Stress and the Developing Brain

It is well known that the early months and years of life are critical for brain development. But the question remains: just how do early influences act on the brain to promote or challenge the developmental process? Research has suggested that both positive and negative experiences, chronic stressors, and various other environmental factors may affect a young child's developing brain. And now, studies involving animals are revealing in greater detail how this may occur.

One important line of research has focused on brain systems that control stress hormones—cortisol, for example.[1,2] Cortisol and other stress hormones play an important role in emergencies: they help our bodies make energy available to enable effective responses, temporarily suppress the immune response, and sharpen attention. However, a number of studies conducted in people with depression indicate that excess cortisol released over a long time span may have many negative consequences for health.[3-5] Excess cortisol may cause shrinking of the hippocampus, a brain structure required for the formation of certain types of memory.

In experiments with animals, scientists have shown that a well-defined period of early postnatal development may be an important determinant of the capacity to handle stress throughout life.[2] In one set of studies, rat pups were removed each day from their mothers for a period as brief as 15 minutes and then returned. The natural maternal response of intensively licking and grooming the returned pup was shown to alter the brain chemistry of the pup in a positive way, making the animal less reactive to stressful stimuli. While these pups are able to mount an appropriate stress response in the face of threat, their response does not become excessive or inappropriate. Rat mothers who spontaneously lick and groom their pups with the same intensity even without human handling of the pups also produce pups that have a similarly stable reaction, including an appropriate stress hormone response.[6]

Striking differences were seen in rat pups removed from their mothers for periods of 3 hours a day, a model of maternal neglect, compared to pups that were not separated. After 3 hours, the mother rats tended to ignore the pups, at least initially, upon their return. In sharp contrast to those pups that were greeted attentively by their mothers after a short absence, the "neglected" pups were shown to have a more profound and excessive stress response in subsequent tests. This

response appeared to last into adulthood.[7,8]

The implications of these animal studies are worrisome. However, research is in progress to determine the extent to which the hypersensitive or dysregulated stress response of "neglected" rat pups can be reversed if, for example, foster mothers are provided who will groom the pups more intensely, or if the animals are raised in an "enriched" environment following their separation. An enriched setting may include, for example, a diverse and varied diet, a running wheel, mazes, and changes of toys.

Animal investigators are well aware of another kind of long-term change, again rooted in the first days of life. Laboratory rats are often raised in shoebox cages with few sources of stimulation. Scientists have compared these animals to rats raised in an enriched environment and found that the "privileged" rats consistently have a thicker cerebral cortex and denser networks of nerve cells than the "deprived" rats.[9,10]

Another study recently reported that infant monkeys raised by mothers who experienced unpredictable conditions in obtaining food showed markedly high levels of cortiocotropin releasing factor (CRF) in their cerebrospinal fluid and, as adults, abnormally low levels of cerebrospinal fluid cortisol.[11] This is a pattern often seen in humans with post-traumatic stress disorder and depression.[5] The distressed monkey mothers, uncertain about finding food, behaved inconsistently and sometimes neglectfully toward their offspring. The affected young monkeys were abnormally anxious when confronted with separations or new environments. They were also less social and more subordinate as adult animals.

It is far too early to draw firm conclusions from these animal studies about the extent to which early life experience produces a long-lived or permanent set point for stress responses, or influences the development of the cerebral cortex in humans. However, animal models that show the interactive effect of stress and brain development deserve serious consideration and continued study.

For More Information

National Institute of Mental Health (NIMH)
Office of Communications and Public Liaison
Public Inquiries: (301) 443-4513
Media Inquiries: (301) 443-4536
E-mail: nimhinfo@nih.gov
Web site: http://www.nimh.nih.gov

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301-443-4279
301-443-5158 (FAX 4U)

Street address:
National Institute of Mental Health
Office of Communications
Room 8184, MSC 9663
6001 Executive Boulevard
Bethesda, Maryland 20892-9663 USA
