

Somatosensory cortical activation in the preterm brain identified with a programmable hand interface and functional MRI

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Aims/Background: Activation in the primary somatosensory cortex can be identified in the newborn brain using electrophysiological techniques and near infrared spectroscopy, but these methods provide relatively poor spatial specificity. Functional MRI (fMRI) has been used to detect activation in term infants¹, but not preterm due to difficulties identifying positive Blood Oxygen Level Dependent (BOLD) signals, and the lack of a reliable and reproducible MR-safe stimulus. We hypothesised that well localised cortical activation could be identified in the preterm brain using an appropriate synchronised tactile and proprioceptive stimulus.

Methods: 3 preterm infants of gestational age: 30, 33, and 34 weeks, and 4 term control infants (2 born preterm at 34 and 36 weeks) were imaged using a 3T Philips MRI scanner (Best, Netherlands) located within a Neonatal Intensive Care Unit. Written consent was taken from parents following discussion with one of the investigators and the provision of written information.

The somatosensory stimulus was elicited by a programmable hand interface, consisting of a tailor-made inflatable balloon (composed of 2 layers of latex around a nylon mesh), a control box and customisable software (see figure 1). The control box consists of a pressure regulator valve controlled by software on a standard PC, both of which were connected to the MRI scanner via a DAQ card. Synchronised stimulation was achieved via detection of the MRI scanner TTL pulse with each TR.

The balloon was sized and placed in the right hand of each subject, and then intermittently inflated/deflated via a 7m plastic pipe connected to the control box outside the examination room. Inflation resulted in passive extension of the fingers, while deflation allowed flexion. An “on-off” block stimulation paradigm was programmed on the device, with alternating periods lasting 24 seconds each (16 TRs). During each “on” period, the subject received a periodic sinusoidal inflation/deflation stimulus at a frequency of 0.33 Hz, at an amplitude adjusted appropriately for hand size (balloon volume range 1.2cm³ – 3.1cm³). A sinusoid waveform was chosen to obtain a progressive inflation/deflation of the balloon. During each “off” period, the balloon was kept in deflation by switching off the valve. Before use with newborn infants, it was confirmed that the device was MR compatible and produced characteristic cortical activation in adult volunteers.

MRI was performed with a phased array head coil using an echo-planar imaging (EPI) sequence (TR/TE/FA = 1.5 s/45 ms/90°, 2.5'2.5 mm², 22 slices) lasting 6 minutes and 30 seconds (total 256 volumes). Data analysis was performed using FEAT v5.98 (part of FSL www.fmrib.ox.ac.uk/fsl)².

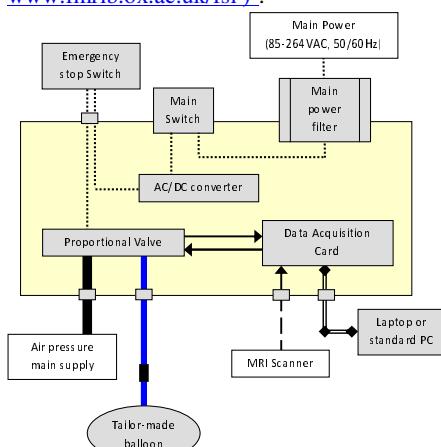


Figure 1: schematic diagram of the portable hand interface

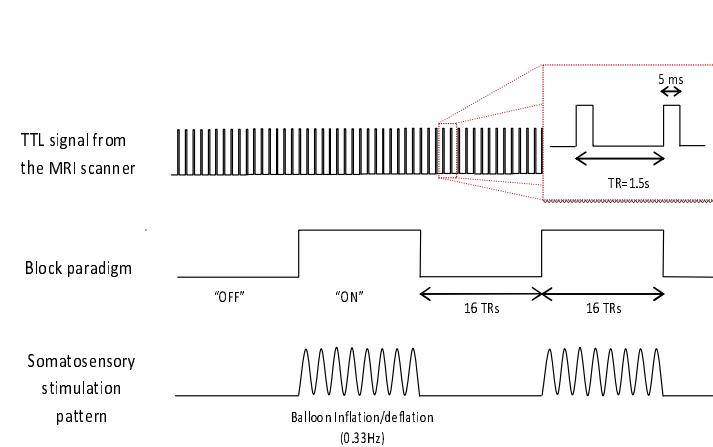
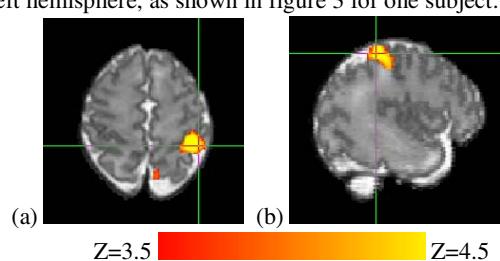


Figure 2: the experimental block paradigm

Results: Well-localised contralateral and bilateral activation in the primary somatosensory cortex was identified in the term infant group, as described previously¹. In all 3 preterm neonates, passive stimulation of the right hand resulted in contralateral positive BOLD signal activation which was well localised to the primary somatosensory cortex in the left hemisphere, as shown in figure 3 for one subject.

figure 3 (a) axial and (b) sagittal T2-weighted images of the brain of a 34 week gestational age preterm infant. Thresholded statistical maps have been superimposed showing activation in the contralateral primary somatosensory cortex with a corrected cluster significance threshold of $p=0.05$.



Conclusion: This preliminary data shows that it is possible to identify well localised functional activation in the primary somatosensory cortex of preterm infants. Use of the fully synchronised automated device described will generate reproducible results for further work, and may be of great value in elucidating the effects of white matter injury and testing therapeutic interventions in the preterm population.

References: [1] Erberich SG et al. Neuroimage, 29: 155-61, 2006. [2] Smith SM et al. Neuroimage, 23(S1):208-219, 2004.