Enhancement of FA in child`s brain after long-term abacus mental calculation training

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Introduction

Abacus mental calculation (AMC) is a special kind of mental calculation relying on the basic principle of abacus calculation. Comparing with their age-matched counterparts, children who have received AMC training for long time demonstrate a high ability in mental calculation. In our previous study, it was found that brain regions involved in mental calculation were quite different between children who employed AMC strategy and those used common mental calculation method [1]. In this study, we attempt to explore whether there are anatomic structure alteration occurred in the brain by AMC training. Fractional anisotropy (FA), which driven from diffusion tensor imaging (DTI) data, is used to seek answer for this questions.

Subjects

Twenty one right-handed healthy abacus children (8 female, 10.29 ± 0.54 years) and twenty one right-handed healthy control children (11 female, 9.98 ± 0.54 years) participated. All abacus children have received AMC training for about 4 years and 0.5–1 hour per day. The controls had no experience in abacus training.

Images Acquisition and Analysis

All the participants underwent the same protocol for DTI scanning using a 3.0T Phillips MRI scanner with SENSE coil technology. DTI data were obtained using with single-shot echo planar imaging sequence (TR/TE = 5500/78 ms, FOV = 240 mm, matrix size = 288 × 288, 50 slices, slice thickness = 3 mm, no gap) with 15 isotropically distributed orientation for the diffusion-sensitizing gradients at a b-value of 800 s/mm^{-2} and one non-diffusion image. All DTI data were first corrected for eddy current distortions and head motion before diffusion tensor estimation. Voxelwise statistical analysis of the FA data was carried out using TBSS (Tract-Based Spatial Statistics [2], part of FSL [3]. TBSS projects all subjects' FA data onto a mean FA tract skeleton, before applying voxelwise cross-subject statistics.

Results and Discussion

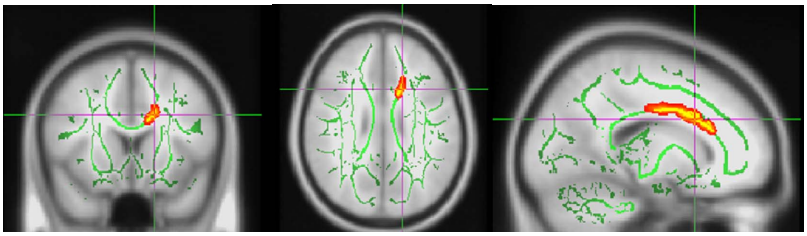

Figure.1. Long-term abacus mental calculation trained children show higher FA intensity across the left callosum in TBSS analysis result. (t-test, $p < 0.05$, corrected). Mean FA skeleton of all subjects is shown with green color overlapped on the MNI152 template.

Abacus group shows a stronger FA intensity than the controls in middle callosum (figure1). No regions have been found with higher FA intensity in the controls even at an uncorrected $p < 0.05$. The callosum is a core part associating the two hemispheres. In the integration view, higher intensity of FA at callosum indicates a stronger connection in anatomic structure. The result may indicate that neuronal connectivity will be enhanced by long-term training of AMC in children. However, whether a stronger FA map indicates a more integrated and robust brain network, and if stronger connectivity in structure will facilitate the brain to enhance its function still remains to be investigated further.

Reference

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[3] Smith, S.M., et al. (2004) NeuroImage, 23(S1), 208-219.