# fMRI Measures of the Dorsal Visual Cortex Correlates with Behavioral Performance and Cortical Thickness

Tanya Poppe[1], Myra Leung[1], Anna Tottman[2], Jane Alsweiler[3], Frank Bloomfield[2], Jane Harding[2], and Ben Thompson[1,4]

*[1]Department of Optometry and Vision Science, University of Auckland, Auckland, New Zealand, [2]Liggins Institute, University of Auckland, Auckland, New Zealand, [3]Department of Paediatrics: Child and Youth Health, University of Auckland, Auckland, New Zealand, [4]Department of Optometry and Vision Science, University of Waterloo, Waterloo, Ontario, Canada*

TARGET AUDIENCE: Paediatricians, vision scientists and neuroscientists, particularly those with an interest in neurodevelopment and neuroprotection. Physicians and researchers interested in fMRI in children.

PURPOSE: Preterm birth is associated with a range of risk factors for abnormal neurodevelopment. The aim of this study was to assess the relationships among gestational age at birth, cortical thickness, global motion perception and functional activation of dorsal extrastriate visual area hMT+ in a group of seven-year-old children born very preterm. The dorsal visual cortical stream serving hMT+ has been hypothesised to be vulnerable to abnormal neurodevelopment (1,2), and may thus provide a sensitive biomarker. The hypothesis was that gestational age would influence each of the measures of brain structure and function.

METHODS: Participants were 29 seven-year-old children born before 30 weeks' gestation and recruited into a follow-up study investigating the effects of tight glycaemic control with insulin in hyperglycaemic extremely low birth-weight neonates (<1000 g) (3). The children were scanned on a 3T (Siemens; MAGNETOM Skyra) MRI scanner, using an additional 32-channel phased array head-coil. T1 magnetisation prepared rapid acquisition gradient echo (MPRAGE) scans (TR=2000ms, TE= 3510ms, TI=1010ms, flip angle = 9°) with isometric 0.85mm$^3$ voxels and a resolution of 256x256 voxels were acquired through 176 sagittal slices. T2*-weighted echo planar imaging (EPI) blood oxygen level dependent (BOLD) functional MRI (fMRI) (TR=2500ms, TE=27ms and a flip angle=90° for anterior to posterior phase-encoding) was acquired with isometric 3mm$^3$ voxels, through 48 slices, and 104 TRs. The visual stimulus used during fMRI was designed to activate the hMT+ complex, a group of motion-sensitive areas within the dorsal extrastriate visual cortex that are thought to be particularly vulnerable to developmental risk factors (1,2). This "global motion" stimulus consisted of 100 white dots (diameter 0.24°) presented on a mean-luminance background within a 5° circular aperture. Each dot had a "limited lifetime" (a 5% chance of disappearing in each frame and reappearing in a random location within the stimulus) to prevent tracking of individual dots. The stimulus was presented in three different configurations: coherent motion, whereby all the dots moved at a speed of 6°s$^{-1}$ in the same direction (up or down, alternating across trials); incoherent motion, whereby each dot moved in a random direction; and stationary, whereby dots still had a limited lifetime, which gave the stimulus a "twinkling" appearance, and maintained a level of temporal modulation. Stimuli were presented in blocks of 20 trials with each trial lasting 1 s (750ms stimulus presentation, 250ms inter-stimulus interval). Each 20 s block of coherent or incoherent motion was interleaved with a block of static stimuli. Coherent and incoherent blocks were each presented three times, in a pseudo-random order. Throughout scanning, participants were presented with static images of cartoon characters, which acted as the fixation point, and were asked to press a button whenever they saw a pre-specified character. Sensitivity to global motion was also measured for each child outside of the scanning environment as part of the vision assessment: motion coherence thresholds were measured using the global motion stimulus by varying the proportion of signal (coherently moving dots) and noise (randomly moving dots) following a 2-down 1-up staircase procedure.

RESULTS: hMT+ activity was identified in 9 of the 24 children for whom fMRI data were successfully collected (Figure 1, top), and cortical thickness was measured in these 9. Mean gestation was 27.6 ±3 weeks. Gestational age at birth did not correlate with cortical thickness, the functional response of hMT+, global motion perception, visual acuity, or stereopsis. However, fMRI measurements revealed a greater BOLD response in hMT+ for coherent relative to incoherent global motion and the magnitude of the BOLD response was significantly positively correlated with psychophysical measurements of motion coherence thresholds (Figure 1, middle) (for which a higher threshold indicates a poorer performance) ($p$ = 0.007). BOLD activity in hMT+ also correlated positively with average whole-brain cortical thickness (Figure 1, bottom) ($p$ = 0.034).

DISCUSSION: These results link motion coherence thresholds to hMT+ BOLD signal in seven-year-old children. Therefore, both behavioural and fMRI measures can be used to explore dorsal visual cortical stream function in children, and this may provide a sensitive marker for neurodevelopment. Gestational age was not correlated with behavioural, structural or functional measures in this cohort of children. Future work will explore the effect of hypo and hyperglycaemia on these outcome measures in the same group of children.

CONCLUSION: Gestational age at birth did not predict measures of brain structure or function at seven years of age in this group of children born very preterm. fMRI can be used to investigate brain development in seven-year-old children at risk of abnormal neurodevelopment.

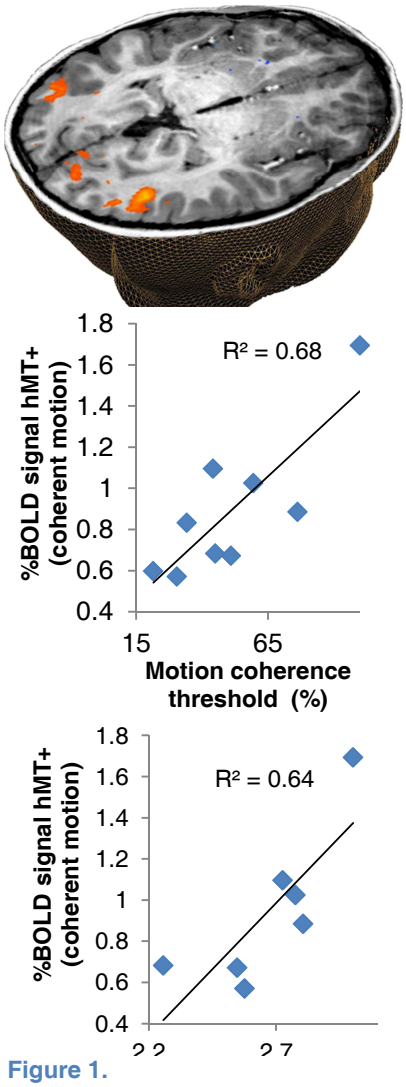


**Figure 1.**
Top: Bilateral hMT+ and primary visual cortex activation in response to a visual global motion stimulus.
Middle: The relationship between BOLD signal in hMT+ and behavioural measures of motion coherence thresholds for individual participants.
Bottom: The relationship between the % BOLD signal change in hMT+ in response to coherent motion and mean whole-brain cortical thickness.

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