Differences in Brain Activation Associated with Infant Diet: An fMRI Study

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INTRODUCTION: The World Health Organization recommends exclusive breastfeeding, which has been associated with higher IQ, better school performance, and better neurocognitive development in children. When breastfeeding is not possible or not chosen, cow's milk formula has been the recommended formula. Milk formulas are made with bovine milk protein, and while the amino acid composition is similar to that of human breast milk, there are significant differences in the overall composition of milk formulas and human breast milk. It is possible that these differences can impact the developing brain. The aim of this study was to evaluate brain function in healthy 8-year-old children who were fed predominantly breast milk or cow's milk formula during the first year of life. Our hypothesis was that infant diet has significant effects on brain functioning in school aged children. To test this hypothesis, we performed a visual perception/language fMRI to compare brain activation in these two diet groups.

METHODS: Forty-one healthy 7.5-8.5 years old children who had parental report of predominant breast milk or cow's milk-based formula feeding during the first year of life were recruited for this IRB approved study. Predominantly breastfed (BF, N=22) infants were breastfed for at least 6 months before transitioning to formula. Predominantly milk formula-fed (MF, N=19) infants were fed for the same type of formula for at least 8 months. All participants were born full-term with birth weight between 5-95th percentile-for-age. Participants underwent a MRI examination performed on a 1.5 Tesla Philips Achieva system with a conventional sagittal T1-weighted 3D turbo field echo sequence for structural MRI and an axial single shot gradient echo planar imaging (EPI) sequence for fMRI. The fMRI used a block design and included a perception component in which the participants were requested to determine whether two symbols on the screen (i.e., / \) match with the two symbols on the previous screen (i.e., \ \, / /, \ /), and a language component in which the participants were requested to determine whether two words presented one after the other on the screen rhyme or not. After the scan, the images were exported to a workstation with BrainVoyager software for standard fMRI data processing, including slice scan time correction, motion correction, spatial smoothing, and temporal filtering. The T1-weighted 3D images were also exported to BrainVoyager to create an anatomical image series, and the processed fMRI images were co-registered to the anatomical images and transformed to the Talairach Atlas to create a 3D-aligned time course data set. A stimulation protocol was then created to represent the block design and general linear model (GLM) analysis was performed to calculate activation maps for the 3D-aligned time course data set for each subject. The average activation maps for each diet group were calculated by multi-study multi-subjects GLM and compared. The activated cluster size in different brain lobes were compared between diet groups. In addition, task performance parameters such as percentage of response made within the allocated reaction time interval for all trials and percentage of correct answer were also compared among groups.

RESULTS: Average activation maps (P<0.001, corrected, cluster size>30) for the perception (**Figure 1**) and language fMRI (**Figure 2**) both showed decreased activation in MF children compared to BF children. A quantitative analysis of activation cluster size (**Table 1**) revealed that MF children had significantly less brain activation in the right frontal, left temporal, and right temporal lobes when processing the perception task. MF children also had significantly less brain activation in the left temporal/occipital lobe when processing the language task. In addition, the fMRI task performance data also showed that MF children had significantly lower performance in 3 out of the 4 measures (**Figure 3**).

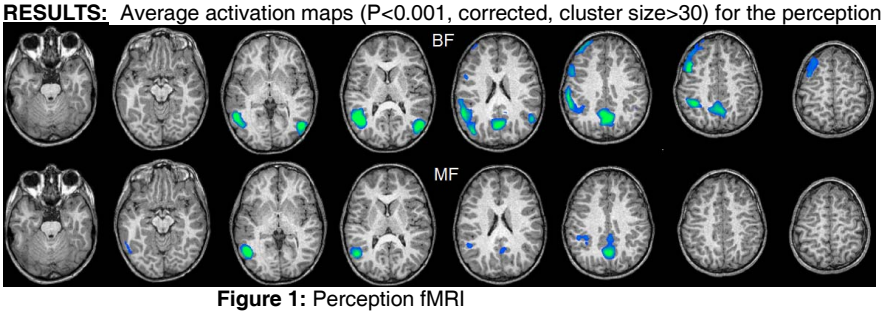

Figure 1: Perception fMRI

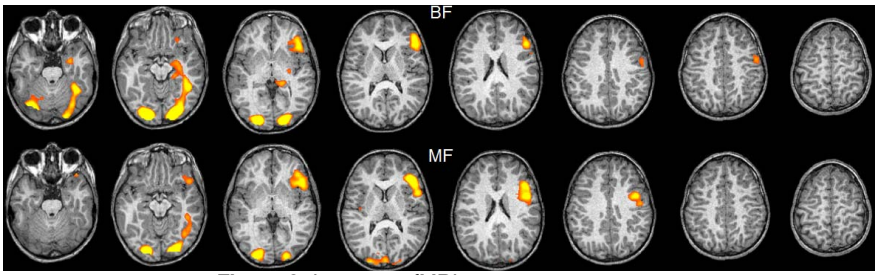

Figure 2: Language fMRI

	BF (mean/ste)	MF (mean/ste)	P value
perception			
Right frontal	1280(814)	6(6)	**0.002**
parietal	1263(488)	723(546)	0.445
Left temporal	1394(680)	112(86)	**0.011**
Right temporal	2263(1364)	33(22)	**0.041**
rhyming			
Left frontal	1125(616)	261(113)	0.513
Left temporal/occipital	2632(650)	613(213)	**0.04**
Right temporal/occipital	1894(609)	909(369)	0.251

Table 1: Comparison of total size of activation clusters for the fMRI

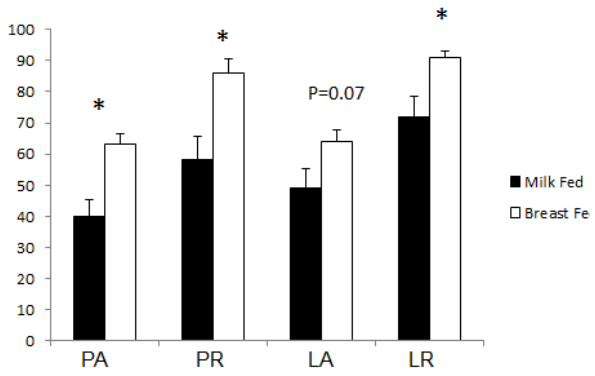

Figure 3: Task performance data (* P<0.05 for BF and MF comparisons, y axis is the percentage):
PA: percentage of correct answer for the perception task;
PR: percentage of response for the perception task;
LA: percentage of correct answer for the language task;
LR: percentage of response for the language task

CONCLUSIONS: Our results showed that BF and MF children utilize their brain differently when processing visual perception and language functions.BF children performed better on both tasks. Our results indicated that there is a difference in brain functioning associated with infant diet.

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