A combined fMRI / MTI study of the developing visual spatial integration in children

E. Fornari[1], R. Meuli[1], M. G. Knyazeva[1], R. Martuzzi[1], P. Maeder[1]
[1]Department of Radiology, Centre Hospitalier Universitaire Vaudois (CHUV), Lausanne, Switzerland

Purpose

In humans, visual spatial integration belongs to the higher-order functions, which develop slowly (Atkinson, 2000). Spatial integration across visual fields is based on interhemispheric interaction via the corpus callosum (CC), which gradually matures during the first two decades of life (Thompson et al. 2000). This combined fMRI and MTI study was aimed at comparison between children and adults in terms of local neural circuits involved in the interhemispheric visual integration.

Material and Methods

In the fMRI experiments, subjects (14 children, aged 7-13 years and 14 adults) viewed bilateral iso-oriented (IG) and orthogonally-oriented (OG) moving gratings alternated with background. The gratings were centered on a fixation point, had a spatial frequency of 0.5 cpd, and drifted with a temporal frequency of 2 Hz. Gaze fixation was monitored with an eye tracking system.

In children, magnetization transfer imaging (MTI) was used to assess the brain maturation with a general index of myelination (van Buchem et al. 2001).

We restricted our analysis to the Magnetization Transfer Ratio (MTR) changes in the ROI defined as the CC splenium. Further, we performed an AnCova on the group data with individual IG activation as dependent variable, splenium mean MTR as covariate, and total brain mean MTR as nuisance variable.

Results

Our previous experiments showed that, in adults, bilateral IG stimulus fusible into a single image induced interhemispheric synchronization between occipital EEGs signifying interhemispheric integration. The same stimulus, compared to OG, also induced BOLD increase within VP/V4 areas (fusiform and lingual gyri).

In children, the BOLD differential activation for this contrast was significant in the lingual gyrus although less extended. Assuming that the difference between children and adults could be due to the late myelination of the interhemispheric fibers, we correlated the MTI and fMRI measures in children.

The AnCova results revealed areas of visual activation associated with the splenium myelination. Specifically, lingual gyrus activation was proportional to splenium myelination across subjects (***P*** (corrected) < 0.05, Fig. 1).

Furthermore, using MTR mean values to classify our children population in two groups, for the group with more advanced myelination, we have shown an increase in VP activation for the IG > OG contrast, which resulted in activation patterns intermediate between low myelinated children and adults (Fig. 2).

Conclusion

Our data suggest that interhemispheric integration is mediated by cortico-cortical connections and that their myelination is a significant factor behind the maturation of visual spatial integration.

References
Atkinson J. The Developing Visual Brain. NY. Oxford University Press. 2000
Thompson PM et al. Nature 2000 404: 190-3
van Buchem M.et al. AJNR 2001 22:762-766

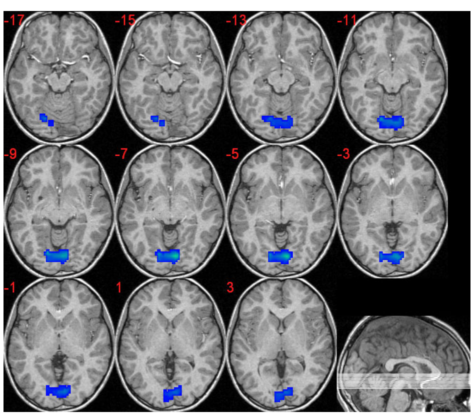

Fig.1 AnCova results: in lyngual gyrus 79% of the variance of BOLD response can be explained by myelination measured in the splenium by MTR mean value.

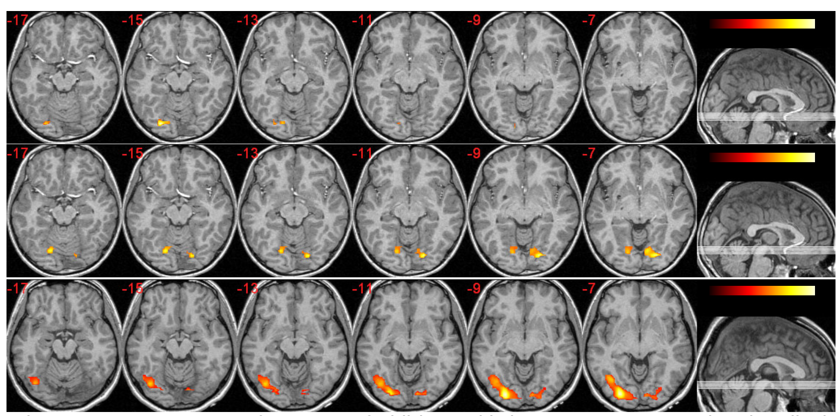

Fig.2 IG vs OG contrast for group of children with lower MTR mean value (top line), higher MTR mean value (middle line), and adults (bottom line)