RESEARCH SUMMARY

Toward Understanding How early-life stress reprograms cognitive and emotional brain networks

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The development of the brain involves processes that are regulated by genetic factors and also by environmental input. A young baby's brain is far from maturity and continuously undergoes significant developmental processes. Stress during this critical early-life period can have an impact on brain function that is long-lasting or even permanent, unlike in adults where stress has a transient effect. Research for many years has focused on the mechanisms by which brain development is affected by early-life stress, with maternal input having perhaps the greatest influence on the environment experienced during development. Chen and Baram's review examined results from many studies carried out on early life stress in rodents, as well as examining research on early-life stress in humans. This summary will focus on the research carried out on humans.

In humans, the outcome of early-life stress depends on several aspects of the 'stressful' experience: its timing, quality, severity and duration. Developmental stress can have long-lasting consequences for several brain networks affecting the output of many emotional, social and cognitive behaviours. Because the majority of mental and neuro-cognitive illnesses most often start early in life, it is necessary to improve our understanding of the type of early-life events that influence cognitive and emotional outcomes and the mechanisms by which those influences take place.

Stress is a signal which indicates a potential or perceived threat; it also has high biological significance because it enables rapid, delayed and enduring adaptive processes to changing circumstances. The central nervous system has several sensing mechanisms to identify stress, as well as processes that respond to stress signals and which can be modified by them. The context and nature of the stress are both important. Mild or short-lasting stress often enhances memory and decision making, whereas when it is intense or long-lasting it may provoke detrimental effects.

A child's developing brain responds to stress in an age-specific manner with profound and enduring consequences. The type and magnitude of changes induced by stress can vary widely according to when it occurs. The stage of early post-natal life comprises complex and overlapping developmental processes, and these can have a strong influence on the consequences of any experiences or environmental disturbances, be they positive or negative.

Chronic stress in early life has physical and emotional components, with the emotional aspects being dominant. The majority of early-life stress stems from abnormal patterns of maternal care, from neglect to inconsistency and lack of sensitivity.

Complete absence of maternal care can result in very seriously damaging consequences for the child's cognitive and emotional development: for example, at the extreme end, these sad outcomes have been found in studies of emotionally deprived children raised in orphanages.

Hundreds of human studies over more than six decades have illustrated close statistical associations of early-life adversity and a variety of emotional problems. Stress occurring in the early years of life can permanently alter vital processes in the brain; for example it can interfere with the normal construction and maturation of synaptic connections in the brain, as well as promote the premature destruction of these links.

Epidemiological studies in humans suggest that cognitive problems in those who suffered chronic stress during childhood emerge, rather surprisingly, during middle age and are also a risk factor for developing dementia. Where children have suffered early-life emotional deprivation followed by environmental enrichment, it is suggested that intervention beyond the first two or three years of life is less effective; this means that it is the earliest years of life that contain the sensitive period for producing the major long-term effects of the early stress that can result from difficult and emotionally deprived childhoods, so intervention during that early period is clearly optimal.

The review suggests a number of areas that raise questions for future research. Firstly, although early-life stress is a major risk factor for illness later in life, there is some variability in this outcome. Therefore, the factors that impart vulnerability or resilience to the effects of early-life stress should be studied.

Secondly, as individuals exposed to early stress are likely to be those who experience stress throughout their lives, interactions between early-life stress and stresses experienced later in life need to be examined. For example, it would be interesting to see whether there are other sensitive periods, such as adolescence, when the brain is particularly vulnerable to stress, that could be further influencing these outcomes.

The third area to look at is the nature and biology of sex-specific consequences of early-life stress. Epidemiological studies indicate that stress-related psychopathologies are more prevalent in females, but it is necessary to examine how genetic and hormonal sex differences may contribute to any sex-specific consequences of early-life stress.

Finally, although this review paper included many studies carried out on rats and mice, and these have certainly given some useful insights into the consequences of early-life stress on brain development and the mechanisms involved, even so it is necessary to take care when applying these findings to humans. However, it can be clearly seen from the paper, that where the areas of research involving humans has been highlighted, it has emphatically been shown that early-life stress can have profound and long-lasting effects, both on brain structure and on future behaviours.

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