Excessive Stress Disrupts the Architecture of the Developing Brain

The ability to cope with novel and/or potentially threatening situations, such as an unfamiliar environment or physical danger, is essential to survival. According to the National Scientific Council of the Developing Child, this capacity is built into specific brain circuits whose development is influenced by multiple experiences beginning early in life. Environmental stimuli that activate these circuits are often referred to as stressors, and stress reactions are the body's chemical and neural responses that promote adaptation.

Stressful events can be harmful, tolerable, or beneficial, depending on how much of a bodily stress response they provoke and how long the response lasts. These, in turn, depend on whether the stressful experience is controllable, how often and for how long the body's stress system has been activated in the past, and whether the affected child has safe and dependable relationships to turn to for support. This matters because a child's ability to cope with stress in the early years has consequences for physical and mental health throughout life. Categorizing the nature and severity of early stressful experiences helps us make better judgments about the need for interventions that reduce the risk for later negative impacts.

Toxic Stress refers to strong, frequent or prolonged activation of the body's stress management system. Stressful events that are chronic, uncontrollable, and/or experienced without the child having access to support from caring adults tend to provoke these types of toxic stress responses. Studies indicate that such stress responses can have an adverse impact on brain architecture. In the extreme, such as in cases of severe, chronic abuse, toxic stress may result in the development of a smaller brain. Less extreme exposure to toxic stress can change the stress system so that it responds at lower thresholds to events that might not be stressful to others, thereby increasing the risk of stress-related physical and mental illnesses.

Tolerable Stress refers to stress responses that could affect brain architecture but generally occur for briefer periods that allow time for the brain to recover and thereby reverse potentially harmful effects. In addition to their relative brevity, one of the critical ingredients that make stressful events tolerable rather than toxic is the presence of supportive adults who create safe environments that help children learn to cope with and recover from major adverse experiences, such as the death or serious illness of a loved one, a frightening accident, or parental separation or divorce. In some circumstances, tolerable stress can even have positive effects. Nevertheless, it also can become toxic stress in the absence of supportive relationships.

Positive Stress refers to moderate, short-lived stress responses, such as brief increases in heart rate or mild change in the body's stress hormone levels. This kind of stress is a normal part of life, and learning to adjust to it is an essential feature of healthy development. Adverse events that provoke positive stress responses tend to be those that a child can learn to control and manage well with the support of caring adults, and which occur against the backdrop of generally safe, warm, and positive relationships. The challenge of meeting new people, dealing with frustration, entering a new child care setting, getting an immunization, and overcoming a fear of animals all can be positive stressors if a child has the support needed to develop a sense of mastery.

The capacity to deal with stress is controlled by a set of highly inter-related brain circuits and hormonal systems that are specifically designed to deal adaptively with environmental challenges. When an individual feels threatened, stress hormones are produced that convert the physical or emotional stress into chemical signals that are sent throughout the body as well as to the brain.

The neural circuits for dealing with stress are particularly malleable (or "plastic") during the fetal and early childhood periods. Early experiences shape how readily they are activated and how well they can be contained and turned off. Toxic stress during this early period can affect developing brain circuits and hormonal systems in a way that leads to poorly controlled stress-response-systems that will be overly-reactive or slow to shut down when faced with threats throughout the lifespan.

Well-functioning brain-systems that respond to stress are essential to preserve life. However, like the immune system, which defends the body against threatening infections but can cause autoimmune disease when it turns against the body's own cells, a poorly controlled response to stress can be damaging to health and well-being if activated too often or for too long.

Frequent or sustained activation of brain systems that respond to stress can lead to heightened vulnerability to a range of behavioral and physiological disorders over a lifetime. These undesirable outcomes can include a number of stress-related disorders affecting both mental (e.g., depression, anxiety disorders, alcoholism, drug abuse) and physical (e.g., cardiovascular disease, diabetes, stroke) health.

Stress responses include activation of a variety of hormone and neurochemicals systems throughout the body. Two hormonal systems have received extensive attention in this regard: the sympathetic-adrenomedullary (SAM) system, which produces adrenaline in the central part of the adrenal gland, and the hypothalamic-pituitary-adrenocortical (HPA) system, which produces cortisol in the outer shell of the adrenal gland. Both chemicals are produced under normal circumstances and help prepare the body for coping with stressors.

Adrenaline production occurs in response to many forms of acute stress. It mobilizes energy stores and alters blood flow; thereby allowing the body to effectively deal with a range of stresses. Its release is essential to survival.

Cortisol also is produced in response to many forms of stress, and likewise helps the body cope effectively with adverse situations. It also mobilizes energy stores, as well as suppresses immune responses, when it is released acutely. Longer term effects of cortisol include regulation of gene expression in neural circuits involved in modulating stress responsiveness, emotion, and memory.

Sustained or frequent activation of the hormonal systems that respond to stress can have serious developmental consequences, some of which may last well past the time of stress exposure. For example, when children experience toxic stress, their cortisol levels remain elevated for prolonged periods. Both animal and human studies show that long-term elevations in cortisol levels can alter the function of a number of neural systems, and even change the architecture of regions in the brain that are essential for learning and memory.

The relationships children have with their caregivers play critical roles in regulating stress hormone production during the early years of life. Those who experience the benefits of secure relationships have a more controlled stress hormone reaction when they are upset or frightened. This means that they are able to explore the world, meet challenges, and be frightened at times without sustaining the adverse neurological impacts of chronically elevated levels of hormones such as cortisol that increase reactivity of selected brain systems to stress and threat. In contrast, children whose relationships are insecure or disorganized demonstrate higher stress hormone levels when they are even mildly frightened. This results in an increased incidence of elevated cortisol levels which may alter the development of brain circuits in ways that make some children less capable of coping effectively with stress as they grow up.

Research has shown that the presence of a sensitive and responsive caregiver can prevent elevations in cortisol among toddlers, even in children who tend to be temperamentally fearful or anxious. Thus, sensitive and responsive caregiving from a parent or a child care provider can serve as a powerful buffer against stress hormone exposure, even in children who might otherwise be highly vulnerable to stress-system activation.