMRI is critically dependent on understanding the relationship between observed blood flow responses and the underlying neuronal changes. We have established a linear neurovascular coupling relationship between fMRI BOLD and somatosensory evoked potential (SEP) amplitude in human sensorimotor cortex using changes in stimulus intensity [1]. Finger movement during a stimulus is known to attenuate electrical SEP responses in somatosensory cortex (movement gating) [2,3], however it is also a common method of inducing fMRI BOLD activity in sensorimotor cortex, suggesting that electrical and haemodynamic cortical responses diverge. Here we examined the effects of finger movement during sensory stimulation on fMRI BOLD and SEP amplitude in sensorimotor cortex, in order to establish whether movement can modulate this relationship.

Methods

Normal volunteers were subject to 0.2 millisecond square-wave electrical pulses delivered to the median nerve at the wrist, at 50 – 175 % of predetermined motor threshold. SEPs were recorded from contra-lateral parietal cortex, Cp3/4, referenced to Fz, over 450 averages. Gradient-echo EPI BOLD imaging was performed on a 3.0 Tesla Bruker Medical S300 using a blocked design with TR 4 sec. Imaging was acquired for all intensities, which were pseudo-randomised, then the experiment was repeated with subjects performing a self-paced thumb twitch during the stimulus. Images were analyzed using SPM99.

Results

Without movement, fMRI BOLD responses paralleled changes in SEP N20-P27 amplitude ($p<0.05$) as both increased with increasing intensity ($p<0.05$; $p<0.05$ respectively). However, thumb movement increased fMRI BOLD signal intensity change ($p<0.05$) but caused a significant decrease in SEP N20-P27 amplitude across all intensities in all subjects ($p<0.05$).

Conclusion

SEP amplitudes increased with increasing stimulus intensity, as did fMRI BOLD signal intensity changes, consistent with a close neurovascular coupling relationship. However the effect of simultaneous movement is to reset this relationship by increasing the cerebral blood flow response and suppressing the electrical response. The apparent coupling relationship can therefore be modulated by movement.

References

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