Effects of early nutrition on brain structure

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Introduction

The first experimental study designed to test the impact of early nutrition on cognitive development into adult life began in the early 1980's (1) when preterm infants were assigned to different nutritional intakes. In one arm of the study, these newborn infants were assigned either to a control diet (n=210) or a nutrient-enriched diet (n=213) designed to promote faster growth and nutrient accretion. Follow-up studies of this cohort have shown that, at 7-8 years of age, there was an IQ advantage in those fed the enriched diet, reaching 12 points for Verbal IQ in males (2). The present study uses voxel-based morphometric analysis of 3D stuctural MRI datasets, in the same intervention studies, to examine the impact of early nutrition on brain morphology.

Methods

We obtained scans from 52 adolescents, 30 from those assigned to the control diet (CD group: 12M,18F; mean age 16y3m) and 22 from those assigned to the enriched diet (ED group: 11M,11F; mean age 15y10m). There were no significant differences between the groups on a series of perinatal variables (birthweight, gestational age, Apgar scores, days at ventilation) nor on social class or mothers' education. MRI examinations were carried out using a 1.5 Siemens Vision system, and included 3D MPRAGE acquisition with TR 10ms; TE 4ms; TI, 200ms; flip angle, 12 degrees; matrix size, 256x256; field of view, 250mm, partition thickness, 1.25 mm; 128 sagittal partitions in the third dimension, and acquisition time, 8.3 min. The scans were analysed using voxel-based morphometry (VBM; Wellcome Department of Imaging Neuroscience, Institute of Neurology, London), which provides a means of detecting subtle abnormalities not seen on visual assessment. The images were spatially normalised, segmented, smoothed (12 mm FWHM) and then entered into statistical analyses. We carried out t-test comparisons between the two groups on grey and white matter separately. Because of a wide range of age at scan (14y7m - 19y3m), we used this variable as a covariate in the analyses to rule out differences attributable to brain development over this period.

Results

As Figure 1 shows, we found an area in the left parietal lobe where the ED group had significantly more grey matter than the CD group ($p<0.018$). The white matter analysis showed the reciprocal relationship, i.e. the CD group had more white matter in this area ($p<0.006$). These p-values are corrected, using the familywise error procedure, for the multiple comparisons inherent in the method. Talaraich coordinates for the two peak voxels were almost identical (grey matter: -26, -57, 42; white matter: -26, -58, 42), placing both in the region of the left intraparietal sulcus. Since developmental anomalies are frequently bilateral, we then conducted a conjunction analysis, with scans normalised to a symmetrical template, that searches explicitly for the presence of symmetrical bilateral abnormalities (3). This revealed a bilateral difference in grey matter in the same region (±22, -56, 42; p corrected = 0.142, uncorrected = 0.0001), consistent with a homologous effect in the right hemisphere.

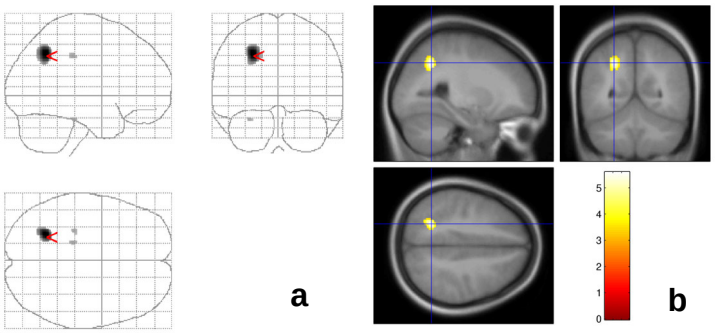

Fig. 1. Statistical parametric maps showing regions where the enriched-diet group had significantly more grey matter than the control-diet group; (a) glass brain representation; (b) the superimposition of Z-scores on the mean anatomical image is shown in colour for planes through the most significant parietal lobe voxels. A threshold of $p<0.001$, uncorrected, was chosen for display.

Conclusions

An impact of early nutrition on long-term brain structure in humans has not previously been demonstrated. Now that suitable tools have emerged, however, we have been able to undertake this sort of study. The demonstration here of long-term and, probably, lifetime effects of early nutrition on the structural development of the brain has major potential biological and social implications, given the prevalence of malnutrition.

References

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(3) Salmond et al. Hum. Brain Mapp. 2000; 11:223-232.