The Neuro Psycho Physiological Effects of Chronic and Excessive Stress

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Introduction

Stress is an unavoidable aspect of our daily lives. We face deadlines and get stuck in traffic, experience conflict and financial struggles, and live in a race against time. All things considered, humans are remarkably resilient against stress. It's even useful to a point. When stress becomes chronic or excessive, however, it can exceed our natural ability to cope, resulting in harmful consequences for both the body and mind (Benson & Stuart, 1992). In this literature review, we will closely examine the biological components of stress in order to fully understand its impact. We will then see how these components can lead to serious neurobiological, physiological, and psychological consequences when prolonged or in excess. The review concludes with research-based interventions that could aid in both the prevention and treatment of various physical and psychological illnesses. More prevalent utilization of these approaches could potentially improve the effectiveness of our current efforts, while promoting overall health and wellness throughout society.

Defining Stress

Stress is a common topic of conversation, and yet there is considerable ambiguity in the definition of the term. People often use it to describe both the precipitating event (the stressor) and the reaction (the stress response). It is most commonly used in the negative sense, which would be more appropriately termed *distress*(McEwen, 2000). For the purposes of this paper, however, *stress* will be used to describe the total response of one's mind and body to an event that poses a real or perceived threat to one's wellbeing (Kabat-Zinn, 1990; McEwen, 2000).

Stress can result from any change you must adapt to, because change--good or bad--poses a threat to our *homeostasis*, or internal stability (Balch, 2006; Davis, Eshelman, & McKay, 2008). As Balch (2006) defines it, this can include any "physical, mental, social, or emotional stimulus that requires a response or alteration to the way we perform, think, or feel" (p. 455).Stressors include both external and internal forces that bear on us and generate changes in our bodies, lives, or social status. External stressors include physical, environmental, social, financial, and political influences, such as crowded transportation, problems with loved ones, or bodily danger (Davis, Eshelman, & McKay, 2008; Kabat-Zinn, 1990; Balch, 2006; Benson & Stuart, 1992).

Internal stressors, on the other hand, include our perceptions of these outside forces, as well as any thoughts and feelings that surpass our ability to respond effectively. Examples include negative self-talk, unrealistic expectations, and inability to accept uncertainty. Thoughts can become stressors even when they are not based in reality. Believing you have a serious disease, for example, could create a great amount of stress within you and even become disabling, regardless of whether you are truly ill or not (Davis, Eshelman, & McKay, 2008). Balch (2006) stated that some people create their own stress, finding things to worry about even when there is nothing objectively wrong in their lives. For these people, he explained, stress can become a type of addiction, propelling them forward on a sea of drama. The more comfortable they become in this state, the less comfortable they might feel in a state of calm stillness.

The Stress Reaction

Kabat-Zinn (1990) explained that stress acts on various levels of our being, including the physiological, neurological, psychological, and social levels. All of these levels are interconnected and affect one another, influencing the overall state of one's wellbeing. How a person reacts to a stressor is dependent upon whether his or her brain identifies it as a threat.

This could be a threat to one's physical health, emotional stability, sense of self, or any other aspect of his or her wellbeing. Whenever a threat is identified, an automatic alarm reaction is triggered throughout our body (Kabat-Zinn, 1990).

The Fight-or-Flight Response

Walter B. Cannon, a great American physiologist, conducted a number of studies on the physiology of the alarm reaction. In one study, Cannon examined a cat's reaction to a barking dog. He realized that the changes the animal went through mobilized its body to either fight or flee. As a result, he termed this response *the fight-or-flight reaction* (Balch, 2006). Humans experience a similar instantaneous reaction when they feel threatened (Kabat-Zinn, 1990).

The fight-or-flight reaction is our body's way of "clearing the decks" to face immediate danger with defensive or aggressive action (Kabat-Zinn, 1990; Balch, 2006). It does this by rapidly signaling a series of biochemical changes and nervous-system firings. These changes then produce heightened senses so that we can take in relevant information as quickly as possible (Kabat-Zinn, 1990; Davis, Eshelman, & McKay, 2008). Our pupils dilate to sharpen vision, our hearing becomes more acute, and the hair on our body stands up to increase sensitivity to vibrations. Our heart rate and blood pressure also increase and blood flow is rerouted to the larger muscles of our arms and legs. Overall, we become more alert, attentive, and prepared to fight for our lives (Kabat-Zinn, 1990; Davis, Eshelman, & McKay, 2008).

Freeze: An Alternate Response

While the responses of fight or flight tend to be the most commonly recognized, there is a third physiological response to stress that we occasionally utilize, which has been termed as the *freeze response*. Diane Byington explains that this response has survival value in certain cases, such as a deer freezing in the woods to avoid being seen or a mouse "playing dead" so the cat will release it. When faced with an inescapable stressor, our body responds by releasing endogenous opioids (otherwise known as endorphins or our body's natural morphine). These neurotransmitters have an analgesic effect and thus serve to numb pain--both physical and emotional--when death or harm seems inevitable. In humans, this response often manifests as dissociation, immobility, or "shutting down" (Lester, Wong, & Hendren, 2003; Bussey& Wise, 2007).

The Stone Ages vs. the 21st Century

The fight-or-flight response was crucial to survival in a time when people needed brief spurts of energy to defend themselves against predatory animals like saber-toothed tigers (Davis, Eshelman, & McKay, 2008). Fighting or running away were effective responses to this kind of acute threat, and stress subsided as soon as safety was attained (Benson & Stuart, 1992). In modern day, we still face occasional acute stressors in which the fight-or-flight reaction can be useful. Avoiding a moving car, for example, is one beneficial use of the stress response. In this event, your brain interprets the car as a threat and a series of biological changes occur to help you move quickly out of harm's way. Once safe, you breathe a sigh of relief and your body winds down to its normal state (Benson & Stuart, 1992). This physiological reaction is responsible for many miraculous stories, as well, such as that of a father lifting an impossibly heavy object to save his child.

Unfortunately, the majority of stressors we face in the 21st century are not physical threats, but interpersonal, psychological, and financial. The physiological response to these threats, however, is the same (Balch, 2006). In these situations, fighting or running away typically isn't socially acceptable nor is it effective for resolving the problem at hand (Goleman & Gurin, 1993). Instead, we repress these emotions and attempt to carry on as usual. As a result, the body has no way to dissipate the energy, leaving us physically aroused for quite some time after the stressor has passed (Benson & Stuart, 1992). Without physical release and resolution, we may find ourselves in a chronic state of hyperarousal. Left unchecked, this can lead to major physical, neurological, and psychological consequences (Kabat-Zinn, 1990).

Acute vs. Chronic Stress

There are two classifications of stress--acute and chronic. Acute stress comes and goes over a short period of time, such as meeting a deadline at work. This type of stress typically peaks and then moves into recovery. Chronic stress, on the other hand, affects us for more extended periods of time. Examples may include caring for a disabled family member, marital conflict, or multiple subsequent stressors (Davis, Eshelman, & McKay, 2008).Over time, chronic exposure to stress can tax our body beyond its limits to respond and adapt. The normal, functional responses to short-term stress are abnormally prolonged, leading to long-term physiological dysregulation and negative health consequences (Kabat-Zinn, 1990; Benson & Stuart, 1992; Goleman & Gurin, 1993).Excessive and traumatic stress appears to have similar physiological effects to chronic stress, only more marked and with more rapid onset. When stress is both chronic and traumatic (such as in domestic violence situations) may have the most prolonged, severe effects.

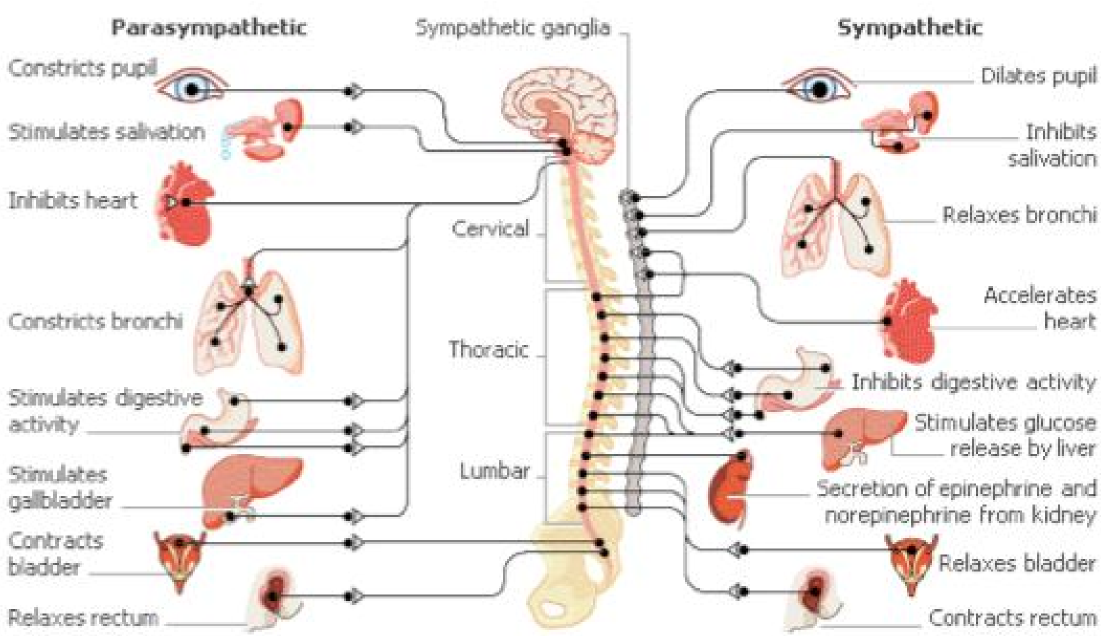
Neurobiological Effects of Stress

The Role of the Autonomic Nervous System

The autonomic nervous system is the regulator of our body's internal states, such as heart rate, blood pressure, and digestion (Kabat-Zinn, 1990). This system responds to our diurnal cycles of activity and rest, as well as the stressors we face each day (McEwen, 2000). It is divided into two subsystems--the *sympathetic* and *parasympatheticnervous systems*--which produce contrasting responses. The sympathetic nervous system is the system of mobilization. It speeds things up and prepares the body for emergencies by increasing heart rate, blood pressure, and muscle tension in the body (van der Kolk, 2003). In other words, this system is responsible for the fight-or-flight reaction.

The parasympathetic nervous system, on the other hand, is the system of recovery. It can be understood as the brakes, inducing relaxation and helping the body compensate for periods of arousal (van der Kolk, 2003). This system brings the body back into a biologically regenerative state by lowering heart rate, blood pressure, and muscle tension (Goleman & Gurin, 1993). It also plays a significant role in affect regulation (van der Kolk, 2003).As you can see, the two systems work together to maintain balance within the body. See Figure 1 for a clearer understanding of the functions of each of these systems.

Figure 1: Nervous System Responses



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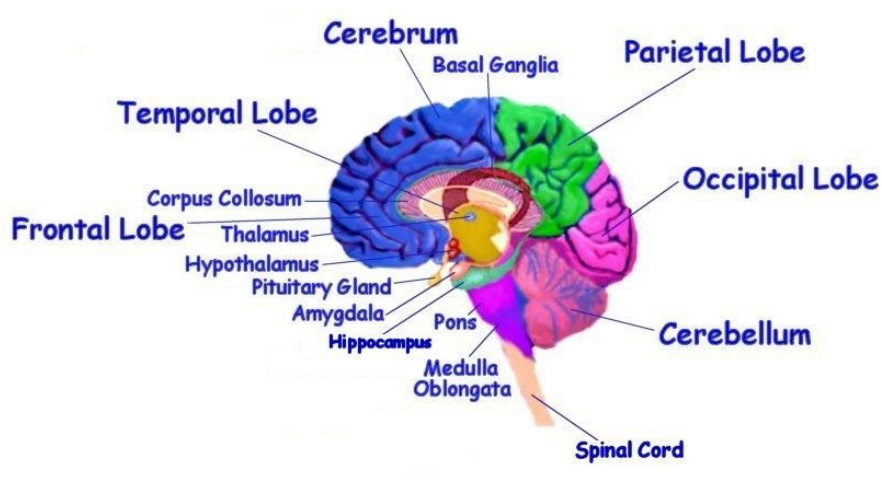
The Role of the Brain

Our brain is the master controller which interprets what is stressful or not, and thus manages the physiological and behavioral responses suitable to that interpretation.

Though the brain is the manager of the stress reaction, it can also fall victim to its consequences. See Figure 2 for a diagram of the parts of the brain to aid in understanding of future sections.

Figure 2: Brain Diagram



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Locus Coeruleus

The *locus coeruleus* is located in the pons of the brain stem and involved in several physiological responses to stress. This brain structure regulates many bodily functions, sleep-wake cycles, pain, arousal, attention, learning, behavioral irritability, anxiety, and the startle response. It sends noradrenergic projections to the spinal cord, cerebellum, midbrain, olfactory bulb, thalamus, hypothalamus, and cerebral cortex. When repeatedly stimulated by stress, the locus coeruleus may become more sensitized, leading to increased brain reactivity (Lester, Wong, & Hendren, 2003).

Limbic System

The *limbic system* is a complex set of brain structures, which includes the amygdala, hippocampus, hypothalamus, and various other midbrain structures (Kabat-Zinn, 1990). Van der Kolk(2003) describes this system as “the seat of our emotions.” It also plays a large role in our biological regulatory mechanisms, as well as functions pertaining to motivation, behavior, long-term memory, and olfaction. The system filters incoming sensory input and determines what information is relevant for further mental processing. This appraisal often bypasses cortical evaluation (such as logical reasoning performed by the frontal cortex) to promote more rapid emergency responses. In acute situations, this can promote self-preservation. In cases of chronic stress, however, the prolonged activation of the limbic system may contribute to irrational decision-making and exaggerated emotional reactions to daily stressors (van der Kolk, 2003).

Hypothalamic-pituitary-adrenal Axis

McEwen (2000) defines the *hypothalamic-pituitary-adrenal axis* (HPA axis) as the major neuroendocrine stress response system. It is a complex set of interactions between the hypothalamus, pituitary gland, and adrenal glands (located on top of the kidneys). The *hypothalamus* is a gland of the limbic system and the master control switch of the autonomic nervous system, activating both the sympathetic and parasympathetic responses (Kabat-Zinn, 1990). Under conditions of stress, the hypothalamus releases corticotropin-releasing factor (CRF), which signals the *pituitary gland* to secrete a messenger called the Adrenocorticotropic Hormone (ACTH)**.** ACTH then travels to the *adrenal glands* to trigger the secretion of *stress hormones* (such as cortisol), which in turn exert effects on other brain structures involved in the stress response (Friedman, Keane, &Resick, 2007).

As the evidence shows, the HPA axis plays an important role in the stress response, as well as the restoration of homeostasis. It is also involved in the regulation of mood and emotions, the immune system, energy storage and expenditure, sexuality, and digestion (McEwen, 2000). Excessive or traumatic stress can overly challenge this system, resulting in prolonged dysregulation and consequential effects on the other systems it manages (van der Kolk, 2003).A large number of studies on Post-traumatic Stress Disorder (PTSD) have found indications of exaggerated sensitization and malfunctioning in the HPA axis, leading those affected to handle acute stress differently and cope less effectively with subsequent trauma (Friedman, Keane, & Resick, 2007;Lester, Wong, & Hendren, 2003).

Stress Hormones

Kabat-Zinn (1990) describes hormones as “chemical messengers that travel far and wide in the body to transmit information and trigger specific responses from cell groups and tissues” (p. 252). In other words, they are like keys that turn on or off the switches throughout the body. Once they arrive at their destinations, they latch onto receptor molecules to deliver their messages. The most pertinent hormones involved in the stress response are *glucocorticoids* (such as cortisol) and *catecholamines* (epinephrine and norepinephrine). These hormones increase locomotor activity, blood pressure, and carbohydrate metabolism while suppressing immune function, growth, and reproductive systems. They also affect multiple brain regions and neurotransmitter systems, resulting in multiple behavioral consequences (Friedman, Keane, &Resick, 2007). In the short run, these effects are protective and adaptive. In situations of chronic or excessive stress, however, these hormones are overproduced and can cause physicalharm(McEwen, 2000). According to van der Kolk (2003), exposure to large amounts of glucocorticoids can damage the central nervous system, hippocampus, and several other organs of the body. It can also age brain cells more rapidly, build fat around the body’s midsection, and cause learning deficits (Balch, 2006; van der Kolk, 2003).

Amygdala

Van der Kolk (2003) defines the*amygdala* as the first structure of the limbic system to interpret whether an incoming stimulus constitutes a threat. This brain structure can also read indirect cues of danger (such as facial expressions of fear) and thus plays a part in the formation of conditioned fear, as well as other conditioned emotional responses. Lester, Wong, &Hendren (2003) add that the amygdala is involved in emotional learning, stimulus-reward associations, and consolidation of emotional memory, as well. When theamygdale declares a stimulus threatening, itprojects emotional and hormonal signals to other structures in the brain to command action. The connection between the thalamus and amygdala is several synapses shorter than the cortex-amygdala connection, which means the amygdala receives input from the thalamus at a much faster rate. This imbalance often reduces a person’s ability to respond appropriately to certain stressful situations. It can also make it difficult to determine the origins of his or her emotional reactions.

Chronic or traumatic stress can generate prolonged, excessive activation of the amygdala. This structure’sability to encode and receive cues (both explicit and contextual) in relation to traumatic experiences may be one of the primary causes of intrusive memories(flashbacks) when excessively triggered (Lester, Wong, &Hendren, 2003). Prolonged activation of the amygdala can also lead to misinterpretations of ambivalent stimuli as threatening and signal stress reactions inappropriate to the context of the situation (van der Kolk, 2003).

Hippocampus

The *hippocampus* is known for its involvement in episodic, declarative, contextual and spatial learning, attention, and memory. It plays a particularly significant role in the conscious recollection of specific life events (van der Kolk, 2003). Regulation of affect and the processing of polysensory information are two other, less-recognized functions of this part of our brain (Lester, Wong, &Hendren, 2003).

The high density of glucocorticoid receptors in this brain structure tells us that it plays an important roleinthe stress response. During emotionally-charged or traumatic events, glucocorticoids and catecholamine prompt the hippocampus and amygdalato form especially vivid memories of these incidents in order to promote avoidance of similar situations in the future(van der Kolk, 2003). Lester, Wong, and Hendren (2003) explain that the hippocampus remembers the circumstances of a traumatic event, while the amygdala remembers the affect. In situations of prolonged or excessive stress, the hippocampus is highly vulnerable to damage.

While moderate amounts of glucocorticoids facilitate memory, large or prolonged doses actually impair both explicit memory and cognitive function (Balch, 2006; van der Kolk, 2003; McEwen, 2000). It is hypothesized that excessively high levels of cortisol cause hippocampal cell death and atrophy. Studies of prolonged child abuse have revealed significantly reduced hippocampal volumes in survivors, often resulting in deficits in new learning--especially learning from negative experiences (van der Kolk, 2003). A study by Gurvitz et al. in 1996 found volumes decreased by 22-26% in Vietnam veterans exposed to combat compared to those without combat exposure.

Studies also show the severity of PTSD symptoms to be directly proportional to the size of the hippocampus in both Vietnam veterans and women who were sexually abused during childhood (Lester, Wong, &Hendren, 2003). McEwen (2000) found that the hippocampus adapts to stress by remodeling the dendrites of its neurons in order to avoid excitotoxicity. While essentially protecting the brain, this restructuring might also play a role in the flashbacks and nightmares associated with post-traumatic stress. Lester, Wong, & Hendren (2003) hypothesize that each flashback then causes additional cell damage, leading to increasing loss in volume over time. Damage to the hippocampus may create memory and attention deficits, as well (Lester, Wong, &Hendren, 2003).The hippocampus also assists with the inhibition of the HPA axis' response to stress; impaired functioning in the one structure, therefore, may contribute to further dysregulation in the other (Friedman, Keane, &Resick, 2007).

Prefrontal Cortex

According to van der Kolk (2003), the *prefrontal cortex* is the part of the frontal lobe responsible for executive decision-making, problem solving, planning, and organizing. This region also performs subtle stimulus discrimination by taking incoming information, registering it into consciousness, comparing it with current knowledge, and then determining an appropriate response. As a result, this cortexmodulates limbic activity and helps to inhibit inappropriate responses (Lester, Wong, & Hendren, 2003). When a person feels threatened by a stressor, however, the rapid limbic system often reacts before the slower prefrontal cortex has a chance to evaluate the stimulus. Excessive stress hormones also impair the functioning of the prefrontal cortex--especially if the stress occurred during a child's development. According to Friedman, Keane, and Resick (2007), this leaves a person in "a physiological state dominated by poorly inhibited limbic activity," which leads to increased impulsivity, as well as impaired problem solving and inappropriate responses to various levels of stress (van der Kolk, 2003).

Anterior Cingulate Cortex

The *anterior cingulate cortex* is considered a part of the limbic lobe and is associated with emotional processing and decisions around whether certain behaviors, thoughts, or feelings will be rewarding. The number of neurons in this structure may decrease in response to prolonged stress, leading to a diminished response to emotionally relevant stimuli (Lester, Wong, & Hendren, 2003).

Left and Right Hemispheres

The *left hemisphere* of the brain specializes in perceiving and expressing language, while the *right hemisphere* processes spatial information and negative emotions. Studies of adults who were abused during childhood have indicated underdevelopment of the left hemisphere and a more dominant right hemisphere(van der Kolk, 2003).Because left-hemispheric damage has been linked to depression, the experience of prolonged, traumatic stress during childhood may create a predisposition for depression (National Geographic, 2012). This underdevelopment likely contributes to survivors' common struggles around creating linear, coherent narratives of their experiences.

Broca's Area

The *Broca's Area* is a small part of the brain, located in the left hemisphere, which is involved in language processing, speech production, and higher cognitive functioning. This area is typically deactivated during the stress response, creating difficulties in speech and expression through the use of words (van der Kolk, 2003).Think about when two people are in a heated argument and suddenly start stuttering and forgetting words they've known since they were children. This is an example of the Broca's response to stress. In trauma survivors, intrusive memories repeatedly trigger the stress response, causing the Broca's Area to start shutting down. This can make it difficult to verbally recollect the experience, and can even lead to temporary mutism (more commonly seen in children) (Lester, Wong, & Hendren, 2003; van der Kolk, 2003).

Corpus Callosum

The *corpus callosum* is the pathway that connects the two hemispheres of the brain. Middle portions of the corpus callosum have been shown to be significantly smaller in victims of child abuse or neglect, leading to more marked *hemispheric lateralization* (using one hemisphere or the other as opposed to involving both at the same time) (van der Kolk, 2003). This may make tasks like creative problem solving and abstract reasoning more difficult.

Cerebellum

The *cerebellum*, most commonly recognized for coordinating motor movements, has also been found to play a role in cognitive integration, executive function, perception of time, visuospatial abilities, linguistic processing, attention, and mood modulation (Madore, 2012; Lester, Wong, & Hendren, 2003). The *cerebellervermis* is a part of the cerebellum that is important for postural, attentional, and emotional balance. It's responsible for integrating sensory information with motoric action, suppressing electrical irritability in the limbic system, and regulating emotional stability. The cerebellervermis has a high density of cortisol receptors, making it vulnerable to stress. Chronic or excessive stress leads to diminished functional activity in this region. Anderson et al. found decreased functional-MRI-measured blood flow in this region in young-adult subjects that had been exposed to repeated child abuse (Lester, Wong, & Hendren, 2003).This inhibited functioning results in amplified reactivity, increased distractibility, and emotional instability (Teicher et. al, 2006; van der Kolk, 2003).

Physiological Effects of Stress

Stress is often seen as a psychological issue, but it has very real physical effects. In fact, almost every organ and bodily function is impacted by it (Balch, 2006). Unfortunately, when fight-or-flight physiological responses become chronic, they can have very negative, long-term effects on our health. Digestion, growth, reproduction, and immune system responses are all important functions for keeping the body healthy. The inhibition of these systems during short-term stress serves to focus the body's energy on more necessary functions for immediate survival. If these systems are shut down continuously, however, it's easy to see how this could be dangerously detrimental (Davis, Eshelman, & McKay, 2008).

According to Balch (2006), stress may contribute to as many as 80 percent of major health problems, including cancer, cardiovascular disease, skin disorders, endocrine and metabolic diseases, and infectious illnesses. Two physician researchers at the National Institutes of Health further support this idea by providing additional evidence for the role of stress in a number of psychiatric disorders, functional disorders of the intestinal tract, autoimmune diseases, coronary heart disease, chronic pain, and several other medical disorders (Goleman & Gurin, 1993).

Effects on the Heart and Blood Pressure

During the fight-or-flight response, heart rate, blood pressure, and blood cholesterol are all elevated to enhance our ability to fight harder or run faster. The composition of the blood also changes to promote clotting in the case of wounding during the fight (Balch, 2006). Over extended periods, however, chronic elevation of heart ratecan raise the risk of cardiac arrhythmia (Goleman & Gurin, 1993; Kabat-Zinn, 1993). Extreme stress or exertion may also inhibit the brain's control over heart rate and lead to fibrillation and sudden death (Goleman & Gurin, 1993). Elevated cholesterol levels can do permanent damage to coronary artery walls (McEwen, 2000).Chronically-elevated glucocorticoid and insulin levels, in combination with increased clotting tendencies, elevated blood pressure, and stress-induced constriction of coronary arteries all promote the formation of atherosclerotic plaques in the coronary arteries, thus contributing to the risk of a stroke or heart attack (Balch, 2006; Goleman & Gurin, 1993; McEwen, 2000).

Effects on the Gastrointestinal Tract

During the stress response, digestion slows or even stops in order to redirect blood flow and energy to more pertinent functions for confronting immediate danger. Many people experience this rerouting of blood as "butterflies" in their stomachs (Goleman & Gurin, 1993; Kabat-Zinn, 1990). Digestive enzymes are reduced and fats and sugars are released from stores in the body to provide additional energy (Bussey & Wise, 2007). When this response is extended over time, digestive problems may occur. Changes in appetite, ulcers, chronic diarrhea, and irritable bowel syndrome are a few possible consequences of chronic stress (Balch, 2006; Kabat-Zinn, 1990).

Effects on the Musculoskeletal System

Muscle tension is increased during the stress response in order to promote more rapid movement and reactions (Balch, 2006). Chronic muscle tension, however, can lead to headaches, backaches, or aggravated pain (Goleman & Gurin, 1993; Kabat-Zinn, 1990; Balch, 2006). Each person seems to store his or her tension in a particular area of the body, such as the shoulders, the jaw, or the hands (Kabat-Zinn, 1990). Many psychiatrists speculate that the majority of back problems--a prevalent ailment in the United States--are closely related to stress (Balch, 2006). According to Goleman & Gurin (1993), the stress response also depletes calcium levels in the bones, which may accelerate the development of osteoporosis and fragility in the elderly.

Effectson the Immune System

Under acute stress, immune functions are suppressed in order to focus energies toward self-defense. Blood levels of immune cells, including lymphocytes, monocytes, and natural killer (NK) cells, are reduced in number. Stress hormones then traffic any remaining immune cells in the body toward tissues, such as the skin, to promote more direct healing in case of injury. Studies on medical students revealed decreased response of immune cells to stimulation, as well as decreased activity of NK cells (the cells that fight viral infections and tumors), during stressful examination periods. The body's production of the chemical that stimulates the growth of NK cells also decreased by as much as 90 percent. T-cells (disease-fighting white blood cells) responded more poorly to test-tube stimulation, as well (McEwen, 2000).

This decreased immune response increases the body's susceptibility to illness or disease and slows recovery processes (Goleman & Gurin, 1993; McEwen, 2000).Thomas Holmes, MD, and his research associates found in their studies that subjects were more likely to develop illnesses after experiencing several changes in their lives (Davis, Eshelman, & McKay, 2008). Davis, Eshelman, & McKay (2008) also claim that this inhibited immune response may exacerbate diseases such as cancer and AIDS. Interestingly, levels of the immune system protein interleukin-6 (IL-6) are actually increased during the stress response. This protein has been associated with several disorders, including Alzheimer's disease, osteoporosis, diabetes, arthritis, cancer, cardiovascular disease, and periodontal disease. It has also been linked to functional decline in older adults (Balch, 2006).

There has been much debate over the years regarding the role of stress in the development of illness. A quote by the well-known physiologist, Selye, makes a good point regarding this matter:

> Significantly, an overwhelming stress (caused by prolonged starvation, worry, fatigue, or cold) can break down the body's protective mechanisms. This is true both of adaptation which depends on chemical immunity and of that due to inflammatory barricades. It is for this reason that so many maladies tend to become rampant during wars and famines. If a microbe is in or around us all the time and yet causes no disease until we are exposed to stress, what is the 'cause' of our illness, the microbe or the stress? I think both are--and equally so. In most instances, disease is due neither to the germ as such, nor to our adaptive reactions as such, but to the inadequacy of our reactions to the germ.
>
> (Kabat-Zinn, 1990, p. 236)

Psychological Effects of Stress

Just as we've seen that acute stress can have short-term physiological benefits, it can produce short-term psychological benefits, as well. Drs. Robert M. Yerkes and John D. Dodson, of Harvard University, found that as stress and anxiety increase, performance and efficiency increase, as well--but only in the short run. At a certain point, as stress continues to increase, performance and efficiency begin to decrease (Benson & Stuart, 1992). Common cognitive consequences associated with stress include poor concentration, anxious thoughts, memory problems, and fearful anticipation. Emotional manifestations may include feelings of tension, irritability, inability to relax, restlessness, worry, and low self-esteem (Goleman & Gurin, 1993; Balch, 2006).

Kabat-Zinn (1990) contends that excessive stress with insufficient coping can result in depleted psychological resources. He explains that a person may begin to feel psychologically exhausted and ultimately lose his or her drive and enthusiasm for life--otherwise known as *burnout*. Continued autonomic arousal with little control over the stressor may create feelings of hopelessness and helplessness, and what used to bring pleasure no longer does.

At this point, chronic depression can set it, along with a diminished level of functioning (Kabat-Zinn, 1990). Balch (2006) seconds this theory, stating that stress is a common precursor of depression, as well as many other psychological disorders.

When a stressful event exceeds an individual's ability to cope, disorders such as anxiety, panic attacks, post-traumatic stress disorder, obsessive-compulsive disorder, dissociative disorders, anorexia nervosa, and phobic disorders may manifest (Balch, 2006; Davis, Eshelman, & McKay, 2008; Kabat-Zinn, 1990).Another possible explanation for the link between stress and depression is the freeze response. As described above, this response seems to kick in when a person feels powerless against an inescapable stressor or overwhelming circumstances (Lester, Wong, & Hendren, 2003; Bussed& Wise, 2007). The analgesic effects of aflood of endogenous opioids may result in immobilization, or "shutting down," which is a common characteristic of depressive disorders. It may be that once a person has exhausted their fight-or-flight resources, a prolonged freeze response sets in.

Freezing is also a common response to traumatic events. Many trauma survivors describe having felt separated from their bodies during the event, as if they were looking in on themselves from the outside. Several say they also felt numb--both emotionally and physically--while the trauma was occurring. This dissociation and numbing often continues over an extended period of time in those with post-traumatic stress disorder. Though this response was adaptive during the traumatic event, dissociative symptoms can interfere with daily responsibilities and prevent a trauma survivor from processing and learning from his or her experience.

Interpersonal Effects

Chronic or excessive stress may have a significant impact on a person's interpersonal relationships. To begin with, the physiological and psychological consequences have residual effects on those closest to us. In addition, operating out of fight-or-flight with a lack of reasoning abilities can lead to irrational arguments and unresolved conflict. A frequent urge to flee and the impulse to fight or lash out in anger can put considerable stress on a relationship and may lead to its collapse (Kabat-Zinn, 1990).

The Weakest Link

Kabat-Zinn (1990) explains that our body can only take so much overload and abuse before it begins to wear out and break down. Everyone has a weakest link, and this is usually the first to give out under conditions of chronic or excessive stress. This weakest link is determined by the combination of a person's genes, environment, and maladaptive lifestyle. For example, a person with a strong family history of heart disease, combined with maladaptive habits of smoking and eating a high-fat diet, would likely be prone to heart-related issues in reaction to chronic stress. Alternatively, a person with a family history of cancer, a poor diet, and excessive exposure to carcinogens may be more prone to immune system dysregulation, increasing susceptibility to cancer (Kabat-Zinn, 1990).

The Negative Stress Cycle

As we've seen, chronic activation of the sympathetic nervous system can cause negative physical and psychological symptoms. These resulting symptoms then add to our stress, which in turn exacerbates our symptoms, and our problems compound. To further complicate the issue, this stress reaction is often accompanied by inadequate or maladaptive attempts to cope, such as overworking, overeating, or substance dependency, which may cause additional damage to our health (Kabat-Zinn, 1990). This cycle of stress, health consequences, maladaptive coping, and compounded stress is called the negative stress cycle. Unfortunately, this cycle has become a way of life for many of us (Benson & Stuart, 1992).

Preventing of Cumulative Effects of Stress

Because the effects of stress are cumulative, we must learn to break the negative stress cycle in order to prevent future damage. Our bodies are designed to react to stress for brief periods of time, and then return to normal levels. The body returns to this baseline state by activating the parasympathetic nervous system to counteract the activities of the sympathetic nervous system. We can assume, therefore, that the regular, intentional elicitation of this parasympathetic relaxation response could reduce the cumulative consequences of stress.

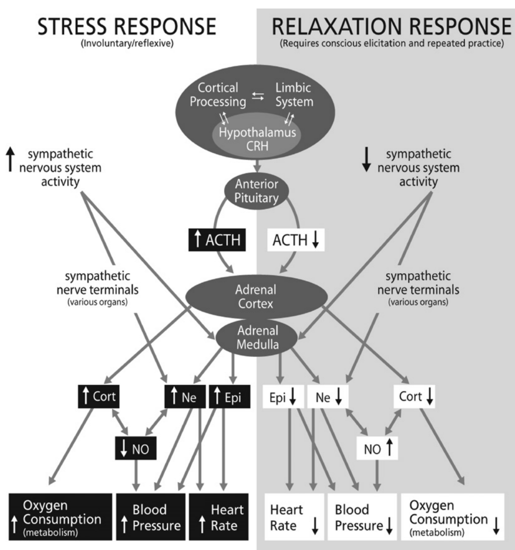
Promoting Resilience

The ability to adapt to our circumstances and maintain effective functioning is referred to as *resilience*. It is what allows us to "bounce back," per se. Resilience can be learned and enhanced to serve as a buffer against the negative effects of stress or trauma on our wellbeing. On the contrary, a lack of resilience has been shown to perpetuate chronic illness (Park et al, 2013). Three tasks in particular have the potential to increase our resiliency: the regular elicitation of the parasympathetic nervous system, the adoption of a mindful attitude (primarily awareness and acceptance), and the presence of social support (Park et al, 2013). The more resiliency factors a person develops, relative to the amount of stress faced, the more likely he or she is to remain healthy (Park et al, 2013).

The Relaxation Response

The *relaxation response* occurs when the parasympathetic nervous system is activated, which serves as a counterbalancing mechanism against the sympathetic nervous system (fight-or-flight) response. This parasympathetic response involves a set of physiological changes, including a decrease in heart rate and blood pressure, stimulation of the digestive system, and reduced muscle tension. It is a state of profound rest that has the potential for lasting positive effects throughout the day when practiced regularly (Benson & Stuart, 1992).Compare the changes of the relaxation response to those of the fight-or-flight response in Figure 1:

Figure 1:Stress response and relaxation response



(Retrieved from www.psychosomaticsjournal.org)

Eliciting the relaxation response

The relaxation response can be elicited through several techniques. Some of the most common methods include meditation, guided imagery, diaphragmatic breathing, progressive muscle relaxation, yoga, exercise, repetitive prayer, and biofeedback (Park et al, 2013; Benson & Stuart, 1992). All of these techniques involve two basic components. The first is a mental focusing device, such as the observance of one's breath or the repetition of a word, sound, image, phrase, prayer, or physical motion. The second involves adopting a passive attitude toward one's thoughts. This means that a person gently observes and accepts thoughts, but then allows them to pass and directs the mind back to the focusing device. These techniques help us to "let go" more deeply than we ordinarily would without such help (Benson & Stuart, 1992).

Benefits of the relaxation response

Several studies have shown that the regular elicitation of the relaxation response over time can result in significant improvement in neurological, physiological, and psychological functioning (Chang, Dusek, & Benson, 2011). It has been shown to decrease stress-related physical symptoms, anxiety, self-criticism, and negative thoughts, while improving concentration, sleep, self-acceptance, and efficiency (Benson & Stuart, 1992).

It has also been shown to cultivate health-promoting attitudes and consequentially reduce the frequency of medical symptoms (Benson & Stuart, 1992). Benefits are dose-dependent, meaning the more relaxation elicited over a longer period of time, the more benefits and changes that occur in neurofunctional networks (Rubia, 2009).

Neurobiological benefits

Extensive research and clinical work has found that elicitation of the relaxation response combats stress through a down-regulation of the sympathetic nervous system. Physiological evidence has revealed that techniques such as meditation and diaphragmatic breathing reduce stress-related autonomic and endocrine measures, with improved modulatory action on levels of stress hormones such as cortisol (Rubia, 2009; Vera et. al, 2010; Spinazzola, Rhodes, Emerson, Earle & Monroe, 2011). Park et. al (2013) adds that this practice can also reduce adrenergic end organ responsivity, creating a physiological buffer against stress. Their research with long-term meditators found these subjects to have reduced psychological, physiological, and electrophysiological reactivity to stressful stimuli. Neuroimaging studies demonstrate that techniques such as mindfulness meditation up-regulate and increase gray matter density in various parts of the brain, including the frontal and prefrontal cortices, temporal lobes, and hippocampus. This increase in matter results in improved emotional regulation, attention control, learning, memory, self-referential processing, and perspective taking (Spinazzola, Rhodes, Emerson, Earle & Monroe, 2011; Rubia, 2009; Luders, Clark, Narr, & Toga, 2011).Exercise has been shown to increase the volume of the hippocampus, as well. Essentially, these techniques have the potential to literally reverse hippocampal damage from traumatic stress or age-related atrophy (Luders, Clark, Narr, & Toga, 2011).

Yoga is another method of eliciting the relaxation response that evidence has shown to help regulate both the hypothalamic-pituitary-adrenal (HPA) axis and sympathetic nervous system (Ross & Thomas, 2010). The regulation of these systems consequentially allows more access to frontal brain regions while improving both physical and mental health. Stimulation of the cerebellar vermis through exercise, rocking, and movement exerts calming effects, which could be used to counter anxiety, hypervigilance, and irritability (van der Kolk, 2003). In addition to improved functioning in specific areas of the brain, meditation has also been shown to enhance connectivity throughout the entire brain, resulting in better linkage between the body, affect, and thought (Luders, Clark, Narr, & Toga, 2011; Rubia, 2009; Siegal, 2006). Siegal (2006) believes the prefrontal cortex to be highly involved in this integration and have a number of functions that help to decrease the effects of stress and trauma. He outlines these prefrontal functions to include balancing the opposing branches of the autonomic nervous system, maintaining emotional balance, promoting flexible responses, inhibiting impulses, promoting attuned communication, calming fearful responses, and increasing empathy, insight, intuition, and morality. Some preliminary studies suggest that mindful meditation practice may lead to enhanced growth of these prefrontal regions, as well as preserved neural tissue that would otherwise atrophy with aging (Siegal, 2006).

Physiological benefits

Studies have shown many relaxation techniques toact as buffers against the negative impact of stress on physical health (Park et al, 2013; Goleman & Gurin, 1993).Meditation, breath work, exercise, and physical fitness have all been shown to decrease heart rate, blood pressure, and muscle tension over time (Goleman & Gurin, 1993). In one experimental study of runners versus sedentary individuals, the runners showed significantly lower increases in anxiety, muscle tension, and blood pressure in reaction to stressful circumstances than the sedentary group. Deep parasympathetic activation may also play a role in the prevention and treatment of many stress-related illnesses, such as cardiovascular, hypertensive, and respiratory diseases (Rubia, 2009; Goleman & Gurin, 1993). Goleman and Gurin (1993) have found sharp reductions in the amount of medical symptoms reported by their patients after only eight weeks of meditation practice. They explain that certain problems, such as tension headaches, can be completely eliminated through relaxation. Others studies found positive results inthe reduction of symptoms patients experience in anticipation of chemotherapy, such as nausea and vomiting. For those with chronic conditions, such as nerve damage, regular relaxation can at least offer partial pain relief and reduce the amount of suffering associated with the condition.

In addition to these findings, Goleman and Gurin found that the elicitation of the relaxation response, in combination with other behavioral techniques, actually slows brain wave patterns in patients with insomnia, causing them to fall asleep four times more rapidly.

Guided imagery, in combination with other relaxation and stress management techniques, can contribute to a wide array of physiological changes, as well, including changes in heart rate, blood flow, blood pressure, brain wave rhythms, breathing patterns, sexual arousal, and output of certain hormones and neurotransmitters. Therefore, these techniques could serve as an effective component of treatment for conditions such as high blood pressure, heart palpitations, autoimmune diseases, allergies, and cold and flu symptoms. They could be highly beneficial for stress-related gastrointestinal and reproductive problems, as well (Goleman & Gurin, 1993). Goleman and Gurin claim that imagery may even be able to speed healing after injuries (1993). Breath work is another technique that has been shown to improve heart rate variability, and biofeedback is often utilized in the treatment of chronic pain, headaches, high blood pressure, asthma, incontinence, Raynaud's disease, and muscle disorders. Both exercise and imagery have been shown to improve the functioning of the immune system, as well (Spinazzola, Rhodes, Emerson, Earle & Monroe, 2011).In addition to the physiological benefits of the relaxation response, regular practice may also provide better coping mechanisms to replace maladaptive ways of dealing with stress, such as smoking, drinking, or overeating, thus reducing the health consequences associated with these habits (Goleman & Gurin, 1993). Individuals in Goleman and Gurin's relaxation study reported more health-related attitudes and behaviors, as well as increased motivation to take care of themselves.

Psychological benefits

Several research studies indicate that the elicitation of the relaxation response results in greater psycho-emotional stability and resilience (Spinazzola, Rhodes, Emerson, Earle & Monroe, 2011; Park et. al, 2013; Rubia, 2009). Mindfulness meditation has been shown to increase levels of mood-stabilizing neurotransmitters and neuro-hormones (such as serotonin, dopamine, and melatonin), whereas deficiencies have been associated with many mental health disorders (Rubia, 2009).

Consistent practice of the relaxation response also decreases anxiety, anger, hostility, and depression (Goleman & Gurin, 1993). Another study by Goleman and Gurin (1993) found long-term meditators to have significantly lower scores in personality traits of neuroticism and psychoticism, while scoring higher in traits of emotion recognition and expression. Neuroimaging also revealed more theta and alpha activity over left frontal regions of these meditators' brains, resulting in more positive emotions and reported feelings of happiness (Zeidan, Johnson, Diamond, David, & Goolkasian, 2010; Rubia, 2009). The practice of relaxation techniqueshasbeen found to increase feelings of self-confidence, assertiveness, and control over life, as well. All in all, the relaxation response has the potential to improve a person's ability to cope with the physical and emotional challenges they face throughout life (Goleman&Gurin, 1993).

Considering these results, we can see how the regular activation of the parasympathetic nervous system could be effective in the treatment of many mental health problems--particularly with disorders of mood, anxiety, and attention (Goleman & Gurin, 1993; Rubia, 2009). Regular practice could serve not only as a buffer against future stress reactions, but also as an effective component of post-traumatic treatment. Recent research has found practices of yoga, diaphragmatic breathing, and guided imagery to all significantly reduce post-traumatic symptoms of hyperarousal, nightmares, and flashbacks (Spinazzola, Rhodes, Emerson, Earle & Monroe, 2011; van der Kolk, 2006; Jain et al, 2012).

A Mindful Attitude

In addition to physical relaxation, it is important to elicit cognitive relaxation to reduce our stress reactivity. This involves reducing mental activity, as well as changing the way we appraise stressful situations (Rubia, 2009). Lazarus and Folk man suggest that the amount to which a person experiences a situation as stressful is dependent not only upon the situation, but also the individual's assessment of the situation (Park et. al, 2013). Because we cannot always change our environment, we can learn to use our mind to control our reactions to it (Benson & Stuart, 1992). Kabat-Zinn (1990) believes that, with regular practice, we can actually choose not to go the fight-or-flight route. He further explains that by adopting an attitude of moment-to-moment, mindful awareness, we gain some control over the flow of events in situations during which we would otherwise react automatically.

Siegel defines this type of mindful awareness as "paying attention, in the present moment, on purpose, without grasping onto judgments" (2006, p. 250). Simply bringing conscious recognition to both the situation and our reactions to it may shift us away from the automatic limbic responses and toward the frontal and prefrontal cortices, where we can more accurately assess the threat involved.

It may also provide us with recognition of how our own unbalanced view may be promoting an overreaction in relation to what the circumstances actually warrant. With regular mindful practice, we can train the mind and body to automatically respond with more calmness and clarity. Even when our equilibrium is initially thrown off by a stress reaction, this mindful attitude can help us to recover more quickly (Kabat-Zinn, 1990).

Park et. al (2006) has found that we can further decrease our stress reactivity by identifying the warning signs of stress and proactively generating more positive cognitions, emotions, and behaviors. We can change the way we perceive stressors, choosing to view them as challenges and opportunities for growth, rather than as threats (Park et. al, 2013; Kabat-Zinn, 1990). Turning within ourselves to cultivate an inner calmness, acceptance, and openness gives us a chance to slow down, more accurately assess the situation, and renew our inner balance (Benson & Stuart, 1992).

Benefits of a mindful attitude

Research has found that this type of interception can result in significant mental, physiological, and interpersonal improvements (Siegel, 2006). It may also increase our tolerance of feelings and sensations, thus reducing the mental suffering associated with stressful situations and reactions (van der Kolk, 2006).

Neurobiological benefits

Mindfulness training has been found to significantly improve working memory, executive functioning, and visuo-spatial processing (Zeidan, Johnson, Diamond, David, & Goolkasian, 2010).Siegel's research has found that mindful awareness of our thoughts, feelings, and bodily input may enhance integration throughout the brain by linking our somatic regulatory functions with memory, affective states, attachment, motivational drives, and appraisal of meaning. This augmented connectivity is correlated with enhanced wellbeing. Siegel goes on to explain that focal attention may also promote memory integration by bringing the puzzle pieces of implicit (unconscious) memory into light, where they can be organized and made sense of. This could consequentially reduce the flashbacks and nightmares that commonly occur from free-floating, trauma-related, implicit memories (Siegel, 2006).

Physiologicalbenefits

Attitudes are thought to influence our physical health in a number of ways (Goleman & Gurin, 1993). To begin with, decreases in psychological distress levels are positively correlated with reductions in physiological levels of stress (Chang, Dusek, & Benson, 2011). Several studies have found a link between physical health and psychological traits, such as hope, optimism, and sense of control. On the flip side, traits of hostility, learned helplessness, and lack of control have been linked to poor physical wellbeing (Goleman & Gurin, 1993). Mindful practices have been found to improve the functioning of our immune, cardiac, and endocrine systems, as well (Siegel, 2006).

Psychological benefits

Research has found mindful practice to be beneficial in the treatment of a variety of mental health disorders. One study examined the effects of this practice on patients who suffered from panic attacks. Results showed that when individuals were able to bring gentle awareness to their thoughts and breath in the early stages of an attack, it was less likely to turn into full-blown panic (Goleman & Gurin, 1993; Rubia, 2009). Goleman and Gurin teach that the cognitive restructuring that takes place when people are able to recognize irrational thinking patterns can prevent the occurrence or exacerbation of negative emotions, as well. Furthermore, they believe that, for people with physical impairments, the despair felt over the ailment often becomes more demobilizing than the illness itself. For these cases, a positive, mindful, and humorous attitude can provide the energy needed to live a more productive, fulfilling life despite any physical ailments. To add to these benefits of mindful practice, Siegel (2006) found that this kind of attitude tends to increase compassion, empathy, and interpersonal sensitivity, as well--all of which have been linked to a deeper sense of wellbeing and purpose in life.

Social Support

Siegel (2006) has found the brain to be extremely social. The very structure of it reveals how important connections to others are for our inner balance and wellbeing. Development occurs around interpersonal interactions, and can also be shattered by them.

Secure attachments appear to prevent rises in glucocorticoids and reduce stress responses, while disorganized attachments lead to increased cortisol output in response to stressors. This is believed to alter responses to stress later in life, as well as vulnerability to PTSD (Lester, Wong, &Hendren, 2003). Goleman and Gurin (1993) also validate that feeling supported during traumatic situations can moderate the release of stress hormones and shield us against the negative effects of stress. Take the example of walking through a dark alley. A person accompanied by a friend would likely feel more secure than a person walking alone, and one accompanied by a large group would feel less fearful than the other two. Another of Goleman and Gurin's studies found social support to enhance immune function.

The mirror neuron system provides us an additional clue into the importance of social support. Siegel (2006) teaches that through this system, we are able to create an internal state that resonates with that of another person. He goes on to explain that our affective, physiological, and intentional states all adapt to reflect that of the person we are observing. As a result, if one person is able to achieve a state of mindful awareness that state could literally be transmitted to another. This may be a valid argument for "choosing your friends carefully." If we can surround ourselves with those who improve our inner state, we can achieve a greater level of wellness simply by being in their presence.

Conclusion

In summary, our body's stress response was designed to be beneficial for self-preservation in situations of acute danger. In our world today, however, many people experience this response for prolonged periods with few outlets for release of the tension. As we've seen, chronic or excessive activation of the sympathetic nervous system can have very negative effects on the brain, mind, and body. These effects then cause more stress, which exacerbates the symptoms, generating a negative stress cycle. The cycle is then compounded by maladaptive attempts to cope, which further damage our health and wellbeing. As this cycle continues over time, the effects of stress accumulate until our weakest link finally gives in. In order to prevent these negative consequences of stress, we must learn how to break this negative cycle and regularly bring ourselves back into a state of recovery. We must build up our resilience and repair damage already done.

This review found three tasks to be particularly useful for building resilience and promoting healing: the regular elicitation of the relaxation response; the adoption of a mindful attitude; and, the presence of social support. The combination of the three would likely be most effective, considering that each has an effect on another. Social support aids the development of a mindful attitude, a mindful attitude leads to deeper relaxation, and relaxation leads to healthier relationships.

The incorporation of these methods into medical and mental health treatment could result in significant neurophysiological, psychological, and interpersonal benefits. It has the potential to heal both the physical and psychological effects of emotional trauma, with more effective symptom reduction than current cognitive and narrative practices alone. It could stop panic attacks before they start, break the cycle of recurrent depression, and smooth the waves of several other disorders. These methods could also prevent, and even reverse, some of the most prominent diseases and ailments in society, while improving both quantity and quality of life. With reduced health costs and better results, what do we have to lose?

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