Poverty may affect the developing brain through chronic stress

Socioeconomic disadvantage, which is prevalent in the United States and worldwide, is consistently associated with lower academic achievement and higher risk for emotional and behavioral problems. Exposure to socioeconomic disadvantage during childhood can leave long-lasting imprints on an individual's life, increasing their risk for negative health and developmental trajectories persisting through adulthood. Recent research has started to uncover the neural mechanisms underlying these associations. In structural magnetic resonance imaging (MRI) studies, socioeconomic disadvantage has been consistently associated with reduced gray matter, especially in the hippocampus and prefrontal cortex. Socioeconomic disadvantage is thought to exert these effects on the brain through its impacts on aspects of children's immediate environments. In contexts of socioeconomic disadvantage, children are at increased risk for exposure to stressful circumstances and events (e.g., neighborhood violence, noise/crowding, family conflict, household chaos and unpredictability), pointing to chronic stress as a salient factor for children living in socioeconomic disadvantage.

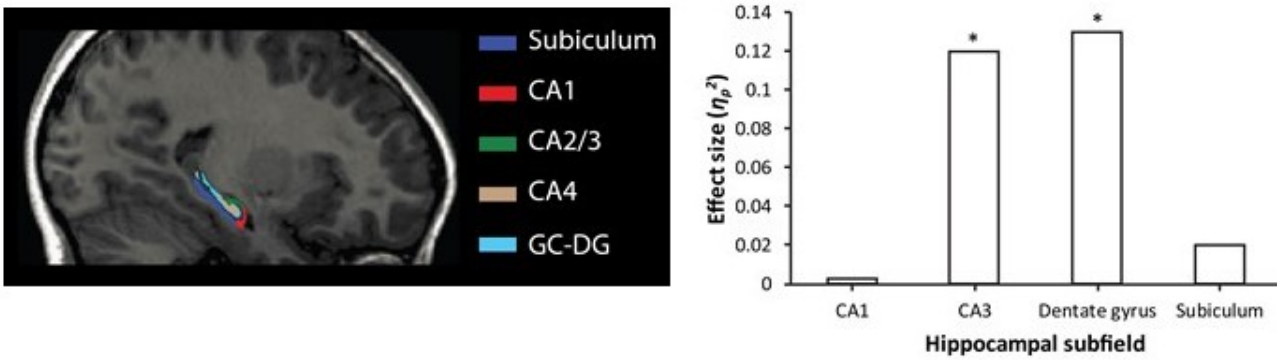

Fig. 1. On the left is a color-coded depiction of the focal hippocampal subfields in a sagittal view from a representative participant. The subfield volumes are overlaid on the whole-brain T1-weighted processed image. CA, cornu ammonis; GC-DG, granule cell layer of the dentate gyrus. On the right are effect sizes for hair cortisol across hippocampal subfields. Medium to large effect sizes were found for the CA3 and dentate gyrus subfields. Child age, sex, and whole brain volume were included as covariates in these analyses.

Socioeconomic disadvantage has also been associated with variability in the levels of hormones associated with stress in the body. Socioeconomic disadvantage has been associated with variability in levels of cortisol, a glucocorticoid released as a result of activation of the hypothalamic-pituitary-adrenal (HPA) axis stress response. Although most research has measured cortisol concentrations in saliva, this measure is highly susceptible to situational and time of day effects. In

addition, salivary cortisol may more closely reflect acute stress whereas socioeconomic disadvantage is thought to pose day-to-day challenges consistent with chronic stress. The measurement of cortisol concentrations in hair is a reliable and valid method of capturing chronic stress as it represents the accumulation of cortisol over a period of months.

In our study, we examined the associations among socioeconomic factors (family income-to-needs ratio, parental education), hair cortisol, the volume of the hippocampus and its subfields, and episodic memory in 5- to 9-year-old children from socioeconomically diverse families. Animal models have revealed glucocorticoids to affect structure in some hippocampal subfields more than others. Thus, we hypothesized that hair cortisol would be significantly associated with structure in these stress-sensitive hippocampal subfields (CA3, dentate gyrus).

Among participants in the study, thirty percent of the sample was living below the U.S. poverty threshold. Children participated in an MRI scanning session, provided a hair sample, and completed neurocognitive tasks. Hippocampal subfield volumes were measured using a reliable automated segmentation technique via well-established software (FreeSurfer 6.0). Findings indicated that lower parental education was significantly associated with smaller total hippocampal volume, CA1 volume, and dentate gyrus volume. Higher hair cortisol concentrations were significantly associated with smaller volume in the CA3 and dentate gyrus hippocampal subfields, but were not significantly associated with CA1 or subiculum volume. Furthermore, higher hair cortisol significantly mediated the association between lower parental education and smaller CA3 and dentate gyrus volumes.

Our study is the first to examine hair cortisol in relation to hippocampal subfield structure in children. Results suggest that elevated hair cortisol levels were associated with the greatest volumetric reductions in hippocampal subfields previously identified as stress-sensitive in translational studies. Findings were consistent with the possibility that elevated hair cortisol may be a mechanism through which socioeconomic disadvantage influences hippocampal structure in children. Incorporating neurobiological measures into studies of poverty alleviation programs and related interventions would yield important information about the mechanisms underlying intervention effects. Such studies are crucial to the design of more effective interventions that benefit a broader range of the population affected by poverty.

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