Early childhood home environment predicts frontal and temporal cortical thickness in the young adult brain

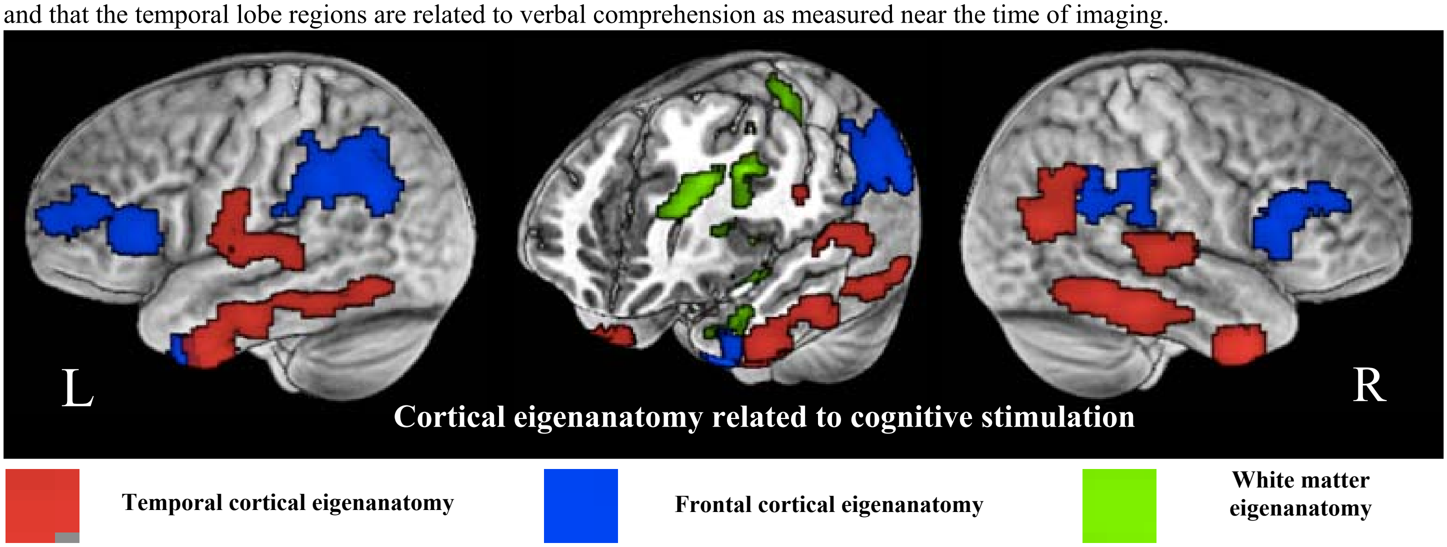
Brian B Avants[1], Gwen Lawson[1], James Gee[1], Martha Farah[1], and Hallam Hurt[2]

[1]University of Pennsylvania, Philadelphia, PA, United States, [2]Children's hospital of philadelphia, Philadelphia, PA, United States

Introduction: Evidence from animal models and humans experiencing early adversity suggests that the early environment has long-term consequences on later cognitive functioning, psychological well-being, and structural brain develop- ment. Substantial work with rodents has shown that early experience such as the variety of the cage environment or the presence of chronic stressors influences brain structure and function across a large number of brain areas (for a review, see [1]). However, very little work has been performed in human subjects to test whether normal variation in early experience has measurable long term effects on the brain [2].

Methods: Our analysis leverages 106 participants from a low socioeconomic status background who were followed from birth and who underwent T1 and diffusion tensor (DT) MR imaging on a Siemens 3T Trio. Of the 106 total individuals with MRI data, 64 both met quality standards for further image processing and underwent the HOME assessment at age 4. Of these 64, 29 are male (a.a. = 19.4 ± 1.17) and 35 are female (a.a. = 19.1 ± 1.30). Differences in the age of the cohort distribution are not statistically significant. Differences in parental IQ between males and females and GSE and controls are not significantly different. Each subject also underwent the HOME assessment at age 4 which is a questionnaire that may be used to quantify a more cognitively stimulating and emotionally supportive home. Each of these two components may be treated independently as they derive from subsets of the HOME questionnaire. The imaging analysis is based on the publicly available and open-source Advanced Normalization Tools (ANTs) and the associated pipelining framework PipeDream. In this work, we use neuroimaging to test the hypothesis that networks supporting cognition should be enhanced by increased stimulation and nurturance during childhood. We therefore use a statistically powerful dimensionality reduction technique (Eigenanatomy) to extract covarying structure from T1-derived voxel-based cortical thickness measures (via the DiReCT method) and fractional anisotropy of the DTI. This dimensionality reduction leads to sets of voxels that are summarized by a single measure and which may be tested for unique association with early cognitive stimulation. Our statistical model, implemented in the **R** programming language, controls for age, gender and parental IQ.

Results: Our results show, for the first time, that cortical thickness in early adulthood is reduced (independently from parental IQ) by increased quality of the home environment at age 4. Only the cognitive stimulation vector of the home environment, not the maternal nurturance component, showed a significant relationship with cortical thickness. These results, which identify a novel network of cortical regions that are directly influenced by parental behavior, appear in Figure 1 below. A further analysis revealed that early cognitive stimulation has a stronger effect on frontal lobe cortical thickness in female subjects ($p < 0.0069$) than in males ($p < 0.5000$) and that the temporal lobe regions are related to verbal comprehension as measured near the time of imaging.



Conclusion: This is one of the few studies to investigate the effect of normal variability in the home on neuroanatomy and, specifically, cortical thickness in a control cohort. The results may have implications for both the timing and specific strategies employed by intervention programs. While specific associations between frontal and temporal lobe neuroanatomy and cognition have been established in the past, our study is perhaps the first to also associate the early home environment with both anatomy and cognition. Such studies are critical to understanding how potentially subtle environmental variations may have lifelong impact on outcome.

References: [1] van Praag H, Kempermann G, Gage FH (2000) Neural consequences of environmental enrichment. Nat Rev Neurosci 1: 191–198.. [2] Duncan GJ, Brooks-Gunn J, Klebanov PK (1994) Economic deprivation and early childhood development. Child Dev 65: 296–318.