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RESEARCH SUMMARY

Childhood trauma and brain structure in children and adolescents. Matthew Peverill, Maya L. Rosen, Lucy A. Lurie, Kelly A. Sambrook, Margaret A. Sheridan and Katie A. McLaughlin. *Developmental Cognitive Neuroscience* (2023), 101180. DOI: https://doi.org/10.1016/j.dcn.2022.101180

We now know that adverse childhood experiences, or ACEs, can give rise to changes in the structure as well as the function of the developing brain. In particular, experience of childhood adversity has been associated with changes to the cerebral cortex and a few other brain structures such as the hippocampus and amygdala. The cortex is the outermost layer of brain tissue, principally involved in sensing and cognition; the hippocampus is involved in consolidating memory, and the amygdala in emotional response.

The term 'adversity', however, is a very broad one that encompasses a wide variety of experiences. Matthew Peverill, a clinical psychologist at the University of Wisconsin, USA, working with colleagues in Harvard and the Clark Science Center, Massachusetts, and the University of North Carolina, has proposed that ACEs can be divided into two categories that may have distinct neurological consequences. The researchers separate these out as 'threat' and 'deprivation'. Threat includes all experiences that involve physical harm, or the threat of harm, to a child, such as physical and sexual abuse, witnessing domestic violence, and experiencing or observing violence in the community. Deprivation, on the other hand, includes physical and emotional neglect, losing a relationship with one or both parents and a lack of cognitive stimulation.

It has already been shown that children who encounter threatening experiences exhibit changes to their learning and memory that make them more sensitive to future threats. This can lead them to over-compensate with defensive, 'fight or flight' responses to cues that are not actually threatening. No similar pattern is observed in response to deprivation. Therefore, Peverill has suggested that children exposed to threat might develop changes in the brain systems that respond to threats and to 'salience': that is, to the property of focusing attention on a stimulus with particular – most often negative – associations. These systems or 'networks' in the brain include parts of the frontal cortex, the amygdala and hippocampus. In contrast, children who experience deprivation perform less well on cognitive tasks involving attention and control.

Most previous studies have focused on broad ACEs or on either threat-based or deprivation-based experiences, without accounting or controlling for the other dimension. The strongest evidence for a distinct influence of threat or deprivation on brain development would come from experiments that examine one dimension while accounting or 'controlling for' the effects of the other.

Peverill and his team set out to examine the association of threat and deprivation separately on the brain structures of children and adolescents, while controlling for the other variable. The brain dimensions studied were the thickness and surface area of the cortex and the volumes of the amygdala and hippocampus. They recruited 161 children and youths from 8-16 years of age from a population participating in a larger study in Seattle, Washington between 2015 and 2017. Half the participants had been exposed to maltreatment of some kind; each of these was matched to one other 'control' participant without such experiences, by age, sex, and handedness. Children and youth with some types of developmental or mental disorder, or substance abuse, or who were unable for any reason to undertake an MRI scan were excluded from the sample, and a few others were withdrawn after problems during the scan.

Each participant was assessed separately for experiences of threat and deprivation. A composite score for threat was built up from several scales, including reports from their caregivers and a questionnaire assessing exposure to domestic and community violence called the Violence Exposure Scale for Children Revised (VEX-R). A similar score for deprivation was built up from questionnaire scores for physical neglect, emotional neglect, food security, and cognitive deprivation. The last of these was assessed using a short form of the Home Observation for Measurement of the Environment questionnaire (HOME-SF), in which an observer conducts an interview with each child and main caregiver at home. Each participant attended the University of Washington Integrated Brain Imaging Center for a single MRI scan of their whole brain. The cortical thickness and surface area, and the volumes of the hippocampus and amygdala, were estimated from these scans. In the case of the hippocampus and amygdala, right and left volumes were summed to give a total volume of each region for each participant.

The researchers performed a complex piece of statistical analysis in which the cortical thickness and surface area were correlated with the numerical scores for threat and deprivation separately, and then the effect of each dimension on the cortex was assessed while controlling for the other. The participants' sex and age and the socio-economic status of their families (expressed as a ratio of income to needs) were also included as additional, potentially correlating variables.

This analysis showed that, in very general terms, the combined threat score had a significantly greater effect on the cortex than the deprivation score. Higher threat scores were associated with thinner cortex, and this association continued after controlling for high deprivation scores in the same children. There was no similar correlation between deprivation and cortical thinning with or without controlling for sex, age or income-to-needs ratio. There was no evidence that these results changed with the child's age or the onset of puberty.

A similar analysis of the hippocampus and amygdala volumes showed that the children who had experienced high levels of threat had, on average, smaller amygdala volumes than the control children. High deprivation scores had no significant effect on the amygdala, and neither dimension affected the volume of the hippocampus. Interestingly, however, the relationship between threat levels and amygdala volume varied consistently with age: the older the children or young people were, the more significant this difference, so that threat correlated with amygdala volume very strongly in the eight-year-old children and hardly at all in the 16-year-old adolescents.

Peverill and his colleagues described the locations of structural differences between the cortex of children who had experienced significant threat and those who had not as those regions that were concerned with salience processing, perception (including the perception of threat), and self-reflection. Controlling for deprivation experienced by the same children led to a decrease in the areas involved, but the broad findings were essentially unchanged. The changes in the cortical regions associated with salience processing were consistent with the hypothesis that, in these individuals, that network had developed to focus specifically on cues that could indicate the presence of further threat. More research is needed to determine how these changes affect children's emotions and behaviour and, particularly, whether they contribute to the decreased emotional awareness that can be observed in young people who have witnessed violence.

The finding that amygdala volume is much more strongly correlated with experience of threat in school-aged children than in adolescents is also consistent with previously published research. However, this has not been observed in longitudinal studies where the same young people were followed over time. Peverill and his colleagues noted that most participants in their study had experienced violence early in childhood, and that further research – in particular, this type of longitudinal study – would be needed to show how the amygdala changes with age and with time since the violent events.

The team considered several reasons why, contrary to their original assumptions, they had observed no correlation between any of the brain structures assessed and deprivation. They suggested that it might be because the study was relatively small and therefore unable to pick up small effects; that it was a cross-sectional study, relying on observations at a single point in time; that they considered fewer measures of deprivation than of threat, and that the deprivation experienced by children in the study was rarely severe. They recommended that further work with larger sample sizes and a wider range of childhood experiences should be undertaken to explore these associations. The inherent difficulties in recruiting the large sample of children and young people that would be needed can be overcome by pooling data between institutions, and some of this work is already underway.

Despite some limitations, this study has proved that trauma and particularly exposure to violent situations in childhood is associated with changes to brain structures that are involved with perceiving and responding appropriately to threatening situations. These children, with such a heightened sensitivity to threat, are likely to be at risk of further mental distress.

Dr Clare Sansom

Policy and practice implications

The relationship between children's exposure to physical harm or threat of harm, in the home or the community, and brain development clearly indicates the need for joined up working, between social care, education, and health.

The nature of brain changes identified in relation to exposure to physical threat are associated with important aspects of emotional regulation and in particular to self-awareness, which allows us to look neutrally at our thoughts, feelings, emotions, and actions. Support for children in, or removed from, threat situations should include ways to promote emotional regulation.

Children experiencing exposure to physical harm are likely to show important and potentially life-long cognitive vulnerability, not only during their school years.