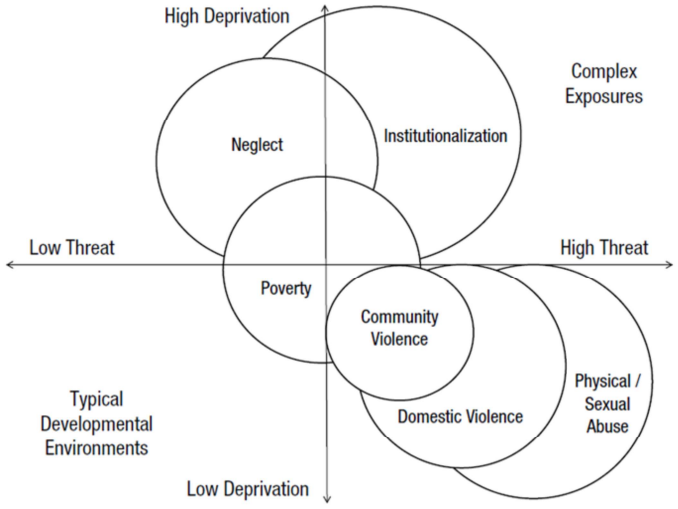
DIFFERENTIAL ASSOCIATIONS OF BRAIN STRUCTURE WITH EARLY THREAT AND DEPRIVATION.

Matthew Peverill, Maya L. Rosen, Kelly A. Sambrook, Margaret A. Sheridan, Katie A. McLaughlin

Adverse Experiences in Childhood

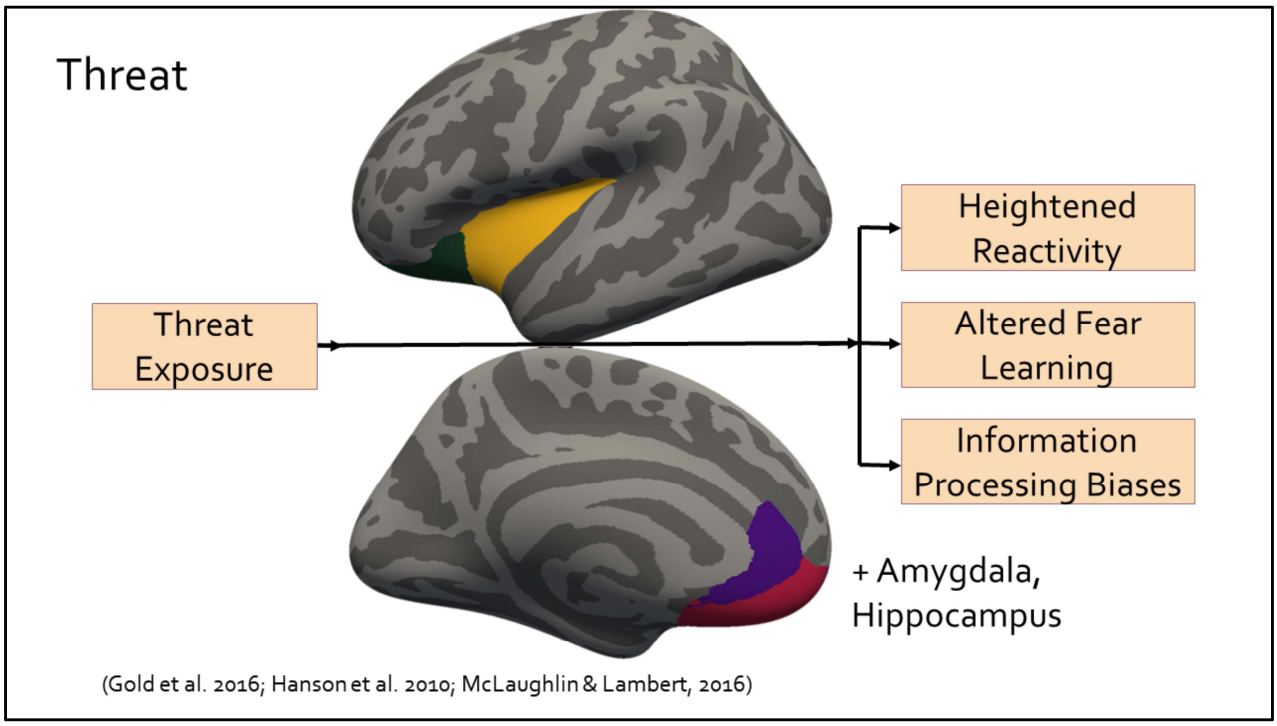


(McLaughlin and Sheridan, 2016)

Our group and others have been investigating a dimensional model of child adversity. Crucially, this model predicts that the consequences of different childhood adversities will not be interchangeable, but instead will be clustered according to specific qualities or dimensions of those experiences. Thus far, investigations have focused on the dimensions of threat, experiences involving harm or threat of harm, and deprivation – experiences involving an absence of expected inputs from the environment.

…

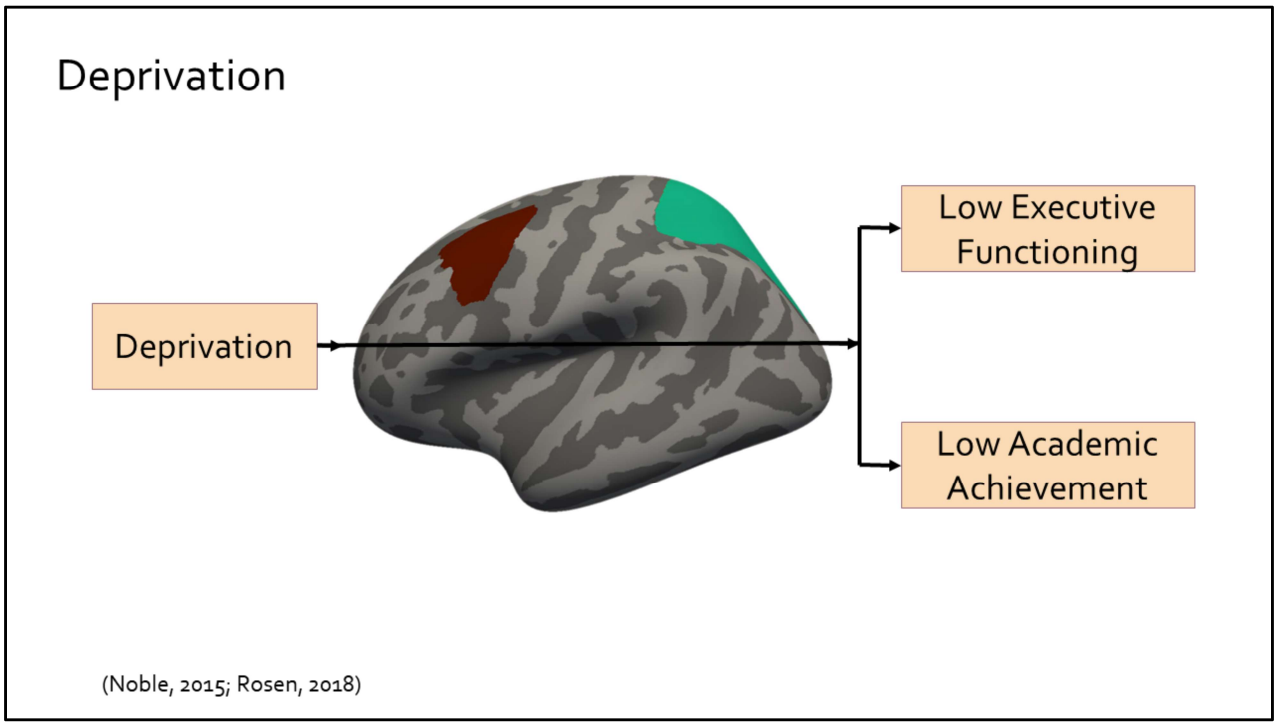
Among other things, this theory predicts differential effects on brain development.



More specifically, we would expect that threatening experiences in childhood would lead to later adaptation in the direction of rapid identification of and response to danger, including heightened reactivity to threat cues, altered fear learning, and biases in information processing towards rapid identification of threat. These are changes that we would expect to be adaptive for young people in dangerous environments

We would expect these differences to be correlated to changes in brain systems involved in processing salience and threat cues. This salience network includes the insula, lateral and medial orbitofrontal cortex, and rostral anterior cingulate, as well as the amygdala and hippocampus.

Past research on neural correlates of child abuse, an experience involving a great deal of threat, has indeed identified structural differences in these areas.



On the other hand, absence of expected inputs in deprivation may have different effects. Lower levels of early cognitive stimulation have been associated with lower levels of executive function and academic achievement later in life. These associations may be mediated by changes in fronto-parietal control networks and other areas associated with executive functioning. For example, work from our lab showed that, in a sample of young children, scores on a scale of environmental complexity were correlated with cortical thickness in both the caudal middle frontal gyrus, and the superior parietal cortex, as illustrated here.

…

So we see associations of both threat and deprivation with brain structure, but stronger evidence for the theory would come from an analysis of differential associations of one dimension of adversity with brain structure while controlling for the other, and that has yet to be tested. So I'm going to be presenting results from one such analysis.

Hypothesis: Threat

Threat will be associated with reduced thickness in the salience network, and decreased volume of the hippocampus and amygdala.

Hypothesis: Deprivation

Deprivation will be associated with reduced thickness in the fronto-parietal control network:

Hypothesis 3: Deprivation and Threat

Brain structure differences associated with threat will persist after controlling for deprivation.

Brain structure differences associated with deprivation will persist after controlling for threat.

METHODS

Sample

- 161 youth (12 excluded due to motion)
- 76 threat exposed
- 79 deprivation exposed
- 48% female
- 8-17 (M=12.8)
- 20% living below poverty line

Participants recruited from the Seattle area. We recruited threat exposed children through schools, after-school and prevention programs and community mental health clinics. We targeted threat-exposed adolescents, as well as matched controls.

Measuring Threat

Definition:

Exposure to any of:

- Physical Abuse
- Sexual Abuse
- Community Violence
- Domestic Violence

Measures:

- Child Trauma Questionnaire
- Child Experiences of Care and Abuse Interview
- Screen for Adolescent Violence Exposure

(Bernstein et al. 1997; Bifulco et al., 1994; Hastings & Kelley, 1997)

Measuring Deprivation

Definition:

Exposure to any of:

- Physical Neglect
- Emotional Neglect
- Low Cognitive Stimulation

Measures:

- Child Trauma Questionnaire
- Child Experiences of Care and Abuse Interview
- Home Observation for Measurement of the Environment

(Bernstein et al. 1997; Bifulco et al., 1994; Mott, 2004)

Analysis

- T1 structural mri
- Automatic thickness calculation in Freesurfer 5.3
  - 15mm smoothing kernel
  - Group comparison with GLM
  - Cluster corrected using Monte-Carlo simulation.
    - Cluster-forming $p < .05$
    - Cluster-wise $p < .05$
- Volume extracted for sub-cortical ROIs
  - Group comparison using ANOVA

(Fischl & Dale, 2000; Hagler, Saygin, & Sereno 2006)

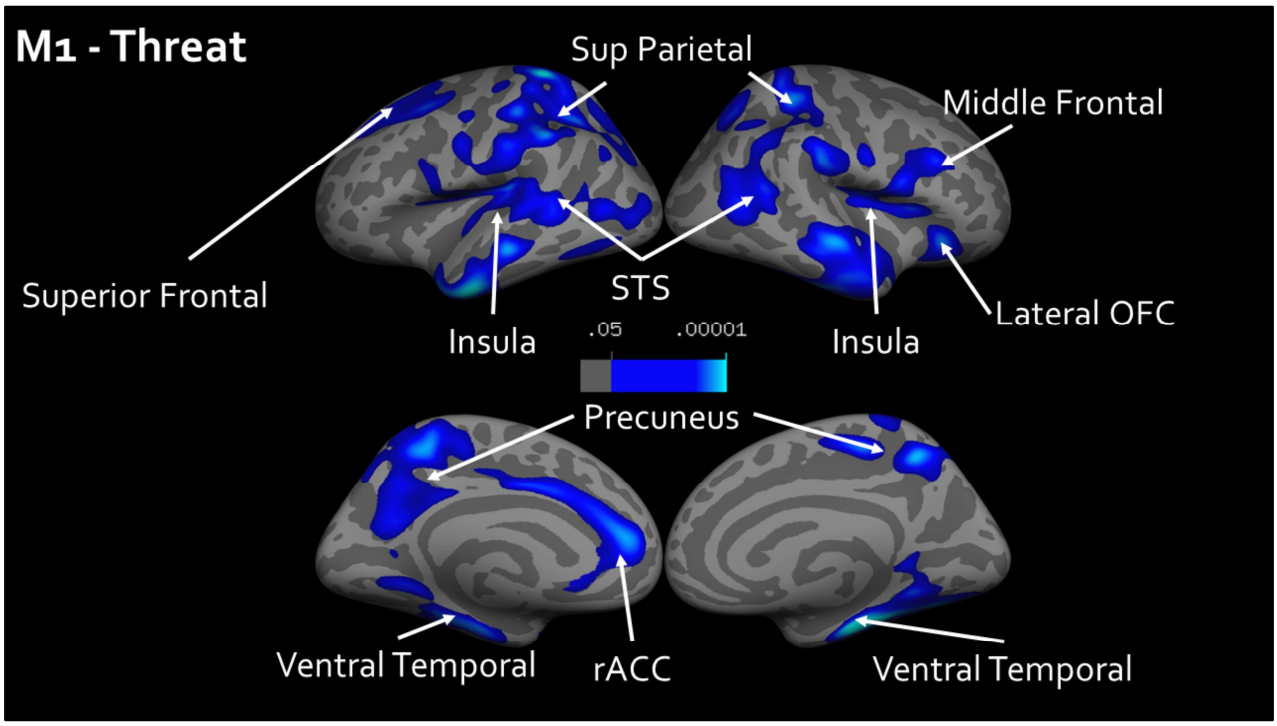
Modeling

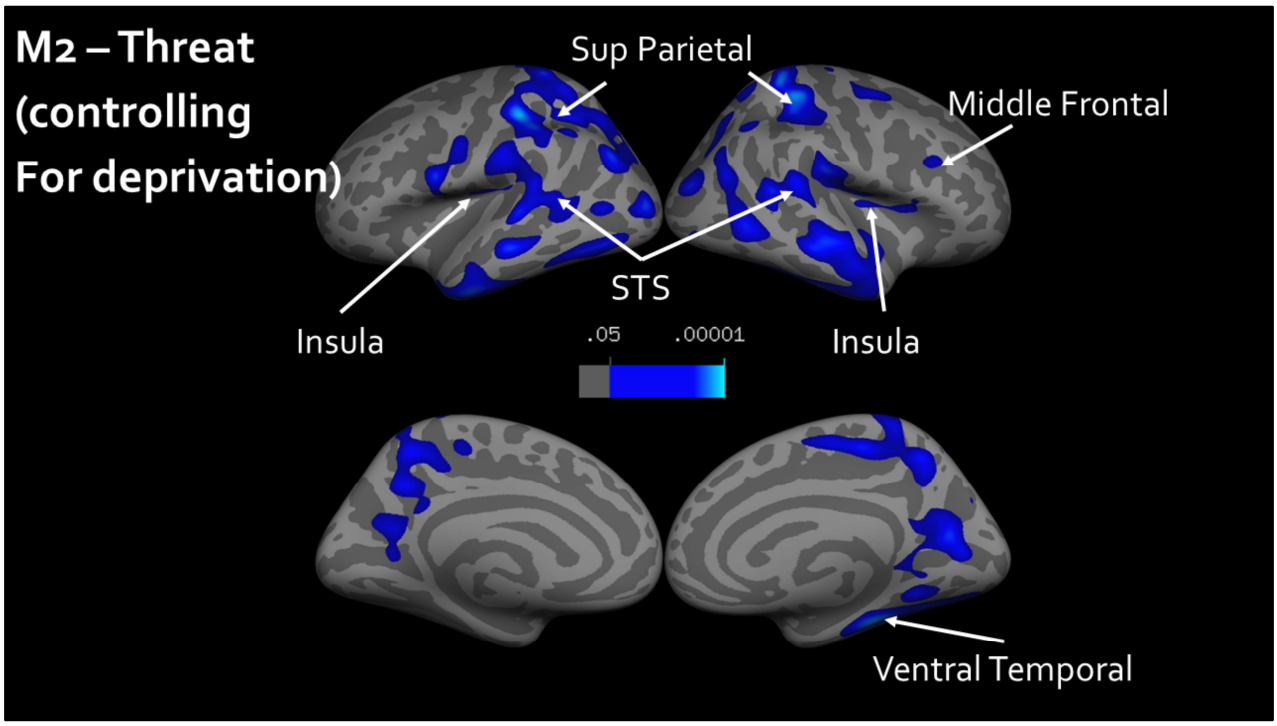
- Model 1: Threat
- Model 2: Threat, controlling for Deprivation
- Model 3: Deprivation
- Model 4: Deprivation, controlling for Threat

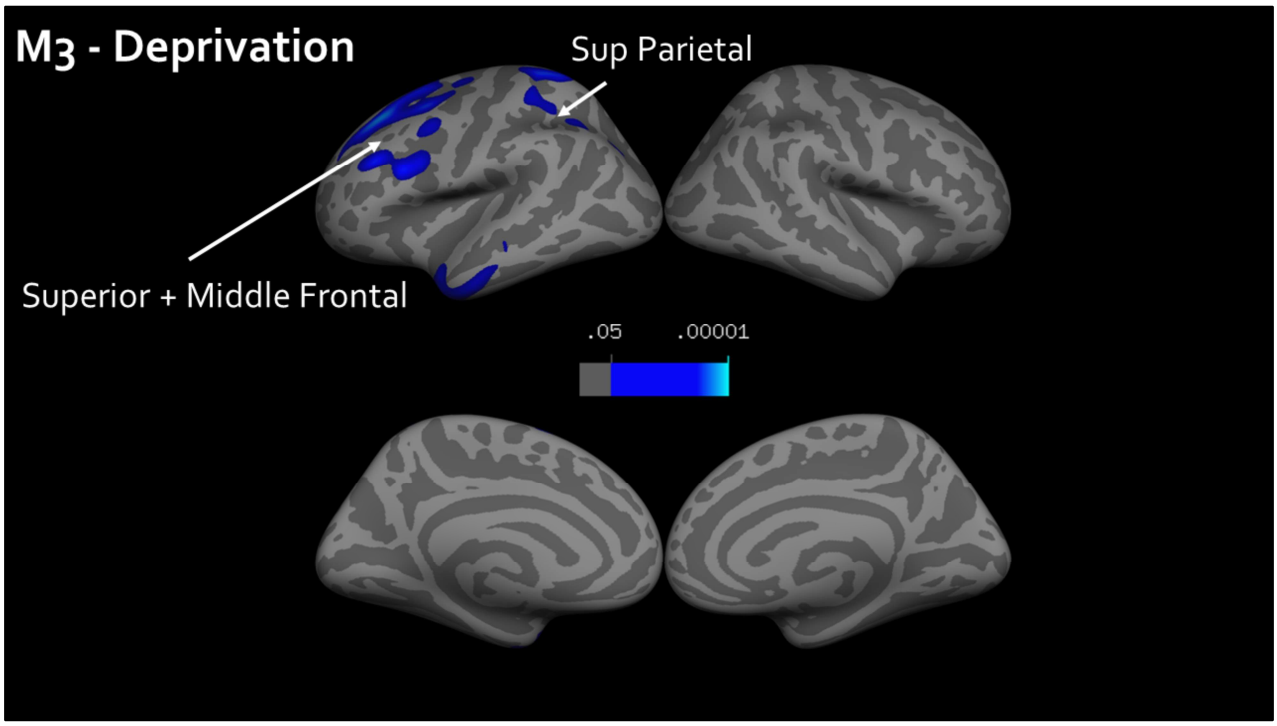
All models controlled for age and sex

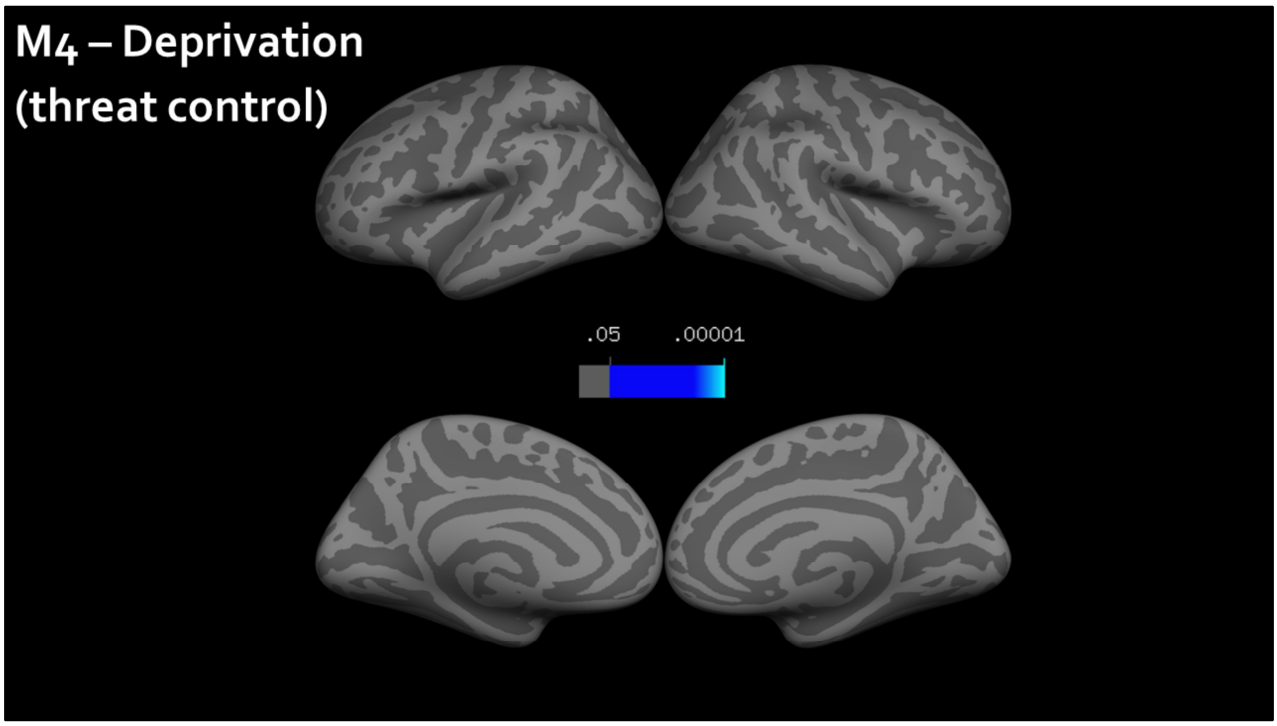
RESULTS

Thin=Blue

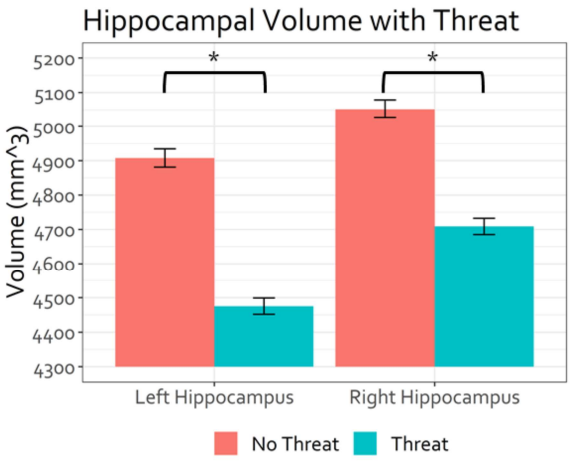

M1 - Threat
Sup Parietal
Middle Frontal
Superior Frontal
STS
Lateral OFC
Insula
.05
.00001
Insula
Precuneus
Ventral Temporal
rACC
Ventral Temporal

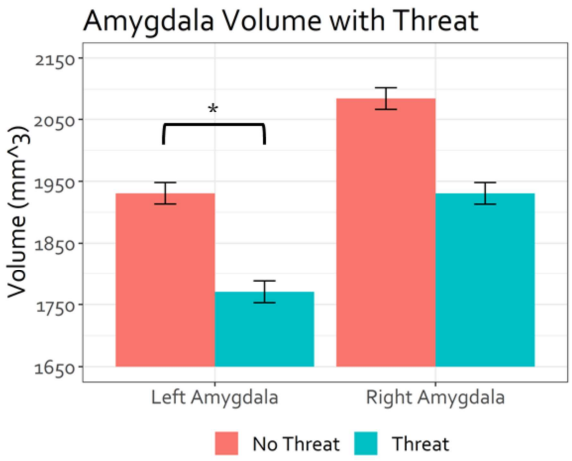

M2 – Threat
(controlling
For deprivation)
Sup Parietal
Middle Frontal
STS
Insula
.05
.00001
Insula
Ventral Temporal


M3 - Deprivation
Sup Parietal
Superior + Middle Frontal
.05
.00001


M4 – Deprivation
(threat control)
.05
.00001

Roi Analysis





Increased threat, but not deprivation was associated with reduced volume in hippocampus after control for age, sex, and intracranial volume. Same relation in left Amyg. No changes for cross control.

DISCUSSION

Effects of Threat on Neurodevelopment

Hypothesized Area	Thinner with Threat	… after Control
Rostral Anterior Cingulate	✓	
Medial Orbitofrontal		
Lateral Orbitofrontal	✓	
Insula	✓	✓
Hippocampus	✓	✓
Amygdala	✓	✓

Effects of Deprivation on Neurodevelopment

Hypothesized Area	Thinner with Deprivation	… after Control
Superior Parietal Cortex	✓	
Middle Frontal Gyrus	✓	

Future Directions

- Longitudinal data
- Higher deprivation samples

Use longitudinal data and cross lag models to establish precedence.

Recruit specifically to capture more range in deprivation experiences. Stay tuned because we have another sample that does just that.

Conclusions

- Threat associated with thinner cortex and reduced subcortical volume in the salience network.
- Deprivation associated with thinner cortex in frontoparietal control network.
- Threat showed associations with brain structure that were independent of deprivation.

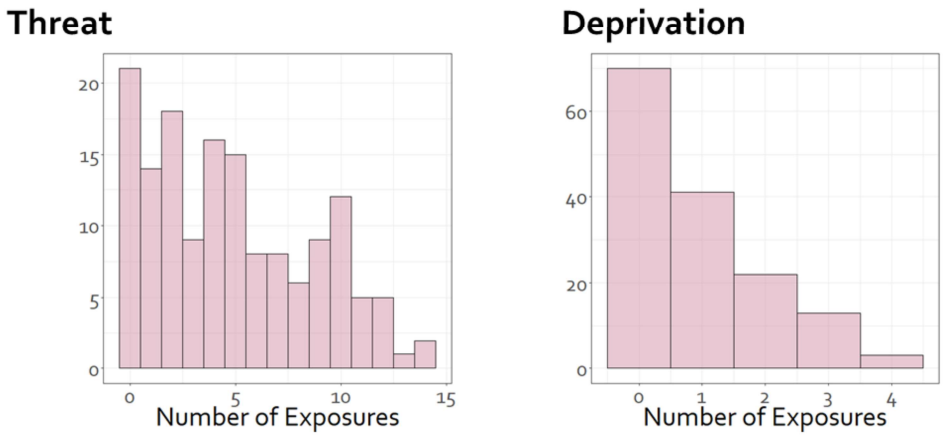
Acknowledgments

NIMH
National Institute of Mental Health

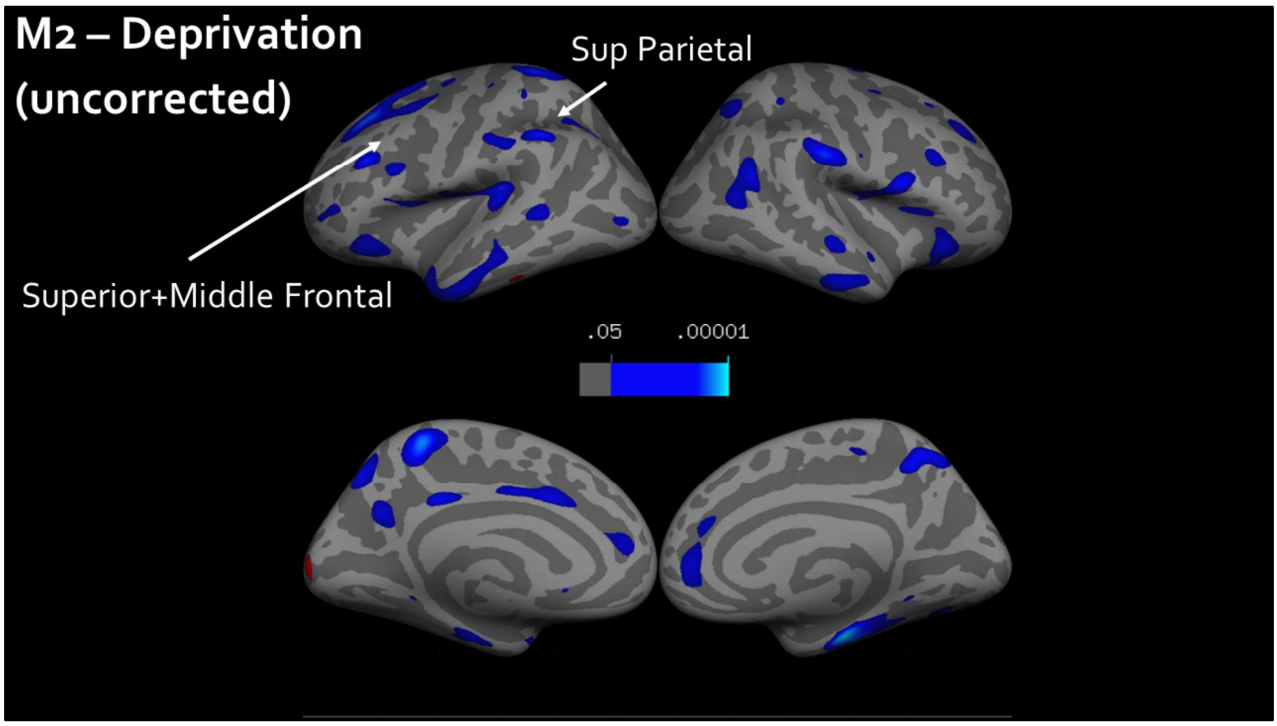
References

- Gold, A. L., Sheridan, M. A., Peverill, M., Busso, D. S., Lambert, H. K., Alves, S., … McLaughlin, K. A. (2016). Childhood abuse and reduced cortical thickness in brain regions involved in emotional processing. *Journal of Child Psychology and Psychiatry*, *57*(10), 1154–1164. https://doi.org/10.1111/jcpp.12630
- Hanson, J. L., Chung, M. K., Avants, B. B., Shirtcliff, E. A., Gee, J. C., Davidson, R. J., & Pollak, S. D. (2010). Early stress is associated with alterations in the orbitofrontal cortex: A tensor-based morphometry investigation of brain structure and behavioral risk. *The Journal of Neuroscience : The Official Journal of the Society for Neuroscience*, *30*(22), 7466–7472. https://doi.org/10.1523/JNEUROSCI.0859-10.2010
- McLaughlin, K. A., & Lambert, H. K. (2017). Child trauma exposure and psychopathology: Mechanisms of risk and resilience. *Current Opinion in Psychology*, *14*(Supplement C), 29–34. https://doi.org/10.1016/j.copsyc.2016.10.004
- McLaughlin, K. A., & Sheridan, M. A. (2016). Beyond cumulative risk: A dimensional approach to childhood adversity. *Current Directions in Psychological Science*, *25*(4), 239–245. https://doi.org/10.1177/0963721416655883
- Noble, K. G., Houston, S. M., Brito, N. H., Bartsch, H., Kan, E., Kuperman, J. M., … Sowell, E. R. (2015). Family Income, Parental Education and Brain Structure in Children and Adolescents. *Nature Neuroscience*, *18*(5), 773–778. https://doi.org/10.1038/nn.3983
- Rosen, M. L., Sheridan, M. A., Sambrook, K. A., Meltzoff, A. N., & McLaughlin, K. A. (2018). Socioeconomic disparities in academic achievement: A multi-modal investigation of neural mechanisms in children and adolescents. *NeuroImage*, *173*, 298–310. https://doi.org/10.1016/j.neuroimage.2018.02.043

Number of Adverse Experiences



We used dichotomous coding in analyses, but here are statistics on number of exposures. You can see fairly wide range of exposure severity on both scales. Participants tended to have more threatening experiences, but also there were more potential exposures on the threat scale so you shouldn't consider they are not directly comparable.


M2 – Deprivation
(uncorrected)
Sup Parietal
Superior+Middle Frontal
.05
.00001