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Magnetoencephalography study of brain dynamics in young children born extremely preterm

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Abstract

Magnetoencephalography (MEG) was recorded while 5–7 year-old children were performing a visual–spatial memory recognition task. Full-term children showed greater gamma-band (30–50 Hz) amplitude in the right temporal region during the task, than children who were born extremely preterm. These results may represent altered brain processing in extremely preterm children who escape major impairment.

Keywords

MEG; Gamma-band; Preterm; Visual-spatial memory; Brain processing

1. Introduction

Neurodevelopmental problems in attention, visual memory, cognition, and executive function are common in children born extremely preterm, even when overall intelligence is in the normal range [1,2]. Selective vulnerability of visual memory and visual–spatial processing has been reported in these children [3,4]. Previous studies using structural magnetic resonance imaging (MRI) have identified reduced volumes in specific brain structures in preterm children at age 7 years, suggesting that preterm birth appears to be associated with abnormal brain development [5,6]. Although these neuroanatomical abnormalities may underlie the cognitive and behavioural deficits frequently observed among this population, very little is known about brain processing in preterm children during the performance of cognitive activities.

Synchronization of gamma-band oscillations (30–80 Hz) is considered to be a fundamental mechanism by which the brain integrates information from distributed sets of neurons to form coherent functional assemblies [7]. This complex orchestration has been implicated in sensory, motor and cognitive functions, and notably as a neurophysiological mechanism to explain binding of multiple features during visual object recognition [8]. In this study we investigated

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differences in gamma-band oscillations at age 5–7 years during visual–spatial memory processing, comparing children who were born extremely preterm and those born at full-term.

2. Materials and methods

Fourteen right handed children age 5–7 years (mean 6.50 years; SD 0.81), with cognitive abilities in the average range or above, on the Woodcock-Johnson III were recruited through the Children's and Women's Health Centre of British Columbia. Six children, born extremely preterm (birth weight<801 g and/or gestation≤29 weeks), were recruited from the Neonatal Follow-up Clinic. Eight healthy children born full-term (gestation≥37 weeks) were recruited as controls (Table 1).

Magnetic fields were recorded over children's heads in a magnetically shielded room using a 151-channel whole-head neuromagnetometer system (VSM Med-Tech Inc. Port Coquitlam, Canada). Children sat comfortably in an upright position while viewing stimuli on a back projected screen approximately 60 cm from their nasion.

The visual–spatial memory recognition task required same–different judgment on consecutively presented pictures of geometric shapes. The visual stimuli were from the visual perception subtest of the Beery-Buktenica Test of Visual-Motor Integration, Fifth Edition (Beery™[1] VMI 5th Edition) (see Fig. 1). The task comprised 52 pairs of spatial forms (26 same, 26 different, presented in random order). For each pair, stimulus 1 (S1) was presented for 1000 ms, then stimulus 2 (S2) for 1000 ms. Time between the two stimuli varied randomly from 500 to 1000 ms, and the interval between stimulus pairs was 2000–3000 ms. The task for the child was to press a button after the appearance of S2 if it was the same as S1. We calculated the gamma-band power for each sensor by first band-pass filtering between 30–60 Hz, then calculating the root-mean-square (rms), and finally averaging the rms values for the entire MEG run.

3. Results

The accuracy of full-term children (91.9±6.0%) did not differ significantly from preterm children (85.6±9.6%) during the visual–spatial memory recognition task. For the MEG data, *t*-tests were carried out only in a-priori selected sensor areas to compare the total mean gamma-band power amplitude of preterm and control children during the visual–spatial memory task. Gamma-band amplitude was greater for preterm children in three sensor regions: left and right occipital, and left temporal, but these differences did not reach statistical significance in this sample. Full-term children showed greater gamma-band amplitude in the right temporal region ($p<0.05$) (Fig. 2).

4. Discussion

These findings are a preliminary step towards a better understanding of the brain correlates of altered neurobiological development in extremely preterm children who escape major impairment. Gamma-band amplitude was found to be greater for full-term than preterm children in the right temporal region, consistent with previous studies showing reduced cortical and subcortical gray matter volumes in preterm children compared to control subjects at ages 7–11 years [6]. The present results in preterm children could indicate compromised visual–spatial integration or binding known to rely primarily on the right hemisphere [9], and/or impaired visual short-term memory encoding. Cognitive deficits related to the right hemisphere (analogical, spatial or organizational problem-solving) have been reported in preterm children

[1]™"Beery" is a trademark of Keith E. Beery and Natasha A. Beery.

at age 3 years [3] and at school-age [10]. Reduced gamma activity in the right hemisphere circuits for visual–spatial memory processing in preterm children may be accompanied by increased activity in brain areas (left and right occipital, and right temporal) in which are not typically prominent for this task healthy controls.

Future studies examining whether differences in brain processing in preterm children correspond to deficit or compensation would help to unveil the nature of the neurodevelopmental mechanisms involved. Better understanding of these mechanisms may be useful to develop interventions to support cognitive vulnerabilities in preterm children.

Acknowledgments

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References

1. Grunau RE, Whitfield MF, Davis C. Pattern of learning disabilities in children with extremely low birth weight and broadly average intelligence. Arch Pediatr Adolesc Med 2002;156:615–620. [PubMed: 12038896]
2. Anderson PJ, Doyle LW. Victorian Infant Collaborative Study Group. Executive functioning in school-aged children who were born very preterm or with extremely low birth weight in the 1990s. Pediatrics 2004;114:50–57. [PubMed: 15231907]
3. Grunau RE, Kearney SM, Whitfield MF. Language development at 3 years in preterm children of birthweight below 1000 g. Br J Disord Commun 1990;25:173–182. [PubMed: 2206965]
4. Vicari S, et al. Spatial working memory deficits in children at age 3–4 who were low birthweight, preterm infants. Neuropsychology 2004;18:673–678. [PubMed: 15506835]
5. Abernathy LJ, Cooke RWI, Foulder-Hughes L. Caudate and hippocampal volumes, intelligence, and motor impairment in 7-year-old children who were born preterm. Pediatr Res 2004;55:884–893. [PubMed: 14764914]
6. Kesler SR, et al. Volumetric analysis of regional cerebral development in preterm children. Pediatr Neurol 2004;31:318–325. [PubMed: 15519112]
7. Buzsáki G, Draguhn A. Neural oscillations in cortical networks. Science 2004;304:1926–1929. [PubMed: 15218136]
8. Joliot M, Ribary U, LLinás R. Human oscillatory brain activity near 40 Hz coexists with cognitive temporal binding. Proc Natl Acad Sci U S A 1994;91:11748–11751. [PubMed: 7972135]
9. Gazzaniga MS. Forty-five years of split-brain research and still going strong. Nat Rev, Neurosci 2005;6:653–659. [PubMed: 16062172]
10. Schermann L, Sedin G. Cognitive function at 10 years of age in children who have required neonatal intensive care. Acta Paediatr 2004;93:1619–1629. [PubMed: 15841771]

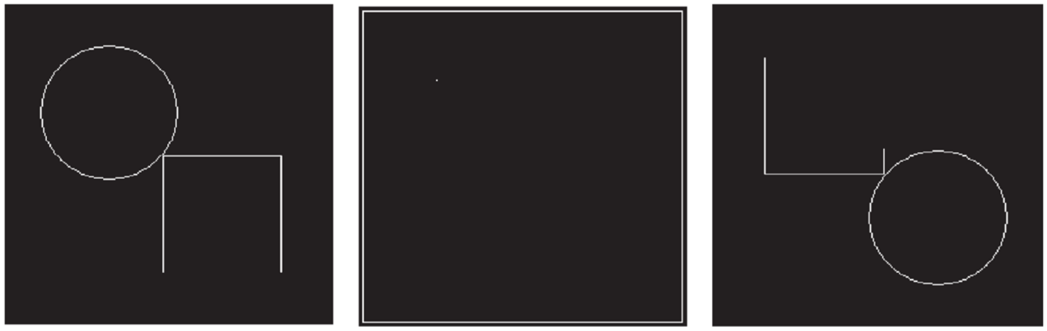

Fig. 1.
Visual–spatial memory task: example of one pair of stimuli (different spatial forms), which were presented sequentially (Stimulus 1, Black screen, Stimulus 2). From the Beery™ VMI, 5th Edition, with permission of the publisher (Copyright © 1967, 1982, 1989, 1997, 2004 Keith E. Beery, Norman A. Buktenica and Natasha A. Beery. All Rights Reserved. Published and distributed exclusively by NCS Pearson, Inc.).

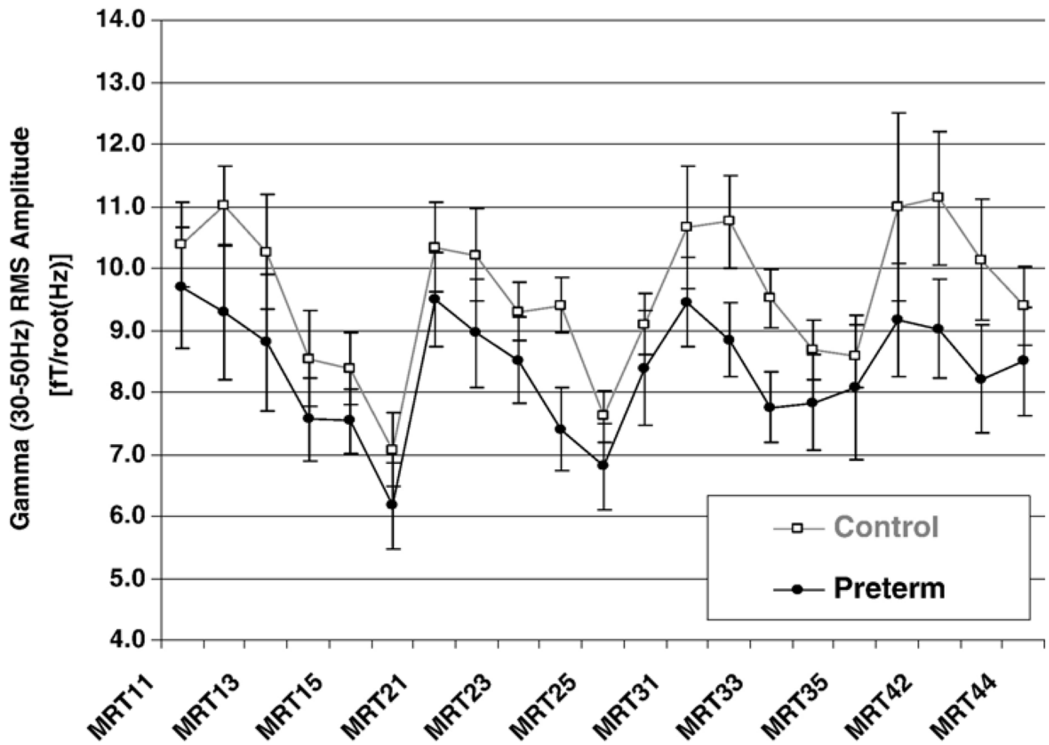

Fig. 2.
Total mean gamma-band power amplitude per sensor in the right temporal region during a visual–spatial memory task, for preterm and full-term control groups.

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Table 1

Characteristics of study participants

	Preterm	**Control**
Number	*n*=6	*n*=8
Sex	*F*=4; *M*=2	*F*=4; *M* =4
Mean corrected age±SD (years)	6.57±0.47	6.45±1.02
Mean gestational age±SD (weeks)	26.31±2.33	≥37