



Early Childhood Stress and Neurobiological Effects

Early childhood is a critical period in a child's life that includes ages from birth to five years old.^[1] Children are constantly developing, physically and emotionally. Stress can be beneficial by helping children develop skills needed to adapt to new situations and deal with dangerous and intimidating situations.^[2] However, there is a point where prolonged stress becomes harmful and can lead to serious health effects. Although **stress** is a factor for the average human being, it can be a molding aspect in a young child's life.^[3] Stress can be beneficial by helping children develop skills needed to adapt to new situations and deal with dangerous and intimidating situations.^[2] Stress is caused by internal or external influences that disrupt an individual's normal state of well-being. These influences are capable of affecting health by causing emotional distress and leading to a variety of physiological changes.^[2] Internal stressors include physiological conditions such as hunger, pain, illness or fatigue. Other internal sources of stress consist of shyness in a child, emotions, gender, age and intellectual capacity.^[3] External stressors include separation from family, exposure to family conflict, abuse, divorce, a new home or school, illness and hospitalization, death of a loved one, poverty, natural disasters, and adults' negative discipline techniques.^[3] Additional external stressors include **prenatal drug exposure**, such as maternal methamphetamine use, other maternal and paternal substance abuse, maternal depression, posttraumatic stress and psychosis.^{[3][4][5]} Stress is an inevitable part of life. Human beings experience stress early, even before they are born. A certain amount of stress is normal and necessary for survival.^[2] A few stressors can be manageable for young children, however, there is a point where prolonged stress becomes harmful and can lead to serious health effects. When stress builds up in early childhood, neurobiological factors are affected.^[1] In turn, hormone cortisol levels are uncontrollable and cannot be brought back to normal ranges.^[1]

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Levels of Stress in Early Childhood

There are three levels of stress seen in children during early childhood; Positive, Tolerable and Toxic.^[1]

[Positive Stress](#) is necessary and promotes resilience, or the ability to function competently under threat.^[6] Good stress or positive stress arises from adverse encounters that are ephemeral.^[2] This type of stress causes minor physiological and hormonal changes to the young child.^[2] The changes include an increase in heart rate and a change in hormone cortisol levels.^[2] The first day of school, a family wedding or making new friends are all examples of positive stressors. Positive stress may also come from adverse experiences that are short-lived and may lead to valuable lessons.^[2] Some examples are being punished or going to the doctor to get immunizations. Dealing with these types of stressors is a normal part of life and part of normal development.^[2] Normally, with the help of supportive adults, young children can learn to control and triumph over positive stress.^[2]

[Tolerable Stress](#) comes from adverse experiences that are more intense in nature but short-lived and can usually be overcome.^[2] The body's stress response is more intensely activated due to severe stressors.^[7] Some examples of tolerable stressors are family disruptions, accidents or a death of a loved one. It is important though to realize that such stressors are only tolerable when managed the correct way. Tolerable stress can turn into positive stress.^[7] With appropriate care from adults, young children can easily cope with tolerable stress and turn it into positive stress. However, if adult support is deficient in a child's coping stages, then tolerable stress can become detrimental.^[2]

Toxic Stress can occur when experiences are long in duration and intensity.^[7] Children need caring and supportive adults to help them because it is difficult for children to handle this type of stress on their own.^[2] Therefore the stress response may be activated from weeks to months or even years.^[2] Prolonged stress leads to adverse effects such as permanent emotional or developmental damage.^[2] If the sufficient support is not available, the results of this type of stress can lead to permanent changes in brain development.^[2] Research has found that children experiencing severe and long-term abuse have smaller brain sizes.^[8] If the situation is not as severe, toxic stress will still alter the stress response system.^[8] The changes in the system will cause children to react to a wider variety of stressors.^[8] However, with sufficient care and support from adults, children can return their stress levels to tolerable or good.^[2] Examples of toxic stress are abuse, neglect, violence and overall hardships without adult support.^[7] Toxic stress can have a cumulative effect on physical and mental health.

Stages of stress in early childhood

Stress is encountered in four different stages in early childhood.^[3] In the first stage, stress usually causes alarm.^[3] Next, in the second or appraisal stage, the child attempts to find meaning from the event.^[3] Stage three (3) consists of children seeking out coping strategies.^[3] Lastly, in stage four (4), children execute one or more of the coping strategies.^[3] However, children with lower tolerance for stressors are more susceptible to alarm and find a broader array of events to be stressful.^[3] These children often experience chronic or toxic stress.^[3]

Causes of Stress/Situations That May Promote Stress

[2][7][9]

- Disrupted homes- Divorce/Separation, [Blended families](#), Both parents working, Parental [incarceration](#)
- Lack of attention
- Separation from parents
- Exposure to violence- [Physical abuse](#), [Mental abuse](#), [Sexual abuse](#)
- [Substance abuse](#)
- Being over scheduled
- Feeling pressured to perform or behave beyond their ability
- [Neglect](#)- emotional/physical
- Meeting new people
- Starting a new school
- Death of a loved one
- Illness- mental/physical
- Difficulty with school work
- Increased pressure/responsibility at home
- Being [bullied](#)

Stress and brain development

Brain circuits and hormone systems are formed and activated in early life.^[2] These neurobiological systems of the body help maintain viability and are necessary for survival in early childhood and along the course of life.^[10] When a child or adult experiences a stressor, the body will attempt to regulate the stress through releasing hormones that pass through the body.^[2] However, effects of the prolonged or frequent biological stress response may increase the risk for future physical and mental health problems in early childhood.^[10] Since, brain circuits are vulnerable in early childhood, early stressors may impact the development of necessary brain connections.^[2] Therefore, toxic stress can alter or impair brain circuit formation and essentially result in a small brain size in young children.^[2]

Stress response pathway in humans

In humans, the stress response pathway consists of the sympathetic-adrenomedullary (SAM) system and the [hypothalamic-pituitary-adrenal axis](#) (HPA).^[10] The SAM system is a part of the sympathetic component of the [autonomic nervous system](#).^[10] These systems are responsible for releasing [epinephrine](#) and [norepinephrine](#) (NE), also known as the [flight or fight response](#) hormones.^[10] When epinephrine is released it will bind to various receptors in various target organs; this will exhibit multiple roles in the fight or flight mechanism.^[10] The HPA system is responsible for producing glucocorticoids from the [adrenal cortex](#); the main [glucocorticoid](#) in humans is the steroid hormone cortisol.^[10] In contrast to epinephrine, which takes a short amount of time for production, cortisol takes up to twenty-five (25) minutes to reach peak levels.^[10] Also, cortisol is able to penetrate the brain through the blood-brain barrier, unlike epinephrine.^[10] Therefore, cortisol takes more time to form, but impacts the brain for a longer period of time.^[10] In conjunction, the SAM and HPA systems work to regulate stress and unite at the [hypothalamus](#), which in turn regulates behavior.^[10]

The sympathetic adrenomedullary system

In humans, there are [chromaffin cells](#) in the [adrenal glands \(medulla\)](#) that get stimulated through the [sympathetic nervous system](#) during a stress response.^[10] These cells release the hormones epinephrine and norepinephrine (NE).^[10] Epinephrine and NE bind to receptors of target organs and instigate the fight or flight response.^[10] As an example, epinephrine increases heart rate and causes blood vessels to dilate in muscles and blood vessels to constrict in the skin and gut.^[10] This allows a sufficient amount of blood to access the brain and muscles.^[10] Also, epinephrine initiates the breakdown of [glycogen](#) in the [liver](#), in turn increasing blood [glucose](#) levels. This energy source allows humans to enact defensive responses due to stress.^[10]

The hypothalamic-pituitary-adrenal system and cortisol

In the human body, the steps that lead to the release of glucocorticoids such as cortisol begin with the release of [corticotropin releasing hormone](#) (CRH) and [arginine vasopressin](#) (AVP).^[10] These hormones

travel through the blood vessels to the [anterior pituitary gland](#) of the brain.^[10] At this location, [adrenocorticotropic hormone](#) (ACTH) is released.^[10] ACTH binds to the receptors in the adrenal glands, which are located atop the [kidneys](#), and this causes the release of cortisol.^[10] Cortisol enters the cytoplasm of cells in the body, including the brain. The hormone then reacts with receptors inside of the [cell](#).^[10] The activated receptors reach the [nucleus](#) of the cells and regulate the transcription of genes. Eventually, the body experiences physiological and behavioral changes.^[10] Because cortisol hormone enters the cell's nucleus, the effects of change take longer to occur, and last for a longer period of time, compared to the hormones of the SAM system.^[10] The effect of cortisol depends upon the type of receptor that it interacts with inside of the cell.^[10] There are two glucocorticoid receptors; one is the [mineralocorticoid receptor](#) (MR) and another is the [glucocorticoid receptor](#) (GR).^[10] Normally, when cortisol is outside of the brain, it will bind to GRs. When cortisol is within the brain cells, it will bind to GRs and MRs.^[10] However, cortisol and other glucocorticoids bind more readily to MRs.^[10] Cortisol's varying affinity toward GR and MR plays an important role in distinguishing between normal and stress responses by the HPA system.^[10] When cortisol is in its basal range, more MRs are bound to cortisol than GRs. GRs are predominantly bound when humans wake from sleep or experience stress.^[10] Therefore, GRs arbitrate most of the stress effects of cortisol and glucocorticoids in other species, while MRs control most basal effects.^[10] Often, cortisol and GR effects oppose the cortisol and MR effects. This leads many researchers to speculate that early childhood (and adult) stress resilience and weakness entail the ratio of MR to GR activation.^[10] Research has found that GRs impair neural flexibility and the processes involved in learning and memory. In contrast, MRs increase the synaptic plasticity.^[10] Therefore, the effects of frequent and prolonged stress responses from the HPA system may cause detrimental results.^[10]

Infancy, early childhood, and stress

When the body undergoes a stressful situation, the stress hormone [cortisol](#) is released. Cortisol helps the body prepare for stressful and dangerous situation. It gives a quick burst of energy, heightened memory, lower sensitivity to pain and heightened memory among other things.^[11] When cortisol is present in the body at high levels and for extended periods of time, however, the body's immune response may be suppressed.^[2] This leaves the developing bodies of children extremely vulnerable to damage and illness. Cortisol is usually bound to proteins in adults. The protein is called the [corticosteroid-binding globulin](#) (CBG).^[10] In newborn babies, CBGs remain low and increase during the first six months after birth.^[10] Therefore, as the amount of CBGs increase, more cortisol becomes bound to the CBGs. Due to this occurrence, plasma and total cortisol levels increase.^[10] Although, there are low levels of cortisol at birth, the levels are sufficient to have serious physiological effects.^[10] Newborns do not manifest typical adult circadian rhythms in cortisol production. Usually, newborns have peak cortisol levels every 12 hours and this does not depend on the time of day.^[10] After 3 months of life, babies begin to experience the adult cortisol production patterns, an early morning cortisol peak and low evening levels of cortisol.^[10] These cortisol rhythmic changes occur throughout infancy and early childhood, along with changes in sleep patterns.^[10] The activity of the HPA stress system adapts by repeated exposure to stressful stimulation.^[12] As newborns progress through the early months of life, babies experience increased cortisol levels during medical examinations. This is physically characterized by the fussing and crying of babies.^[10] After three months of life, babies do not respond to physical examinations with the HPA stress response system. However, babies can still respond to behavioral distress.^[10] As another example, if blood is drawn from a baby, the baby experiences an increased cortisol level.^[12] When this process is repeated 24 hours later, the same increase in cortisol is observed.^[12] In addition, during the first year of life, it becomes difficult to induce cortisol level increases to some mild stressors. These stressors include the approach of a stranger, strange events, few-minute separations from parents, and more.^[10] The decreased sensitivity of the HPA stress response may be due to physiological changes that occur in the system during early ages. The physiological changes that may occur include improved negative feedback regulation of the HPA system, and decreased sensitivity of the adrenal cortex to ACTH.^[10] Also, the availability of adult support for young children helps safeguard the activity of the HPA stress system.^[10] Many experiences can cause structural changes in the HPA system.^[12] The effects of repeated increases in cortisol levels have been researched in many animal studies, but these outcomes are also representative of humans, including young children.^[12] It has been determined that when glucocorticoids, including cortisol, are placed into

various parts of the brain for many days, CRH is produced in increased quantities.^[12] In turn, this causes fear behaviors, increased caution, and activation of the SAM system. Eventually, these effects may cause [PTSD or Post-Traumatic Stress Disorder](#), in young children.^[12] A more serious psychological symptom seen in children, PTSD manifests symptoms such as, heightened fear and anxiety, loss of interests, flashbacks, lacking some emotions, paranoia.^[13] Other serious psychological symptoms of stress seen in children are depression, anxiety, low self-confidence and dysregulated aggression.^{[14][15]}

Stress in children has greatest effects on the [brain](#). The brain is the primary stress organ because it controls all of the stress mechanisms.^[16] Children's brains are constantly growing and developing. Therefore their brains are very vulnerable and stressors can have great impacts on the brain that are irreversible.^[17] Research has shown that children who have experienced extended periods of extreme stress have smaller brains and high difficulties in memory tasks. Cognitive functioning is greatly impaired.^[18] Children who had experienced more intense and lasting stressful events in their lives posted lower scores on tests of spatial working memory.^[17] They had more trouble navigating tests of short-term memory as well. The region of the brain that is most affected by increased levels of cortisol and other glucocorticoids is the [hippocampus](#).^[12] Many times the physical structure of the hippocampus is altered with excessive amounts of cortisol. [Dendrites](#) in this section of the brain can shrink and this leads to cell or [neuron](#) death.^[12] The shortening of dendrites and the loss of neurons in the hippocampus make a significant impact on the HPA stress response and on cognitive processes that involve the hippocampus.^[12] In the HPA system, many of the glucocorticoid receptors become non-functional when there are increased levels of cortisol. If increased cortisol levels persist in a child's early years of life, the hippocampal damages will produce collective and detrimental effects over the life of the individual.^[12] Stress has an outstanding effect on cognition, particularly [memory](#).^[12] [Episodic memory](#), or memory associated with remembering specific events, is mostly affected.^[12] When levels of glucocorticoids or cortisol increase, some cells in the hippocampus do not die. Instead, the activity of the neurons is changed. This creates problems with memory.^[12] Research has found that infants and young children with higher cortisol levels produce smaller electrical changes in their brain when they are forming memories.^[12] This impairs new memory formation.^[12] In addition, children who have increased levels of cortisol, during daycare or nursery school time, experience extreme hardship upholding attention.^[12] Maintaining attention is a part of self-regulation, and these children are not able to regulate their behaviors due to the high cortisol levels.^[12] Therefore, memory, attention-span, and self-regulation are influenced by cortisol production.^[12]

Many children experience stress for prolonged amounts of time.^[12] Usually these factors are toxic stress and can be due to internal or external stressors.^[2] If a child has a sufficient support system, then he or she can display resilience.^[12] Often, children do not have skills to be resilient themselves, and they do not have adults for constant loving care. In these situations, children experiencing stress exhibit persistent effects of varying cortisol levels. Some children manifest low levels of cortisol production, and some experience high cortisol levels. The children with higher levels of glucocorticoids are prone to have the most problems with physical, social, mental, and motor development.^[12] Research has not yet determined whether these effects are permanent, however, it has been found that children experiencing stressful situations after the first 4 to 6 months of life endure from intellectual and social problems.^[12] Also, persistent stress in young children makes the stress regulation mechanisms deviate from normal coping mechanisms.^[1] For children experiencing good or tolerable stress, stress instigates an increase in cortisol levels. When the situation is resolved, cortisol levels will return to normal.^[1] In children experiencing persistent toxic stress, functioning occurs in a fear state and this becomes habitual.^[1] Many times, cortisol levels do not reach basal ranges after the situation has been mitigated.^[1] With chronic toxic stress, children undergo long term hyper-arousal of brain stem activity.^[1] This includes an increase in heart rate, blood pressure, and arousal states.^[1] Also, these children may experience a change in brain chemistry, which leads to hyperactivity and anxiety.^[1] Therefore, it is evident that chronic stress in a young child's life can create significant physical, emotional, psychological, social and behavioral changes.^[12]

Other Symptoms and Effects of Stress on Children

Physical

Stress may make the [body](#) more susceptible to infections, cardiovascular problems such as [heart disease](#) and high blood pressure, [obesity](#), slower healing, viruses and gastrointestinal problems.^{[2][19]} Stress can affect children's growth and development, including the onset of [puberty](#).^[19] Some of the physical cues that may be indicative of stress in children are rashes on skin and skin diseases such as [eczema](#), [acne](#) and [hair loss](#), worsening [asthma](#), insomnia or hypersomnia, frequent headaches, muscle aches, vomiting, constipation and diarrhea.^[19] Extreme fatigue, chest pain, racing heartbeat, shaking, cold and clammy hands and feet, frequently ill, and even [ulcers](#) are some other physical symptoms manifested due to stress.^[19]

Emotional

When children cannot handle stress they may begin to develop emotional problems. They may become severely [depressed](#), [lacking in energy](#) and motivation.^[19] They may develop strange personality traits such as violence and disobedience.^[19] Personality disorders may arise as well. Post Traumatic Stress disorder may come about in children who have experienced stressors that are traumatic such as abuse or neglect.^[13]

Psychological

Changes in mood or personality, increased irritability or aggressiveness are some psychological symptoms indicative of stress in children. Frustration, feelings of guilt or confusion, isolating themselves from family and friends. Children may also exhibit symptoms of [anxiety](#). They may begin to have new fears and nightmares or even paranoia.^[19] They may lie to others to avoid situations to cover up their feelings.^[20] Most often anxiety in children stems from academic stressors and being overwhelmed with responsibilities with workload.^[20] However, anxiety also stems from more serious stressors as well.

Social

Children under extreme stress tend to withdraw from their family and friends.^[19] They spend more time alone and lack motivation. Children may begin to struggle in school and on their assignments.^[21] They may have difficulties in paying attention and act with anger and irritability towards others.^[2]

Behavioral Children may exhibit behavioral symptoms such as over-activity, disobedience to parental or caretaker's instructions. New [habits](#) or habits of regression may appear, such as thumb-sucking, wetting the bed and teeth grinding. Children may exhibit changes in eating habits or other habits such as biting nails or picking at skin due to stress.^[19] They may become more accident-prone, cry more often, stutter, or get into fights.^[21]

Preventing Stress in Children

To help prevent stress in children help the child prepare for everyday stressful situations. Meeting new people, traveling to new places and going to the doctor are all potential stressors to a child.^[22] Talk to the child about the experience and make them understand that it is okay to be stressed and scared but there is nothing to worry about. Communication is very important. Try to keep communication open and spend time together as a family so that no one's feelings go unseen.^[22] Teach children healthy and successful [coping mechanisms](#) to stressors by [modeling](#).^[22] Children learn what they see and going for a walk to deal with stress is positive, whereas getting violent and using substances to deal with stress is negative. Encourage children to express themselves creatively as an outlet or to help others to understand what is stressing the child.^[22] Teaching children to act and think positively will also help the child when they are faced with a stressful situation. They will be able to manage the stress before it becomes overwhelming.^[22] Providing a safe and healthy home and environment for a child is very important as well. Provide children with proper nutrition and attention. Do not expose them to substance abuse,

violence or neglect the child's needs. In providing a healthy environment, children are more likely to be emotionally and physically healthy.

Helping Children Cope with Stress

- Ask the child if something is wrong or what is bothering them.^[23] Then make sure to listen and try to understand where they are coming from. Listen to their side and do not interject with things that they should have done or did wrong.^[23] • Take notice to the child's behaviors and feelings and express interest in hearing what is bothering them. Casually ask the child why or what they are upset about using the emotion you feel they are experiencing.^[23] You seem to be mad about what happened after school yesterday." "Are you still sad about that?"
- Talk about solutions to stress with the child. Help the child with some ideas and encourage them to come up with a few on their own.^[23] Supporting the child's ideas will foster confidence in their coping abilities.
- Help the child to think and act positively. Encourage the child to develop positive habits to deal with stress.^[23]
- Be there for the child. Support them and be a good listener.^[23] Sometimes the child may need to just talk about what is bothering them.
- Have patience. Sometimes the child may not be forthcoming with their emotions due to stress. Also, don't fix the child's every problem.^[23]

Notes

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