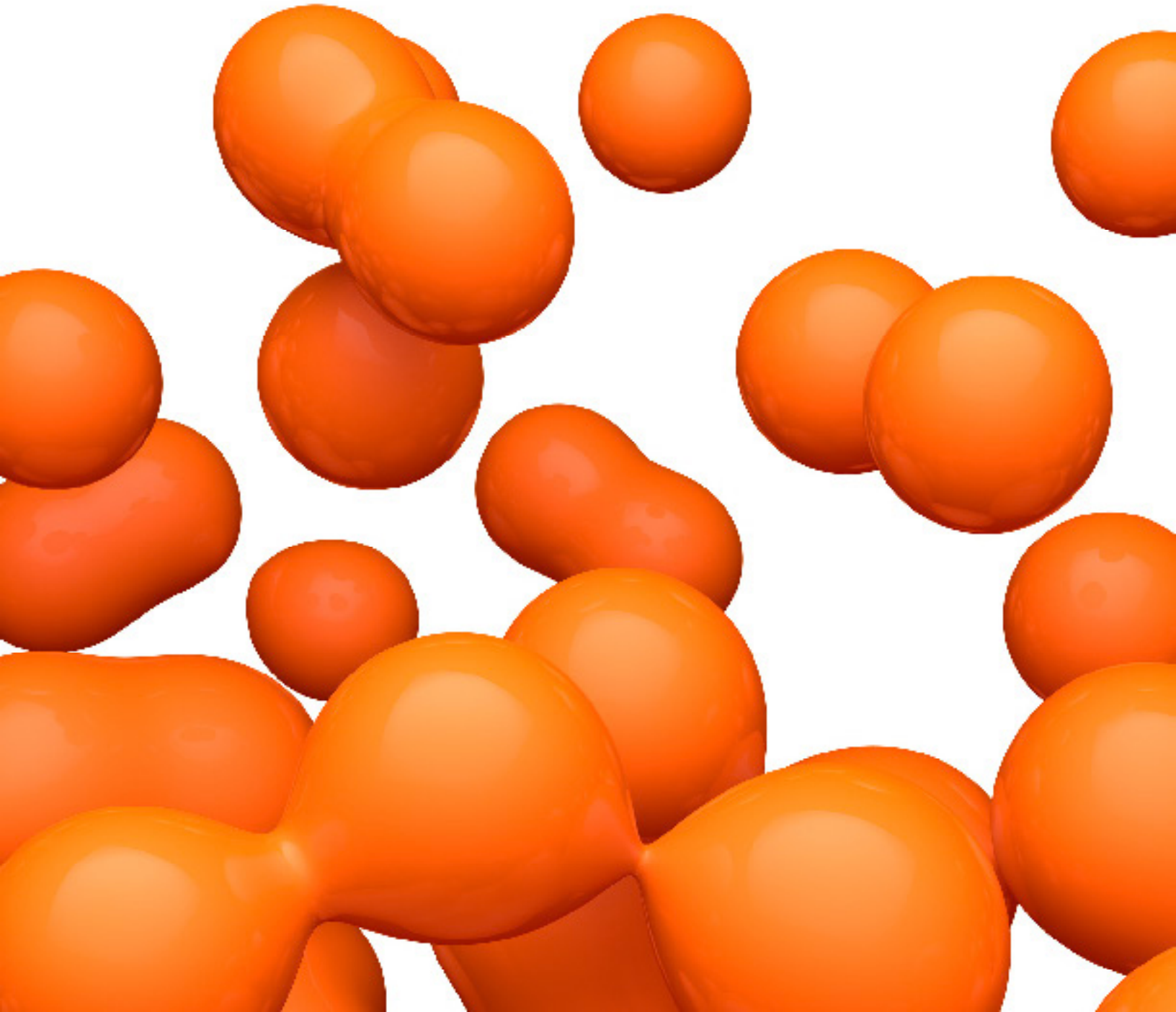
Neuro Therapeutics

From Breakdowns to Breakthroughs

Sarah Wyckoff[1], Heather Larsen[1], Kara Waits[1], Tami Fragedakis[1], Noel Ford[1,2] & Leslie Sherlin [1,2,3]

[1] Neuro Therapeutics, Inc., Mesa, AZ, USA
[2] Department of Mind-Body Medicine, Southwest College of Naturopathic Medicine, Tempe, AZ, USA
[3] Department of Psychology, Ottawa University, Surprise, AZ, USA



Abstract

Millions of Americans experience daily stressors which negatively impact their overall health and wellbeing. While common stressors within the American society have been identified, responding to stress is often influenced by one's perception and attitude, in addition to an individual's social support system and coping skills. Assessments define how an individual experiences stress and can be used to identify personal goals and appropriate treatment. Various interventions, including psychotherapy, pharmacotherapy, and biofeedback training, have been designed to help individuals gain skills needed to effectively cope with and appropriately respond to the stress presented and adapt a healthy lifestyle.

Introduction to Stress

Stress is any event that is taxing emotionally and physiologically, however, this is an ambiguous definition that does not deliver clear meaning regarding how the body adapts to daily stressors, major life events or trauma (McEwen, 2007). It is the brain that interprets these events, classifies them as potential or actual stressors and sets the behavioral and physiological responses to each (McEwen, 2009). In 2014, the American Psychological Association (APA) conducted a nationwide survey and the results clearly state the impact stress is having on Americans. Nearly 75% of the adult population reported experienced at least one indicator of stress, such as irritability, nervousness, anxiety, fatigue, or depression in the past month (American Psychological Association [APA], 2015). Stressful events come from a variety of sources but the common stressors affecting the American population are money, work, family responsibilities and personal health concerns (APA, 2015). Financial stress has the most significant impact on Americans, as 72% of adults report feeling stressed about money at least some of the time, while 26% report feeling stress about money most all of the time. Due to financial stress, nearly 1 in 5 Americans have skipped a needed doctor's visit and 32% of adults report significant limits on their ability to live a healthy lifestyle. In order to manage their stress many Americans engage in sedentary or unhealthy behaviors (APA, 2015). Forty percent watch television/movies for more than two hours per day, 38% surf the internet, 27% nap or sleep, 23% eat, 14% drink alcohol, and 12% smoke. It is evident that stress has an overall negative impact on health (APA, 2015). Additionally, women spend more time and have a higher frequency of lying awake unable to sleep due to stress, younger Americans experience more stress than those over the age of 69, and parents are more likely to experience one symptom of stress in a month (APA, 2015).

While stress often has a negative connotation, it is necessary for handling emergencies as well as attaining peak performance. Some amount of stress can increase performance during experiences that are limited in duration, can be mastered and end with a sense of exhilaration. The ability to successfully adapt when stress is present allows an individual to overcome obstacles and gain a hardiness that is useful in many facets of life (Quick et al., 2013). Those individuals that are able to use stress to their advantage to increase performance are often described as having commitment to self, the belief they can control or

influence events, strong ability to set goals and priorities, as well as good decision making that supports internal balance (Kobasa, 1979; McEwen, 2007). In contrast, distress or being stressed out, does not lead to performance increases and results from experiences that are prolonged or recurrent, irritating, emotionally draining, physically exhausting, and end without a sense of mastery or control (Kobasa, 1979; McEwen, 2007).

We discuss here relevant problems, assessments, and interventions that are within the scope and reach/access of most people. There are a variety of effective interventions such as medication that we only mention briefly, as they require the expertise of a trained professional. We are focused on opportunities that individuals can employ for themselves and/or as adjunctive tools in the hands of a professional.

The Stress Process

The stress process refers to the exposure to and different meanings of stressors that vary from person to person, the access an individual has to stress mediators, and the different effects stress manifests including physical, psychological and behavioral outcomes (Pearlin, 1989). Negative stressors (any stimulus found to be threatening or burdensome) come in a variety of forms including but not limited to chronic tensions, major life events, traumas and daily hassles. Daily stressors are minor events that arise out of day-to-day living that have the potential to affect physical and psychological well-being such as an argument or missing a deadline (Almeida, 2005). Major life events (e.g., divorce) have been found to have long-term consequences and negative health effects (McLeod, 2012). The effects of stressors and their outcomes rely heavily upon the availability of social and personal resources to serve as protective buffers, as well as an individual's ability to cope with the stimuli. There is great research into daily stress that focuses on identification of factors associated with what is collectively known as the daily stress process, specifically exposure and reactivity to such events. Exposure refers to the likelihood of experiencing a stressor, while reactivity is a change in either emotional or physical well-being associated with the experience of a stressor (Almeida, 2005; Bolger & Zuckerman, 1995).

The brain is the central organ of the stress response and it changes structurally and chemically in response to both acute and chronic stressors. A recognizable stress response is the activation of the autonomic nervous system which controls the flight-or-fight response and is the traditional way of demonstrating the behavioral and physiological response to an identified threat (McEwen, 2007). Stressful experiences cause the body to release chemical mediators, such as, catecholamines that increase heart rate and blood pressure. These mediators help individuals adapt to acute stressors, as well as simple acts such as getting out of bed or climbing a flight of stairs. However, if these mediators remain elevated chronically they can cause physical changes in the cardiovascular system that, in time can lead to strokes and myocardial infarctions (McEwen, 2007). While these chemical responses to stress are necessary to survive acute stressful events, many individuals are likely to enter prolonged periods where this system is in use.

To gain further insight into stress mediation two important terms surface: allostasis, which is defined as the process of maintaining stability by active means such as releasing stress hormones or other mediators, and allostatic overload, which is defined as the wear and tear on the body and the brain caused by frequent use of allostasis, particularly when hormones or mediators are dysregulated (McEwen, 2007). Many individuals are unaware of the implications that go along with a heightened, or perhaps unnecessary, levels of stress. While this system is designed to protect from stressors, when the stress response leads to allostatic overload the released stress hormones began to damage specific parts of the brain which regulate sleep, the flight or fight response, the aging process, and cognitive functioning. It is beyond the scope of this review to cover all chemical and hormone mediators generated by experienced stressors and how specific compounds affect brain physiology. For further details regarding this please see the review by McEwen (2007).

Numerous studies have shown that a major mediating construct in coping with stress is social support (e.g., religion, family, medical care system, neighborhood, material resources, and emotional support) which is linked to psychological and physical health outcomes (Pearlin, 1989). Defined the buffering model as it produces a barrier from the influence of stressful events on individuals and provides positive affect, a sense of predictability and stability in one's lifespan, and a recognition of self-worth. When an individual experiences a stressful event or stressor, social support may intervene and prevent or reduce a stress response from occurring and/or assist in redefining the potential for harm and increase the individual's coping ability(s) towards the stressor (Cohen & Wills, 1985). Other mediating variables for coping with stress include locus of control and self-efficacy. How an individual embraces his/her beliefs about situations or events and the feeling of control or choice over them are individuals with an internal locus of control. Research shows these individuals tend to be happier and less stressed than individuals with an external locus of control, who are more susceptible to health problems including grief, anxiety and depression, and report having less control over a stressful event/situation. Locus of control can give insight to a person about their ability to make decisions and is an important social personality variable in relation to coping with daily stress (Khan, Saleem & Shahid, 2012).

While mediators may aide in decreasing the intensity of one's stress response and minimizing one's perceived stress to an event or situation, the outcomes of exposure to stressors, especially prolonged stress, include but are not limited to negative physical/ behavioral and physiological health problems and/or well-being (Pearlin, 1989). It is beyond the scope of this present review to entail all potential health problems that may ascend from stress but some of the most common impacts are briefly described below.

The "fight or flight" response, designed to protect one from bodily harm, is triggered when one interprets a situation as threatening. The response is controlled by the hypothalamus. Once a response is received the body's sympathetic nervous system activates causing the adrenal medulla to release hormones into the bloodstream producing profound physiological changes including increased heart rate, breathing rate and blood pressure. This process causes the body to speed up and become more alert and ready to "fight or flee". If an

individual perceives a stressor as a threat then it is likely that one will fight as opposed to a threat that is perceived to be more formidable in which case flight is more probable (Taylor et al., 2000). Conversely, the relaxation response controlled by the parasympathetic nervous system generally opposes the sympathetic nervous system, decreasing the aforementioned physiological symptoms when inhibited (McEwen, 2007).

Problems with Stress

Stress not only affects the brain but the rest of the body as well. This review will briefly mention disorders including obsessive compulsive disorder (OCD), post traumatic stress disorder (PTSD), and panic disorder (PD), but the main focus will be how stress affects nonclinical populations. When an individual encounters a stressful situation the body releases glucocorticoids (GC), a class of stress hormones, which after being processed by the hypothalamic-pituitary-adrenal (HPA) axis mainly yields cortisol, well known for its potential negative effects (Marin et al., 2011). Because GCs are present in the brain regions that are critical for the regulation of emotion and memory, chronic stress levels can negatively impact cognition and play a role in the development of psychopathologies like those mentioned above (Marin et al., 2011). Many studies have investigated how high levels of chronic stress/cortisol affects quality of life and it is clear that increasing/high levels of cortisol over time lead to memory impairments. For further details about these studies please refer to Marin et al. (2011).

Cardiovascular diseases (CVD) are the major cause of death and morbidity in Western countries, accounting for more than half of all deaths (American Heart Association, 2005). There is alarming evidence about the risk of CVD for individuals that are exposed to stress overload and the devastating effects it can cause including stress-related heart attack, stroke, elevated heart rate and blood pressure (Kubzansky & Alder, 2010). Research has also investigated the correlation between stress, transformed eating patterns, and the adverse physical effects it can cause to a person's body. Some individuals increase their caloric intake while others may restrict food intake in times of stress causing a broad range of health problems from obesity to the development of anorexia nervosa. Changes in eating behavior and weight fluctuation due to stress have been found to also increase cortisol secretion, increasing Body Mass Index (BMI), resulting in an array of health problems (Roberts et al., 2007). Of the many physiological impacts that emerge in response to stressors, one of the most frequently researched is the disruption along the hypothalamic-pituitary-adrenal (HPA) axis, resulting in the increase release of cortisol concentrations in the blood, saliva or urine also mentioned above. This has been found to endanger sensitization of the neuronal process leading to changes in cortisol regulation (Michaud, Matheson, Kelly & Anisman, 2008). The stimulation of the HPA is a normal stress reaction but in excess can cause permanent harm especially in the hippocampus, which can result in memory loss. Prolonged elevations can also result in many adverse disturbances including hypertension, dysphoria, cognitive disturbances, and sleep disorders (Bollini, Walker, Hamann & Kestler, 2004).

Heart disease, cancer, asthma, gastrointestinal disturbances, and the common cold are some of the health concerns that can be exacerbated by stress (McEwen, 1998). Although the process of how stressors cause disease is not fully evident, there are three main rationales for why stress has such a substantial impact on health. First, each individual responds to environmental stressors differently. Second, many daily events are not considered to be stressor but still have negative impacts on the body. Third, the body is comprised of many complex systems, many of which are involved in the stress process and can cause damage, instead of protection, during extreme stress (McEwen 1998). One's ability to avoid illness, rate of aging, sleep quality, blood pressure and other measures of overall health are also altered due to increased levels of experienced stress (McEwen, 2007).

Chronic stress also has psychosocial implications as daily stress at work has been shown to lead to decreased mood and overall health (DeLongis, Folkman, & Lazarus, 1988; Nieuwenhuijsen, Bruinvels & Frings-Dresen, 2010). Additionally, individuals that exhibit low self-esteem and low emotional support show a significantly increased poor moods and physical symptoms when compared to individuals that have higher psychosocial skills (DeLongis, Folkman, & Lazarus, 1988). These individuals often report burnout at work which indicates that they likely have difficulties focusing on tasks, increased daily fatigue, increased inhibition errors, and performance variability on attention tasks (Marin et al., 2011).

At one point or time in a person's life anxiety is experienced when one feels tension, anxious or nervous about a situation and is a common emotion until it persists beyond a person's control. Research has shown that individuals who have a relatively stable proneness for anxiety are more likely to suffer from anxiety disorders (Spielberger & Reheiser, 2009). According to the Diagnostic and Statistical Manual of Mental Disorders, 5th Edition, anxiety and stress disorders are characterized by an excessive fear response and/or worry that interferes with functioning or causes significant distress. Generalized anxiety disorder (GAD) is one of the most common mental disorders in primary medical-care settings, and is associated with increased use of health services (Baldwin, Waldman & Allgulander, 2011). GAD is characterized as an individual who experiences continuous worry, stress and often involves cognitive impairments due to the excess of worrisome thoughts (Liberzon, Duval & Javanbakht, 2015). Symptoms include but are not limited to sleep disturbance, muscle tension, irritability, memory impairments, fatigue, difficulty in concentrating and restlessness (Bandelow et al., 2008). One who has social anxiety disorder (SAD) often experiences persistent fear of social and performance situations and often struggles with attention. Individuals with SAD may experience negative judgment from others, humiliation and marked impairment in multiple domains of functioning, including education, employment, family, and romantic relationships (Liberzon, Duval & Javanbakht, 2015). Often other problematic psychiatric conditions are seen with people who have SAD including mood disorders, insomnia, substance abuse and suicidal thoughts. It is of concern not only from a person-focused perspective but also from a community standpoint, considering the substantial public health costs linked with the syndrome (Schmidt, Richey, Buckner & Timpano, 2009).

Assessments of Stress

Perceived Stress Reactivity Scale. While research indicates a correlation between stress and illness, not all individuals who experience stress will develop illnesses (Cohen & Manuck, 1995). Perceived stress reactivity identifies physiological and psychological stress responses, which may often be difficult to assess due to extraneous variables such as heredity (Bandura, 1994), altered cortisol levels due to exposure of chronic stress (Kirschbaum et al., 1995), and the emotional state of the individual (Dickerson & Kemeny, 2004). In addition, stress responses will vary according to the individual due to personality differences, particularly beliefs of self-efficacy and neuroticism Research indicates poor self-efficacy and high levels of neuroticism correlate with elevated stress responses (Schlotz, Schulz, Hellhammer, Stone, & Hellhammer, 2006). The Perceived Stress Reactivity Scale (PSRS) is a self-report that was developed to assess perceived stress during common stressful situations. The PSRS is comprised of 23 items, categorized into the following five subscales; prolonged reactivity, reactivity to failure, reactivity to social conflicts, reactivity to work overload, and reactivity to social overload. The PSRS is easy to administer and applicable in a variety of settings and can be utilized to screen for mental health, assess therapies implemented within a mental health setting, and assess reactions to environmental situations (Schlotz, Yim, Zoccola, Jansen, & Schulz, 2011).

Perceived Stress Scale. While experiencing stress is normal, how an individual perceives and reacts to stress may vary (Graham & Stevenson, 1963). The perceived stress scale (PSS) was developed to determine if an individual's personal characteristics, including hardiness (Kobasa, 1979) and locus of control (Johnson & Sarason, 1979), in addition to the availability of coping outlets and social support (Pearlin et al., 1989), influence how an individual would perceive stress. The PSS is a self-report comprised of 14 items, in which an individual is asked to identify how often they experienced certain thoughts and feelings over the past month, rating the occurrence of these variables from never to very often. The data obtained from the PSS can be used to predict potential illnesses which may occur as a result of perceived stress (Cohen, Kamarck, & Mermelstein, 1983).

Social Readjustment Rating Scale. Experiencing life changes, which often causes emotional stress, is normal (Graham & Stevenson, 1963; Rahe et al., 1964). Regardless if a major life event is viewed as a positive or negative change, an individual will need to cope with and adapt to or readjust to the changes. Research indicates a correlation between stressful life events which evoke psychophysiological responses and illness (Wolff, 1949). The Social Readjustment Rating Scale (SRRS) was developed to identify the impact of life events and further determine susceptibility to illnesses as a result of emotional stress caused from experiencing these changes (Holmes & Rahe, 1967). Social readjustment identifies as the amount and duration of change in one's daily life as a result of life events and accounts for the intensity and duration of time needed to adjust. Major life events may be described as the changes which occur and alter one's social structure. In the American culture, these life changes may involve a marriage, death of a spouse or family member, or change in job

descriptions. The SRRS is comprised of 43 items which are divided into two categories; changes in the individual's lifestyle and occurrences involving the individual. These life events were identified in Meyer's life chart, which was utilized to recognize changes in habits and categorize medical data (Lief, 1948). Holmes and Rahe (1967) researched the impact of these life changes and determined how much each event could potentially impact the individual in terms of readjustment and potentially lead to illnesses.

Rapid Stress Assessment. Work-related stress is a main contributor to mental health problems in the United States and employees who report high stress at work are three times more likely to have been treated for emotional and mental health problems in the past year. Research into treatment that may reduce or prevent work- related stress is therefore important, both for the workplace and the individual's well-being (Page et al., 2014). The Rapid Stress Assessment scale (RSA) is a practical way to measure individuals self-reported stress in different stressful situations, commonly used in the workplace. The assessment is very easy to administer and rate, taking about 3 minutes to complete and 30 seconds to score. The assessment is a multiple choice rating scale consisting of 15 questions and 4 possible answers ranging from "not at all" to "much". Once completed the scale explores individual responses to stressful situations and divides them into 5 stress-quantifying dimensions: (1) depression (2) aggressiveness (3) anxiety (4) lack of social support and (5) somatization. Each dimension contains its own rating ranging from 0-9. The total stress score is obtained by adding the scores from each dimension (Tomei, 2006).

Quantitative Electroencephalography. Research indicates correlations exist between brainwave activity and functionality (Demerdzieva, 2011; Engle, Bandelow, Gruber & Wedelind, 2008; Éismont, Aliyeva, Lutsyuk, & Pavlenko, 2008; Gauthier, Chevrette, Bouvier & Godbout, 2009; Pavlenko, Chernyi, & Goubkina, 2009). Various techniques, including quantitative electroencephalograms (QEEG) and neuroimaging, have been utilized to identify the connection between brainwave patterns in specific brain regions in relation to behaviors, emotions, and perception. Stress, particularly in the form of anxiety, is represented by distinct electrophysiology when compared to individuals experiencing low forms of stress (Demerdzieva, 2011). Through the use of brain mapping, a correlation between anxiety and prefrontal symmetries involving emotional reactivity, has been identified (Demerdzieva, 2011). In a systematic review of electrophysiological studies of stress and anxiety related disorders, Clark et al. (2009) reported general QEEG patterns reflective of dysregulation in cortical arousal and disorder-specific difficulties with sensory gating and management of attentional resources. Common QEEG findings included deficiency in theta, alpha, and beta brainwave activity along the central and midline regions of the brain, a deviation from what would be considered normal brainwave rhythms. A lack of activity of these particular brain waves within these specific regions has been linked with behavioral characteristics representative of anxiety disorders in individuals ranging from children to adults (Demerdzieva, 2011).

Particular brainwave patterns have been identified in teenagers experiencing various types of anxiety involving self-appraisal, interpersonal, school, and anxiety related to mysterious

phenomenon in which the individual lacks an understanding (Eismont, Aliyeva, Lutsyuk, & Pavlenko, 2008). Utilizing an EEG allows specification of brainwave patterns associated with the type of anxiety expressed. Research has indicated that with these anxieties there are low levels of spectral power density found within alpha brainwaves, sensorimotor rhythm, and low beta when compared to teenagers who did not report experiencing anxiety (Eismont, Aliyeva, Lutsyuk, & Pavlenko, 2008). Alpha rhythms have been known to correlate with emotional stability. Therefore, it makes sense to conclude that a lack of alpha brainwave activities has been associated with emotional instability and social anxiety. Additional research indicates an influx in faster firing brainwaves, particularly beta1 and beta2, to be associated with situational and personal anxiety (Pavlenko, Chernyi, & Goubkina, 2009).

In addition, EEG's have been utilized to analyze brainwave patterns related to sleep disorders in relation to anxiety. Often individuals experiencing anxiety will express trouble obtaining quality sleep as a result of having difficulties either falling asleep or staying asleep. Through the use of an EEG, scientists are able to distinguish between the two disorders and further identify correlations. EEG recordings administered in the morning upon awakening indicated individuals experiencing anxiety showed significantly higher activity in brain wave patterns in the central and occipital regions of the brain when compared to adolescents who did not report experiencing anxiety (Gauthier, 2009). Previous research utilizing QEEG found lower levels of theta and alpha in individuals reporting anxiety at C4 along with increased levels of beta and alpha activity during REM sleep. Even when individuals may not report sleep disturbances, the results QEEGs results indicated individuals experiencing anxiety have abnormal brain wave rhythms which can be a marker of central nervous system malfunctioning (Gauthier, Reisberg, Zaudig, Petersen, Ritchie, et al., 2006).

Neuroimaging. While QEEG is useful for viewing and identifying dysfunctional brain wave patterns in individuals experiencing anxiety, neuroimaging produces pictures of structures of the brain and nervous system through use of computerized tomography and magnetic resonance imaging (Engle, 2009). With these images, researchers are able to identify abnormalities associated with different mental health disorders. For instance, brain images of individuals experiencing anxiety disorders often indicate abnormalities in the prefrontal cortex area of the brain, particularly the amygdala. The amygdala, which is part of the limbic system, is the area of the brain involved in processing and expressing emotions. Neuroimaging provides a visual to identify activation of the amygdala, which often happens during times of acute fear and panic and activity will lessen during times of rumination and worry. A deeper understanding of an anxiety disorder, including the intensity of emotions the individual may be experiencing, may be provided through use of neuroimaging. In addition, the information from the results may help support diagnoses, guide treatment and identify individuals who may be predisposed to developing anxiety disorders (Engle, 2009).

Heart Rate Variability. During a stress response, the heart is required to pump blood through the body at a faster rate, resulting in an increased heart rate. Heart rate vari-

ability (HRV) is a common measurement used to identify the inter-beat intervals within heart rate. Heart rate will vary from beat to beat. By identify the heart rate rhythms and the variance in heart rate, one is able to conclude autonomic nervous system functioning and overall well-being. HRV is measured through both time and frequency domains (Task Force, 1996). The time domain displays how often the heart beats per minute. A sign of distress is often indicated by an increase in heart rate and a decrease in variation between the inter-beat intervals produced within a certain time frame. The frequency domain of HRV measures the fluctuation of the heart rate which occurs during each heartbeat and categorized into the following four frequencies; Ultra low frequency (ULF) produced between .0001 and .003 Hz, Very low frequency (VLF) produced between .003 to .08 Hz, Low Frequency (LF) produced between .08 and .14 Hz, and High Frequency (HF) rhythms produced between .15 and .4 Hz. Each frequency is regulated either by the sympathetic or parasympathetic nervous system. VLF rhythms are regulated by the sympathetic nervous system, HF rhythms are mediated by respiration and regulated by the parasympathetic nervous system activation, and LF rhythms are a combination of both VLF and HF oscillations. LF rhythms are indicative of a balance within the ANS (Gevirtz & Lehrer, 2003). HRV can be utilized to identify signs of cardiac distress. During a stress response, the heart beats rapidly and chaotically and there is little coherence between the inter-beat intervals of the heart rate. HRV is an efficient tool utilized to identify and measure stress response as evidenced by an increase in heart rate and decrease in variability. Experiencing negative emotions including anger, anxiety, embarrassment, and fear are correlated with a decrease in HRV (Kreibig, 2010).

Electrodermal Activity. Another variable used to measure physiological changes during a stress response is electrodermal activity (EDA). During a stress response, an increase in skin conductivity occurs, allowing the body to rid itself of toxins through sweat and metabolize quicker. Therefore, an increase in electrodermal activity is indicative with high levels of arousal and correlates with sympathetic nervous system activity. Measuring EDA can be used to assess levels of arousal. Experiencing both negative emotions including anger, anxiety, disgust, fear, and acute sadness are correlated with elevated levels of EDA (Kreibig, 2010).

Electromyography. Another physiological measurement commonly utilized to measure the impact of stress is an electromyography (EMG; Cram, Kasman, & Holtz, 1998; Lundberg, Kadefors, Melin, Palmerud, et al., 1994; Wijsman, Grundlehner, & Penders, 2013). With the use of an EMG, the action potential, or firing rate, of the muscle is quantified and displayed and may be representative of muscle contraction and tension (Cram, Kasman, & Holtz, 1998). Individuals often complain of musculoskeletal pain and complications which occur as a result of prolonged muscle tension associated with mental stress (Wijsman, Grundlehner, & Penders, 2013). The upper trapezius muscles is a common known area of the body where muscle tension occurs for the general population experiencing stress (Lundberg, Kadefors, Melin, Palmerud, et al., 1994; Wijsman, Grundlehner, & Penders, 2013). In fact, EMG amplitude, when measured on the upper trapezius muscles, often increases when engaging in stress tests including logical puzzles, memory tasks, and calculations (Wijs-

man, Grundlehner, & Penders, 2013), as well as arithmetic and memory tasks (Lundberg, Kadefors, Melin, Palmerud, et al., 1994). In addition, an increase in EMG activity may also occur when individuals are made aware of any errors made while engaging in these activities. Furthermore, there is a significant decrease in EMG amplitude while engaging in a rest period or inducing a state of relaxation when compared to the results recorded while engaging in a stressful task. Therefore, EMG is an effective tool to identify physiological arousal and further evaluate mental stress (Cram, Kasman, & Holtz, 1998; Lundberg, Kadefors, Melin, Palmerud, et al., 1994; Wijsman, Grundlehner, & Penders, 2013).

Interventions

Cognitive-Behavioral Therapy. Several meta-analyses and systematic reviews have examined the effectiveness of interventions aimed at reducing stress and have suggested that cognitive, behavioral, and mindfulness interventions have significantly reduced stress and symptoms of anxiety (Regehr, Glancy & Pitts, 2013). Having awareness of negative thoughts and the ability to challenge them can often be difficult for individuals as it has been found that often times of stress is caused more by how an individual interprets the problem than by the actual problem itself. Cognitive-behavioral therapy (CBT) is a common type of psychotherapy that has proven effective in treating anxiety, depression, and panic disorders (Deckro et al., 2002). The integration of cognitive, behavioral, and social learning theory mechanisms all assist in an individual ability to learn special techniques and skills used to replace stress maintaining negative thoughts with alternative methods to better manage stressful life situations (Regehr, Glancy & Pitts, 2013).

Mindfulness. Mindfulness-Based Stress Reduction (MBSR) is a standardized meditation program developed in 1979 from the effort to integrate Buddhist mindfulness meditation with clinical and psychological practice (Chiesa & Serretti, 2009). MSBR has been used for many years to help individuals cope and reduce both physical and mental stress while promoting the wellbeing of people (De Vibe et al., 2013). This type of training teaches individuals to attend to the present moment, both internally and externally, allowing the brain to refrain from thought rumination. Components include focusing on thoughts, breathing, sounds, body awareness and the ability to shift attention across sensory modalities, all of which consumes energy and strengthens the experience of stress itself (Kilpatrick et al., 2011).

Psychoeducation. Another applied method proven effective to manage stress is through psychoeducation (PSE). Unlike other interventions individuals who seek this type of treatment from executive coaches learn how to reduce his/her perceived stress rather than preventing it by use of knowledge and useful skills to assist in the management of stress. PSE is commonly offered in group sessions that provide self-help and in some occasions homework assignments are assigned as a method to gain these competencies. Some are also offered through the internet as an alternate and convenient method (Van Daele, Hermans, Van Audenhove & Van den Bergh, 2011).

Exercise. The reduction of stress and anxiety sensitivity is one of the many health benefits gained from routine physical exercise. Many of the physiological sensations that are produced during stress and anxiety are also generated during exercise (e.g., perspiration, elevated heart rate and respiration). Regular exercise has been shown to reduce arousal levels including muscle tension and resting heart rate and increase helpful chemicals in the brain including endorphins, resulting in reduced stress and anxiety (Broman-Fulks & Storey, 2008). In addition, individuals that are involved in regular aerobic exercise training have been associated with improvements in cognitive functioning on tests as well as exhibiting reduced cardiovascular responses to stress and report fewer symptoms of anxiety (Fletcher et al., 1996).

Pharmacology. There are many useful pharmaceutical agents, such as sleep medications, anxiolytics, beta-blockers, and antidepressants, which counteract some of the problems associated with being stressed out and also aid in the activation of the parasympathetic response. While these may work for some, others may experience unwanted side effects (McEwen, 2007) including drowsiness, disturbances of memory and impaired psychomotor function. Other problems some experience are tolerance and dependence. Because of this, many physicians only prescribe these medications for short durations (Baldwin, Waldman & Allgulander, 2011).

Biofeedback. Biofeedback, is a tool used to measure, monitor, and display physiological information of an individual through use of noninvasive sensors (Schwartz & Schwartz, 2003). By monitoring direct functioning, identified as intentional body movements, and indirect functioning, identified as unconscious physiological functioning, and displaying progress in the form of visual and auditory cues individuals to gain an awareness of physiological functioning and eventually, with training, control over these processes (Ortiz-Vigon Uriarte et al., 2015). Sensors often used include the following; eye tracker, kinect (monitors body movement), pulsometer (HR), respirometer (breathing rate), electromyography (EMG), temperature, and electrodermal activity (EDA). In 2014, Schoenberg and David published a systematic review of biofeedback interventions, including HRV/RSA, EEG, EMG, EDA, respiratory, and thermal biofeedback, used to treat psychiatric disorders. The outcomes of EDA, respiratory, and thermal biofeedback will be summarized here, with an expanded discussion of outcomes presented for HRV/RSA, EEG, and EMG biofeedback below. While guided breathing exercises have been shown to decrease the effects of stress in a normal population and reduce heart rate as well as aid in preparing the mind and body for sleep (Pal & Velkumary, 2003; Turankar et al., 2013), the effects observed in clinical samples with chronic anxiety and PD have been variable, ranging from no significant improvement on anxiety measures to significant reductions on the Panic Disorder Severity Scale (Schoenberg & David, 2014). Khanna, Paul, and Sandhu, (2007), reported that EDA biofeedback led to reduced pulse rates but not changes in anxiety symptoms among healthy women reporting anxiety and stress. Finally, thermal biofeedback was observed to improve STAI and Hamilton Anxiety scores among individuals diagnosed with schizophrenia and comorbid anxiety (Hawkins, Doell, Lindseth, Jeffers, & Skaggs, 1980).

HRV Training. HRV training is designed to teach an individual how to decrease the over-activation of physiological responses to stress and attain a state of stability in the autonomic nervous system by increasing heart rate variability (Berntson et al., 1994; Gevirtz & Lehrer, 2003; Gevirtz & Dalenberg, 2008). Slow diaphragmatic breathing exercises are involved in training HRV, specifically, during the inhale the heartbeat intervals increase (speed up) and during exhalation it decreases (slows down). The variance of the heart rate is the difference between the increase maximum and the decrease minimum (Zucker, Samuelson, Muench, Greenberg, & Gevirtz, 2009). A decreased breathing rate results in a slowing of the heartbeat. This decrease will ultimately result in an increase of the variability, allowing the individual to achieve respiratory sinus arrhythmia (RSA), or the synchronization of the heart rate with breath pace and create a balanced state within the ANS (Gevirtz & Dalenberg, 2008; Zucker, Samuelson, Muench, Greenberg, & Gevirtz, 2009). This state further improves physical ailments (Sutarto et al., 2010; Wheat & Larkin, 2010), as well as mental clarity, mood, and cognition (Gevitz & Dalenberg, 2008; Sutarto et al., 2010). In addition, the effects from HRV training have been shown to be long lasting (Wheat & Larkin, 2010). HRV training has led to clinical improvements on the State-Trait Anxiety Inventory (STAI), Beck Depression Inventory (BDI), and PTSD symptoms among individuals with PTSD, anxiety, comorbid anxiety and depression, and OCD (Schoenberg & David, 2014). RSA biofeedback has been investigated in the treatment of individuals with moderate daily stress (Sherlin, Gevirtz, Wyckoff, & Muench, 2009), GAD, OCD, phobias, and PTSD leading to improvements on the Pittsburgh Sleep Quality Index (PSQI), STAI, PTSD symptoms, as well as decreased heart rate, increased HRV (Schoenberg & David, 2014), enhance theta and alpha absolute power, and increased alpha relative power in Brodmann's area 24 and decreased relative beta activity in Brodmann's areas 30 and 31 following sLORETA analysis (Sherlin, Muench, & Wyckoff, 2010).

Neurofeedback. Neurofeedback or EEG biofeedback is a non-invasive, non-pharmacologic, therapeutic intervention designed to promote learned self-regulation of brain activity through real-time operant conditioning (Sherlin et al., 2011). In 2005, Moore published a comprehensive review of neurofeedback interventions targeting GAD, OCD, PD, PTSD, high trait anxiety and chronic, reporting positive treatment effects clinical and subclinical participants in 18 of 24 studies (75%) that included EEG and symptom changes. The majority of the studies utilized multiple sessions of an eyes-closed, occipital placement, alpha-enhancement, theta-enhancement, or alpha-theta enhancement protocol. Clinical improvements were observed on the Hamilton Anxiety Rating scale, Global Quality of Life Questionnaire, STAI, and multiple subscales of the Minnesota Multiphasic Personality Inventory (MMPI; Schoenberg & David, 2014). In a healthy community sample reporting mild to moderate daily stress, a single session of alpha enhancement neurofeedback led to significant reductions in STAI scores and demonstrated significantly enhanced eyes-closed resting absolute alpha power post intervention (Wyckoff et al., 2016).

EMG Biofeedback. EMG biofeedback involves the real-time assessment, feedback, and reward of muscle activity. In their review, Schoenberg and David (2014) report the use of EMG biofeedback for the treatment of GAD, PD, PTSD, test anxiety, and subclinical chronic

anxiety and stress. Training protocols generally targeted the reduction of frontalis muscle tension, leading to clinical improvements on the STAI, BDI, MMPI, psychosomatic and anxiety symptom checklists, Hamilton Anxiety Rating Scale, Zung Self-Rating Anxiety Scale, Alpert-haber Achievement Anxiety Test, Taylor Manifest Anxiety Scale, and subjective tension ratings, as well as decreased EMG amplitudes and blood pressure.

Discussion

Stress can be defined as a change within the person, typically on a psychophysiological level, due to a reaction to a stimulus which can either be internal, involving thoughts or emotions, or external, involving situations (APA, 2015; McEwen, 2007). Both chemical and physical responses are involved in a stress response. The chemical changes, which may not always be apparent to the individual experiencing the stress response, include an increase in glucocorticoids and catecholamine. These chemical reactions lead to changes in physiology including increased heart rate, shallow breathing, and sweaty palms; all which may be evident to the individual (Almeida, 2005; APA, 2015; Pearlin, 1998). In addition, physiological states involved with a stress reaction can also lead to changes in brain activity impairing cognition and memory, as well as impacting psychological and emotional wellbeing (Sapolsky, 2009).

While the term stress typically involves a negative connotation, a stress response is not necessarily a bad thing when utilized appropriately. A stress response enables the individual to remove themselves from a harmful situation or resolve a given threat. An individual may benefit from this heightened reaction only when the response appropriately matches the stressor presented, such as those involved in emergency situations or to maximize peak performance (Kobasa, 1979, McEwen, 2007; Quick et al., 2013). When the stress response does not match the stressor presented, the response itself can be damaging to the individual, especially when this reaction becomes chronic. Experiencing a heightened stress response for a prolonged duration of time can lead to physical and emotional illnesses, impairing an individual's overall well being and causing psychosocial implications (Almeida, 2005; Bolger & Zuckerman, 1995). With little or maladaptive coping skills in addition to poor social support and personal resources, stress will continue to be taxing on the individual (Cohen & Wills, 1985; Pearlin, 1989). Most visits to primary care physicians are related to stress (APA, 2015). Common physical implications of a stress response include headaches, cardiovascular disorders, and insomnia while emotional implications of stress often include irritability, irrationality, depression, and anxiety (Almeida, 2005; APA, 2015; McLeod, 2012).

Typically individuals become accustomed to a heightened stress response and functioning in this way becomes normal. Both subjective and objective assessments have been developed to identify and measure how one is reacting and experiencing stress (Cohen & Manuck, 1995; Gevirtz & Lehrer, 2003; Graham & Stevenson, 1963; Kobasa, 1979; Schlotz et al., 2006; Task Force, 1996). Data obtained from assessments can also be utilized to

identify needs of the individual, formulate personal goals, validate experiences, and select appropriate forms of treatment (Cohen & Manuck, 1995). Various interventions have been designed to assist individuals in developing effective ways to manage the stress response. Techniques often involve psychotherapy (Regehr, Glancy & Pitts, 2013; Kilpatrick et al., 2011) psychopharmacology (Baldwin, Waldman & Allgulander, 2011), or behavioral skills training in the form of mindfulness practices (Van Daele et al., 2011), exercise (Broman-Fulks & Storey, 2008), and biofeedback modalities (Cram, Kasman, & Holtz, 1998; Engle, 2009; Gevirtz & Lehrer, 2003; Kreibig, 2010) to assist individual in adapting and implementing healthy lifestyle changes. While a heightened stress response is a common reaction in the American society, interventions are available to assist individuals in attaining positive coping skills in order to enhance their quality of life.

References

Almeida, D. M. (2005). Resilience and vulnerability to daily stressors assessed via diary methods. Curr Dir Psychol Sci, 14(2), 64–68. doi:10.1111/j.0963-7214.2005.00336.x
American Psychological Association (2015). Stress in America: Paying with our health. Washington, D. C.: American Psychological Association. PsycEXTRA Dataset. doi:10.1037/e513292015-001

Baldwin, D. S., Waldman, S., & Allgulander, C. (2011). Evidence-based pharmacological treatment of generalized anxiety disorder. Int J Neuropsychopharmacol, 14(05), 697–710. doi:10.1017/s1461145710001434

Bandelow, B., Zohar, J., Hollander, E., Kasper, S., Möller, H.-J., WFSBP task force on treatment guide, ... WFSBP task force on treatment guide. (2008). World J Biol Psychiatry (WFSBP) Guidelines for the pharmacological treatment of anxiety, obsessive-compulsive and post-traumatic stress disorders – First Revision. World J Biol Psychiatry, 9(4), 248–312. doi:10.1080/15622970802465807

Bandura, A. (1994). Self-efficacy. In: V. S. Ramachaudran (Ed.), Encyclopedia of human behavior (Vol. 4, pp. 71-81). New York: Academic Press. (Reprinted in H. Friedman [Ed.], Encyclopedia of mental health. San Diego: Academic Press, 1998).

Berntson, G. G., Cacioppo, J. T., Quigley, K. S., & Fabro, V. T. (1994). Autonomic space and psychophysiological response. Psychophysiology, 31(1), 44-61. doi:10.1111/j.1469-8986.1994.tb01024.x

Bolger, N., & Zuckerman, A. (1995). A framework for studying personality in the stress process. J Pers Soc Psychol, 69(5), 890–902. doi:10.1037/0022-3514.69.5.890

Bollini, A. M., Walker, E. F., Hamann, S., & Kestler, L. (2004). The influence of perceived control and locus of control on the cortisol and subjective responses to stress. Biol Psychol,

67(3), 245–260. doi:10.1016/j.biopsycho.2003.11.002

Broman-Fulks, J. J., & Storey, K. M. (2008). Evaluation of a brief aerobic exercise intervention for high anxiety sensitivity. Anxiety Stress Coping, 21(2), 117–128. doi:10.1080/10615800701762675

Chiesa, A., & Serretti, A. (2009). Mindfulness-based stress reduction for stress management in healthy people: A review and meta-analysis. J Altern Complement Med, 15(5), 593–600. doi:10.1089/acm.2008.0495

Clark, C. R., Galletly, C. A., Ash, D. J., Moores, K. A., Penrose, R. A., & McFarlane, A. C. (2009). Evidence-based medicine evaluation of electrophysiological studies of the anxiety disorders. Clin EEG and Neurosci, 40(2), 84-112. doi:10.1177/155005940904000208

Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A global measure of perceived stress. J Health Soc Behav, 24(4), 385. doi:10.2307/2136404

Cohen, S., & Wills, T. A. (1985). Stress, social support, and the buffering hypothesis. Psychol Bull, 98(2), 310–357. doi:10.1037/0033-2909.98.2.310

Cohen, S., & Manuck, S. B. (1995). Stress, reactivity, and disease. Psychosom Med, 57(5), 423–426. doi:10.1097/00006842-199509000-00002

Cram, J. R., Kasman, G. S., Holtz, J. (1998). Introduction to surface electromyography (1st ed.) New York, NY: Aspen Publishers.

De Vibe, M., Solhaug, I., Tyssen, R., Friborg, O., Rosenvinge, J. H., Sørlie, T., ... Bjørndal, A. (2013). Does personality moderate the effects of mindfulness training for medical and psychology students? Mindfulness, 6(2), 281–289. doi:10.1007/s12671-013-0258-y

Deckro, G. R., Ballinger, K. M., Hoyt, M., Wilcher, M., Dusek, J., Myers, P., ... Benson, H. (2002). The evaluation of a mind/body intervention to reduce psychological distress and perceived stress in college students. J Am Coll Health, 50(6), 281–287. doi:10.1080/07448480209603446

DeLongis, A., Folkman, S., & Lazarus, R. S. (1988). The impact of daily stress on health and mood: Psychological and social resources as mediators. J Pers Soc Psychol, 54(3), 486–495. doi:10.1037/0022-3514.54.3.486

Demerdzieva, A. (2011). EEG characteristics of generalized anxiety disorder in childhood. Acta Inform Med, 19(1), 9-15. Retrieved from: http://www.scopemed.org/fulltextpdf.php?mno=6643

Dickerson, S. S., & Kemeny, M. E. (2004). Acute stressors and cortisol responses: A the-

oretical integration and synthesis of laboratory research. Psychol Bull, 130(3), 355–391. doi:10.1037/0033-2909.130.3.355

Éismont, E. V., Aliyeva, [illegible]., Lutsyuk, N. V., & Pavlenko, V. B. (2008). EEG correlates of different types of anxiety in 14- to 15-year-old teenagers. Neurophysiology, 40(5-6), 377–384. doi:10.1007/s11062-009-9063-6

Engel, K., Bandelow, B., Gruber, O., & Wedekind, D. (2008). Neuroimaging in anxiety disorders. J Neural Transm, 116(6), 703–716. doi:10.1007/s00702-008-0077-9

Fletcher, G. F., Balady, G., Blair, S. N., Blumenthal, J., Caspersen, C., Chaitman, B., ... Pollock, M. L. (1996). Statement on exercise: Benefits and recommendations for physical activity programs for all Americans: A statement for health professionals by the committee on exercise and cardiac rehabilitation of the council on clinical cardiology, American heart association. Circulation, 94(4), 857–862. doi:10.1161/01.cir.94.4

Gauthier, A.-K., Chevrette, T., Bouvier, H., & Godbout, R. (2009). Evening vs. morning wake EEG activity in adolescents with anxiety disorders. J Anxiety Disord, 23(1), 112–117. doi:10.1016/j.janxdis.2008.04.005

Gauthier S., Reisberg B., Zaudig M., Petersen R. C., Ritchie K., Broich K., et al. (2006). Mild cognitive impairment. Lancet, 15(367), 1262–1270. dio:10.1016/S0140-6736(06)68542-5

Gevirtz, R., & Lehrer, P. (2003). Resonant frequency heart rate biofeedback. In M. S. Schwartz, & F. Andrasik (Eds.), Biofeedback: A practitioner's guide (3rd ed.) (pp. 245-250). New York, NY: Guilford.

Gevirtz, R., & Dalenberg, C. (2008). Heart rate variability biofeedback in the treatment of trauma symptoms. Biofeedback, 36(1), 22–23. Retrieved from: https://www.resourcenter.net/images/AAPB/Files/Biofeedback/2008/biof_trauma_treatment.pdf

Graham, D. T. & Stevenson, I. (1963). Disease as response to life stress. In: H. I. Lief, V. F. Lief, N. R. Lief (Eds). The psychological basis of medical practice. New York, NY: Harper & Row

Hawkins, R. C., Doell, S. R., Lindseth, P., Jeffers, V., & Skaggs, S. (1980). Anxiety reduction in hospitalized schizophrenics through thermal biofeedback and relaxation training. Percept and Mot Skills, 51, 475–482. doi:10.2466/pms.1980.51.2.475

Holmes, T. H., & Rahe, R. H. (1967). The Social Readjustment Rating Scale. J Psychosom Res, 11(2), 213-218. doi: 10.1037/t02251-000

Johnson, J. H. & Sarason, I. G. (1979). Moderator variables in life stress research. In: Sarason, I. G. & Spielberg, C. D. Stress and Anxiety (Vol 6). Washington, D.C.: Hemisphere Publishing Corporation.

Khan, A. A., Saleem, M., & Shahid, R. (2012). Buffering role of locus of control on stress among the college/university teachers of Bahawalpur. Pak J Commer Soc Sci, 6(1), 158-167.

Khanna, A., Paul, M., & Sandhu, J. S. (2007). Efficacy of two relaxation techniques in reducing pulse rate among highly stressed females. Calicut Med J, 5(2), e2.

Kilpatrick, L. A., Suyenobu, B. Y., Smith, S. R., Bueller, J. A., Goodman, T., Creswell, J. D., ... Naliboff, B. D. (2011). Impact of mindfulness-based stress reduction training on intrinsic brain connectivity. NeuroImage, 56(1), 290–298. doi:10.1016/j neuroimage.2011.02.034

Kirschbaum, C., Prussner, J. C., Stone, A. A., Federenko, I., Gaab, J., Lintz, D., ... Hellhammer, D. H. (1995). Persistent high cortisol responses to repeated psychological stress in a subpopulation of healthy men. Psychosom Med, 57(5), 468–474. doi:10.1097/00006842-199509000-00009

Kobasa, S. C. (1979). Stressful life events, personality, and health: An inquiry into hardiness. J Pers Soc Psychol, 37(1), 1–11. doi:10.1037/0022-3514.37.1.1

Kreibig, S. D. (2010). Autonomic nervous system activity in emotion: A review. Biol Psychol, 84(3), 394–421. doi:10.1016/j.biopsycho.2010.03.010

Kubzansky, L. D., & Adler, G. K. (2010). Aldosterone: A forgotten mediator of the relationship between psychological stress and heart disease. Neurosci Biobehav Rev, 34(1), 80–86. doi:10.1016/j.neubiorev.2009.07.005

Liberzon, I., Duval, E., & Javanbakht, A. (2015). Neural circuits in anxiety and stress disorders: A focused review. Ther Clin Risk Manag, 11, 115-126. doi:10.2147/tcrm.s48528

Lief, A. (1948). The commonsense psychiatry of Dr. Adolf Meyer. New York, NY: McGraw-Hill

Lundberg, U., Kadefors, R., Melin, B., Palmerud, G. Hassmen, P., Engstrom, M., & Dohns, I.E. (1994). Psychophysiological stress and EMG activity of the trapezius muscle. Int J Behav Med, 1(4), 354-370. doi: 10.1207/s15327558ijbm0104_5

Marin, M.-F., Lord, C., Andrews, J., Juster, R.-P., Sindi, S., Arsenault-Lapierre, G., ... Lupien, S. J. (2011). Chronic stress, cognitive functioning and mental health. Neurobiol Learn Mem, 96(4), 583–595. doi:10.1016/j.nlm.2011.02.016

McEwen, B. S. (1998). Stress, adaptation, and disease: Allostasis and allostatic load. Ann N Y Acad Sci, 840(1), 33–44. doi:10.1111/j.1749-6632.1998.tb09546.x

McEwen, B. S. (2007). Physiology and neurobiology of stress and adaptation: Central role of the brain. Physiol Rev, 87(3), 873–904. doi:10.1152/physrev.00041.2006

McLeod, J. D. (2012). The meanings of stress: Expanding the stress process model. Soc Ment Health, 2(3), 172–186. doi:10.1177/2156869312452877

Michaud, K., Matheson, K., Kelly, O., & Anisman, H. (2008). Impact of stressors in a natural context on release of cortisol in healthy adult humans: A meta-analysis. Stress, 11(3), 177–197. doi:10.1080/10253890701727874

Moore, N. C. (2005). The neurotherapy of anxiety disorders. J Adult Dev, 12(2/3), 147–154. doi:10.1007/s10804-005-7031-y

Nieuwenhuijsen, K., Bruinvels, D., & Frings-Dresen, M. (2010). Psychosocial work environment and stress-related disorders, a systematic review. Occup Med (Chic Ill), 60(4), 277–286. doi:10.1093/occmed/kqq081

Ortiz-Vigon Uriarte, I., Garcia-Zapirain, B., & Garcia-Chimeno, Y. (2015). Game design to measure reflexes and attention based on biofeedback multi-sensor interaction. Sensors, 15(3), 6520–6548. doi:10.3390/s150306520

Page, K. M., Milner, A. J., Martin, A., Turrell, G., Giles-Corti, B., & LaMontagne, A. D. (2014). Workplace stress. J Occup Environ Med, 56(8), 814–819. doi:10.1097/jom.0000000000000230

Pal, G. K., & Velkumary, S. (2004). Effect of short-term practice of breathing exercises on autonomic functions in normal human volunteers. Indian J Med Res, 120(2), 115-121. Retrieved from: http://icmr.nic.in/ijmr/2004/0807.pdf

Pavlenko, V. B., Chernyi, S. V., & Goubkina, D. G. (2009). EEG correlates of anxiety and emotional stability in adult healthy subjects. Neurophysiology, 41(5), 337–345. doi:10.1007/s11062-010-9111-2

Pearlin, L. I. (1989). The sociological study of stress. J Health Soc Behav, 30(3), 241. doi:10.2307/2136956

Quick, J. C., Wright, T. A., Adkins, J. A., Nelson, D. L., & Quick, J. D. (2013). Preventive stress management in organizations (2nd ed.). doi:10.1037/13942-000

Rahe, R. H., Meyer, M., Smith, M., Kjaer, G. & Holmes, T. H. (1964). Social stress and illness onset. J Psychosom Res, 8(1), 35-44. doi:10.1016/0022-3999(64)90020-0

Regehr, C., Glancy, D., & Pitts, A. (2013). 2614 – Interventions to reduce stress in university students: A review and meta-analysis. Eur Psychiat, 28, 1. doi:10.1016/s0924-9338(13)77263-8

Roberts, C., Troop, N., Connan, F., Treasure, J., & Campbell, I. C. (2007). The effects of stress

on body weight: Biological and psychological predictors of change in BMI**. Obesity, 15(12), 3045–3055. doi:10.1038/oby.2007.363

Sapolsky, R. M. (2009). Stress and the brain: individual variability and the inverted-U. Nat Neurosci, 18(10), 1344-1346.

Schlotz, W., Schulz, P., Hellhammer, J., Stone, A. A., & Hellhammer, D. H. (2006). Trait anxiety moderates the impact of performance pressure on salivary cortisol in everyday life. Psychoneuroendocrinology, 31(4), 459–472. doi:10.1016/j.psyneuen.2005.11.003

Schlotz, W., Yim, I. S., Zoccola, P. M., Jansen, L., & Schulz, P. (2011). The perceived stress reactivity scale: Measurement invariance, stability, and validity in three countries. Psychol Assess, 23(1), 80–94. doi:10.1037/a0021148

Schmidt, N. B., Richey, J. A., Buckner, J. D., & Timpano, K. R. (2009). Attention training for generalized social anxiety disorder. J Abnorm Psychol, 118(1), 5–14. doi:10.1037/a0013643

Schwartz, N. M., & Schwartz, M. S. (2003). Definitions of biofeedback and applied psychophysiology. In M. S. Schwartz, & F. Andrasik (Eds.), Biofeedback: A practitioner's guide (3rd ed.) (pp. 27-39). New York, NY: Guilford.

Sherlin, L. H., Arns, M., Lubar, J., Heinrich, H., Kerson, C., Strehl, U., & Sterman, M. B. (2011). Neurofeedback and basic learning theory: Implication for research and practice. J Neurotherapy, 15, 292-304. doi:10.1080/10874208.2011.623089

Sherlin, L. H., Gevirtz, R., Wyckoff, S., & Muench, F. (2009). Effects of respiratory sinus arrhythmia biofeedback versus passive biofeedback control. Int J Stress Manag, 16(3), 233–248. doi: 10.1037/a0016047

Sherlin, L. H., Muench, F., & Wyckoff, S. N. (2010). Respiratory sinus arrhythmia feedback in a stressed population exposed to a brief stressor demonstrated by quantitative EEG and sLORETA. Appl Psychophysiol Biofeedback, 35(3), 219-228. doi:10.1007/s10484-010-9132-z

Schoenberg, P. L. A., & David, A. S. (2014). Biofeedback for psychiatric disorders: A systematic review. Appl Psychophysiol and Biofeedback, 39, 109-135. doi:10.1007/s10484-014-9246-9

Spielberger, C. D., & Reheiser, E. C. (2009). Assessment of emotions: Anxiety, anger, depression, and curiosity. Appl Psychol Health Well Being, 1(3), 271–302. doi:10.1111/j.1758-0854.2009.01017.x

Sutarto, A. P., & Nubli, A. W., and Nora, M. Z. (2010). Heart rate variability (HRV) biofeedback : A new training approach for operator's performance enhancement. J Ind Eng Manag, 3(1), 176-198.

Task force of the European society of cardiology and the North American society of pacing and electrophysiology. (1996). Heart rate variability. Standards of measurement, physiological interpretation and clinical use. Eur Heart J, 17(3), 354–381. doi: 10.1093/oxfordjournals.eurheartj.a01468

Taylor, S. E., Klein, L. C., Lewis, B. P., Gruenewald, T. L., Gurung, R. A. R., & Updegraff, J. A. (2000). Biobehavioral responses to stress in females: Tend-and-befriend, not fight-or-flight. Psychol Rev, 107(3), 411–429. doi:10.1037/0033-295x.107.3.411

Tomei, G., Cherubini, E., Ciarrocca, M., Biondi, M., Rosati, M. V., Tarsitani, L., ... Tomei, F. (2006). Assessment of subjective stress in the municipal police force at the start and at the end of the shift. Stress Health, 22(4), 239–247. doi:10.1002/smi.1093

Turankar, A. V., Jain, S., Patel, S. B., Sinha, S. R., Joshi, A. D., Vallish, B. N., ... & Turankar, S. A. (2013). Effects of slow breathing exercise on cardiovascular functions, pulmonary functions & galvanic skin resistance in healthy human volunteers-a pilot study. Indian J Med Res,137(5), 916. Retrieved from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3734683/

Van Daele, T., Hermans, D., Van Audenhove, C., & Van den Bergh, O. (2011). Stress reduction through psychoeducation: A meta- analytic review. Health Educ Behav, 39(4), 474–485. doi:10.1177/1090198111419202

Wheat, A.L. & Larkin, K.T. (2010). Biofeedback of heart rate variability and related physiology: a critical review. Appl Psychophysiol Biofeedback, 35(3):229-42. doi:10.1007/s10484-010-9133-y.

Wijsman, J., Grundlehner, B., & Penders, J. (2013). Trapezius muscle EMG as predictor of mental stress. ACM, 12(4), 1. doi:10.1145/2485984.2485987

Williams, S. M., White, L. E., & Mace, A. C. (2005). SylviusVG: Visual glossary of human neuroanatomy. Sunderland, MA: Pyramis Studios, Inc.

Wolff, H. G. (1949). Life stress and bodily disease: A formulation. Res Pub Assoc Res Nerv Ment Dis, 29, 1059-1094. doi:10.1037/11419-01
Wyckoff, S. N., Baughman, C. A., Fakunle, O., Waits, K., Ford, N. L., & Sherlin, L. H. (2016). Brief neurofeedback for anxiety reduction and alpha enhancement: A randomized placebo controlled trial. Manuscript submitted for publication.

Zucker, T. L., Samuelson, K. W., Muench, F., Greenberg, M. A., & Gevirtz, R. N. (2009). The effects of respiratory sinus arrhythmia biofeedback on heart rate variability and posttraumatic stress disorder symptoms: A pilot study. Appl Psychophysiol Biofeedback, 34(2), 135–143. doi:10.1007/s10484-009-9085-2