Prefrontal Cortex Development in Post-Institutionalized Adolescents

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Introduction

Animal studies have documented neuroanatomical and behavioral effects of early life deprivation. Research with post-institutionalized (PI) children suggests that early deprivation is associated with potential deficits in cognitive and socioemotional development (Gunnar et al., 2000), and changes in the limbic system (Mehta et al., 2009; Tottenham et al., 2010) and prefrontal cortex (Eluvathingal et al., 2006; Behen et al., 2009; Govindan et al., 2010). Although individual variability exists, longer duration of institutional care is predictive of reduced physical catch-up growth (Van IJzendoorn et al., 2007) and poorer cognitive achievement (Johnson, 2002).

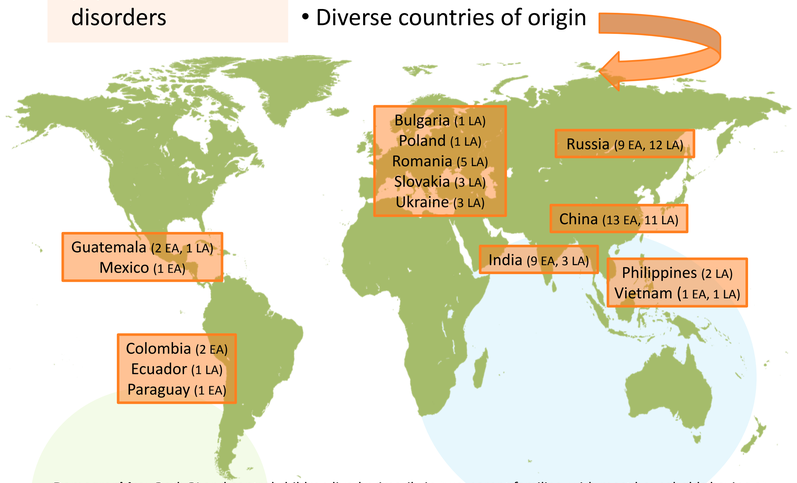
http://www.evolutionaryparenting.com/wp-content/uploads/2011/08/cribs_-_babies_in_orphanage.jpg

Few studies have investigated the relationship between duration of institutional care and prefrontal cortex development during adolescence. Based on animal models of early life stress (e.g. Vyas et al., 2002), we hypothesized that longer exposure to institutional care would be associated with reduced prefrontal volume and atypical cortical thickness.

Participants

12-14 year old children either adopted internationally from institutional care or raised in Minnesota with their biological family

Controls	Early Adopted (PI-EA)	Late Adopted (PI-LA)
N = 38 (18 females)	N = 38 (28 females)	N = 44 (26 females)
Not adopted	Adopted before 12 months	Adopted between 13-72 months
• No developmental, neurological, or psychiatric disorders	• No FAS or developmental disorders • At least 50% of pre-adoptive care spent in an institution • Diverse countries of origin	



Demographics: Both PI and control children lived primarily in two-parent families, with most households having at least one parent who had completed college or a graduate level degree. Median household income was $90,000 for PI children and between $76,000-$100,000 for controls. Unlike PI children, control children were predominantly Caucasian.

Excluded Participants: Twenty-two additional PI children were excluded due to excess motion during the imaging protocol (14), gross brain abnormalities (4), or failure to meet eligibility criteria for the study (4). All non-adopted control children who participated provided useable data.

Questions

Do post-institutionalized (PI) children show altered development of the prefrontal cortex?

Are changes in brain development more pronounced in later-adopted PI children?

Methods

***Structural MRI Scan*:** T1-weighted 3D MPRAGE anatomical series acquired on a Siemens 3T Trio Scanner

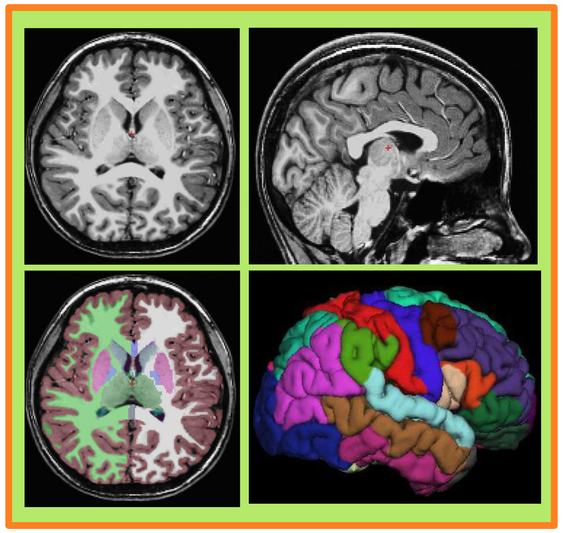
- TR = 2530 ms, TE = 3.56 ms, FOV = 256 mm, flip angle = 7 degrees
- slice thickness = 1 mm, 240 sagittal slices

***MRI Analyses*:** Freesurfer Image Analysis Suite was used to obtain automated, volumetric segmentation data for subcortical and cortical structures

Cortical thickness analyses adjusted for average hemispheric thickness

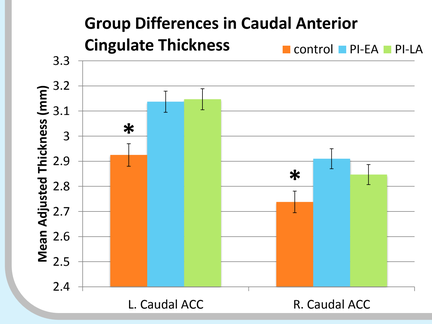
Volumetric analyses adjusted for total intracranial volume

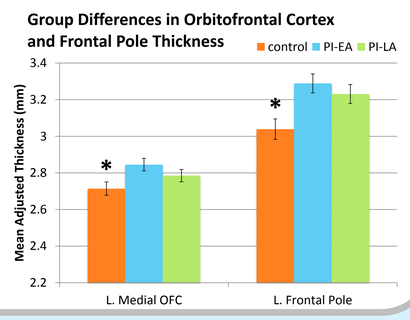
All analyses included age and gender as covariates



Prefrontal Cortical Thickness

- Both EA and LA children had increased cortical thickness in bilateral caudal anterior cingulate, left medial orbitofrontal cortex, and left frontal pole
- No group differences in cortical thickness were detected in any other prefrontal regions





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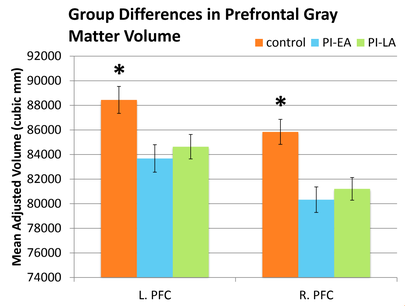
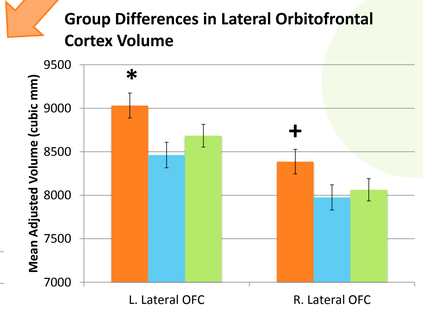
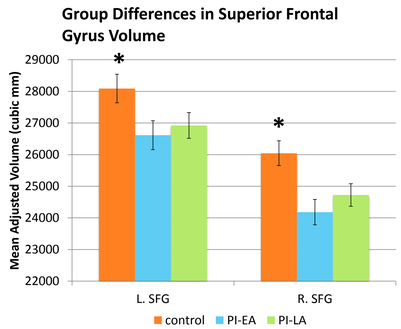
Prefrontal Gray Matter Volume

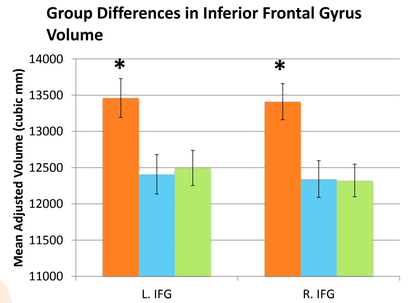


- Both EA and LA children had reduced bilateral gray matter volume in prefrontal cortex

- Volume reductions were driven by effects in left lateral orbitofrontal cortex and bilateral superior and inferior frontal gyri







Discussion

We found evidence for persisting effects of early life deprivation in prefrontal cortex development of PI children, which has been implicated in animal models of early life stress:

- *Prefrontal cortex thickness* was atypical in both EA and LA children in bilateral caudal anterior cingulate, left medial orbitofrontal cortex, and left frontal pole. Does this represent developmental differences in synaptic pruning?
- *Prefrontal cortex volume* was reduced in both EA and LA children. Is this region especially vulnerable to early stress?
  - Group differences were driven by volume reductions in left lateral orbitofrontal cortex and in bilateral superior and inferior frontal gyri.

We did not find strong evidence for the duration of early life stress impacting prefrontal cortex development, given the largest differences in structural brain development were between PI children and non-adopted controls.

Future studies should investigate the functional implications of atypical prefrontal volume and thickness in PI children.

Conclusion

By early adolescence, PI children show altered development of both prefrontal cortical thickness and prefrontal gray matter volume.