MEG and Complex Cognitive Functions in Paediatrics

Organizer: Charline Urbain and Margot J. Taylor

Room: # 105

Date and Time: Tuesday, October4 / 17:00-18:30

MEG Applied to the Understanding of Complex Cognitive Functions in Paediatrics

MEG, with its excellent spatial and temporal resolution, is the ideal modality to assess typical and atypical development of complex cognitive abilities. Studies show tremendous changes with age not only in the localisation of function in the brain, but particularly in the timing of the processing. The challenge has been to develop age-appropriate MEG tasks that are suitable for children and across an age range, and that assess complex cognitive abilities. Also, the resulting MEG data are more complex to analyse than those from simple sensory or motor tasks, as they often contain overlapping and widespread cortical and sub-cortical sources. This field, however, is one that will have increasing importance in translational clinical work. In this symposium, we bring together researchers to present examples of MEG studies of cognitive functions in typically developing children and clinical groups – ranging from working memory to theory-of-mind to cognitive control. These aspects of cognition have protracted maturational courses, and understanding their development in both typical and atypical populations will also facilitate the understanding of these abilities and the brain-behaviour relations in adult populations.

Speakers:

- **Nicola Molinaro, Mikel Lizarazu, Marie Lallier, Mathieu Bourguignon and Manuel Carreiras** (Basque Centre on Cognition, Brain and Language, Spain)
  "Entraining to auditory stimuli in developmental dyslexia"

  It has been recently suggested that the phonological disorder in dyslexia is the result of the malfunctioning of the primary auditory regions. Taking advantage of the excellent temporal resolution of magnetoencephalography (MEG) we analyzed in two studies the functionality of the auditory system in developmental dyslexia. We studied the neural entrainment (i.e., the reactivity of a neural network to synchronize with the rhythmic properties of an external stimulus) to the multiple frequencies of both the speech and non-speech signals, i.e., delta (~1Hz), theta (~4-7 Hz) and gamma (> 30 Hz) bands oscillatory stimulation. The results mainly highlighted that: (i) dyslexic readers show an atypical specialization of the auditory cortex to both low and high frequency amplitude modulations; (ii) such specialization is related to the anatomical properties of the auditory brain regions; (iii) neural synchrony to low-frequency speech oscillations in primary auditory regions hinders higher-order speech processing steps and the sampling of high frequency speech components. Such atypical auditory entrainment has the strong potential to cause severe consequences for both phonological and reading skills. Our findings, thus, strengthen proposals assuming that low-frequency acoustic entrainment hierarchically drives processing of higher speech frequencies and its impairment contributes to the phonological disorders in developmental dyslexia.

- **Duncan Astle** (MRC Cognition and Brain Sciences Unit, UK)
  "Altering developing brain systems with cognitive training"

  Children with poor working memory skills typically suffer from educational underachievement, and high levels of inattention; poor working memory is increasingly seen as central to a number of developmental disorders, including ADHD. Despite high levels of interest in working memory training, especially in childhood, little is known about the mechanisms by which gains are achieved. I will present data from a double-blind randomised controlled training study, using the dynamic electrical activity recorded using

MEG to explore underlying neurophysiological changes following training. We used new methods to explore the spontaneous coordination of electrophysiological signals at rest. Improvements in working memory after training were significantly associated with changes in functional connectivity between areas in fronto-parietal cortex and inferior-temporal cortex. During task performance we also observed enhanced coupling between the upper alpha rhythm (at 16 Hz), recorded in superior frontal and parietal cortex, and high gamma activity (at ~ 90 Hz) in inferior temporal cortex. This is the first demonstration that this hierarchically organised neuronal coupling can be measured in childhood and is associated working memory changes following training. We are exploring the impact of psychostimulant medication on these mechanisms, in children with a diagnosis of ADHD, which I shall also discuss.

- **Marc Vander** Ghinst, Xavier de Tiege (Université libre de Bruxelles, Belgium)
"Investigations of speech-in-noise cortical processing in healthy children and patients with Landau-Kleffner syndrome"

In a multitalker background, adults' auditory cortex follows the attended speech stream rather than the global auditory scene. Converging neurophysiological evidence shows that auditory cortex activity synchronizes with the slow modulations of the attended speaker's voice rather than with the whole acoustic input. This coupling occurs in the delta and theta frequency bands, and declines with increasing background noise level.
Since speech-in-noise and auditory attentional abilities are typically lower in children than in adults, this cortical coupling phenomenon observed in multitalker auditory scenes might be different during childhood.
In this talk, we will present neurophysiological evidence arguing for a different speech-in-noise cortical processing in children compared to adults. Recent magnetoencephalographic (MEG) data from our research group show that children exhibit significant noise-sensitive coupling only in the delta band that is significantly stronger for the whole acoustic input than for the attended speech stream. These results will be compared with those obtained in children at the recovery phase of Landau-Kleffner syndrome.
These MEG data shed light on the neural bases of children's difficulties understanding speech in noisy conditions and argues for a progressive development of speech-in-noise abilities in humans that can be altered by childhood brain disorders.

- **Charline M. Urbain, Veronica Yuk, Sarah Mossad, Rachel Leung, and Margot J. Taylor** (Hospital for Sick Children, Univ. of Toronto)
"Temporo-spatial brain dynamics of executive functions in children with autism"

Mounting evidence suggests that autism is a network disorder, characterized by atypical brain function and connectivity, especially in the context of high level executive processes. We will review MEG from three different studies: working memory (WM), emotional inhibition and theory of mind (ToM) tasks in typically developing (TD) children and children with ASD (20-25/group, 7-12yrs). We identified reduced inter-regional alpha-band (9-15 Hz) phase synchronization in children with ASD during the WM task which encompassed fronto-temporal networks. In addition, reduced connectivity processes anchored in the right fusiform correlated with the severity of symptoms in ASD. In the ToM task, TD children activated familiar ToM regions, such as the precuneus (325-400ms) and temporo-parietal junction (325-400ms), while children with ASD relied on WM and inhibition areas, such as the right inferior parietal lobule (475-600ms) and the right inferior frontal gyrus (425-550ms). In the emotion inhibition task, emotion regulation was associated with atypical brain processes in children with ASD from 225-400ms (ps<.005), particularly during the inhibition of angry faces in fronto-temporal areas. These studies buttress the network disorder hypothesis of ASD and suggest that children with ASD have atypical modulation of cognitive processing across a number of executive domains, impacting their social-cognitive deficits.