Neurophysiological Reactivity to High Pressure

Caleidocons Ltd helps predicting performance of an individual working in positions where desired performance depends on the person's ability to cope under high or even extreme pressure. This approach is based on comprehensive measurement of neurophysiological reactivity and extensive research enabling us to offer more reliable results traditional methods have provided thus far. Results are used for assessment, development and relocation of people.

In order to ensure the highest quality for our results, we measure how the individual's brain tends to react in critical situation when under heavy or extreme pressure. From the neurophysiological point of view, behavior “under heavy or extreme pressure” is, from the outset determined by the individual's genetic predisposition to react to an acute stress, and therefore has to be observed in multiple neurophysiological systems, of which three are dominant overall. Those are sympathetic and parasympathetic nervous systems, and hypothalamus-pituitary-adrenal axis. The function of these systems is involuntary and is not based on life experience or education.

Introduction

Stress is often used in to denote positive or negative strain in a physical or psychological context. In 1936, endocrinologist Hans Selye defined stress as the nonspecific response of the body to any demand (Selye, 1936). This non-specificity meant that exposure to any stressor elicit same type of pituitary adrenocortical and sympathoadrenomedullary response. Although popular, this concept has since then been refined and it has been found that different types of stressors have their own unique central neurochemical and peripheral pattern of responses.

The effects of stress on human behaviour are numerous and have been studied for decades (see McEwen & Sapolsky, 1995). More recently, the pathways through which an acute stress effect on cognition have been shed light to (Lupien et al., 2006; Mizoguchi et al., 2000; Vedhara et al., 2000; Yasumasu et al., 2006), especially the effects via frontal lobe to decision-making, attention and performance (Arnsten et al., 2009). Consequently, recent years have produced a fair amount of applied studies, which aim not only to investigate the links between stress physiology and cognitive outcomes but also to search for future applications to assist in decision-making process, individual stress control, intervention and prevention.

This paper aims to review the psychophysiologically relevant markers of acute stress related to conditions in which an individual is under high or extreme pressure and goes through some of the most influential applied studies that use these markers to predict actual performance. In another words, how to predict the ability to handle pressure and how to predict what type of reactions would the person have under heavy or extreme pressure.

The Most Relevant Stress Systems

Responses to acute stress are observed in multiple parts of the human body and nervous systems, of which three are dominant overall. The first two are sympathetic and parasympathetic nervous systems, which are adrenergically mediated cardiovascular reactions causing a fight-flight stress response, and the third one is hypothalamus-pituitary- adrenal (HPA) axis, which consists of endocrinological responses in brain loci and periphery.

Each of these systems have direct links to cardiovascular system, which consists of the heart and the blood vessels, such as the veins and arteries, which by upholding blood pressure move the blood around the body. Blood pressure is a product of cardiac output and peripheral resistance. The former is the amount of blood pumped by the heart during one minute, and peripheral resistance is a combination of elements that create resistance to regulate blood flow distribution in the periphery. These are the main indices used in the psychophysiological studies, when measuring non-neural activation during the stress. Genetics of physiological stress response have been recently studied and noticed that they do not vary much across life-time (Gillepie et al., 2009; Snieder et al., 2002) and both the cardiovascular and endocrinological response to psychosocial stress seems to have a high test-retest reliability (Schommer et al., 2003).

Reliable Way to Measure Acute Stress and Ability to Handle Pressure

The stress reactivity is an outcome of a long evolutionary processes enabling us to allocate enough resources for either fight or flight in a life-threatening situation. In the modern society, however, acute stress reaction is not necessarily related to a life-threat, although those still exist in various work-life situations (e.g. police, military, pilots, rescue services). Several of the modern demands are mental and lead to similar acute stress reactivity compared. These responses are adaptive, and they enable us to both survive and to recover from external demands. Individual differences in psychological stress reactivity are often measured by examining changes in physiological functioning elicited by aversive, challenging, or engaging laboratory tasks, such as mental arithmetic, cold pressor or public speaking tasks.

In order to achieve the highest ecological validity when studying stress in laboratory environment, it is common to use different types of psychosocial stress tasks. Psychosocial stress tests, especially public speaking tasks, give a reliable and robust responses and activate all three main stress systems (Burleson et al., 2003, Dickerson & Kemeny, 2004). Furthermore, under psychosocial stress, blood pressure is mainly driven by increased vascular resistance but also increased cardiac output. Higher cardiac output during psychosocial stress is less evident in children, but in older individual it is suggested to result from increased myocardial contractility (Uchino et al., 1999; Jones et al., 2008).

Furthermore, evaluative observation results in increased beta-adrenergic activity (Kelsey et al., 2000), increased cortisol production (Dickerson & Kemeny, 2004) and robust vascular and myocardial responses (Christian & Stoney, 2006, Schommer, Hellhammer & Kirschbaum 2003). A meta-analysis of over 200 stress studies (Dickerson & Kemeny, 2004) suggested that by including social evaluative threat, unpredictability and by using combination of speech task and cognitive task with a presence of evaluative observation, the most robust HPA axis stress response is achieved. That is Trier Social Stress Test.

However, when designing the measurement of physiological parameters, we do not necessarily need to use real life situations but can reliably settle for either simulations or standardized stress tests. For example, Magnusson et al. (2002) found in Swedish fighter pilots that several physiological measures taken during a flight simulator experiment resembled greatly to ones taken during real-life flights and thus indicated heightened ecological validity in simulated experiments.

Ability to Handle Pressure - Biopsychosocial Model of Challenge / Threat

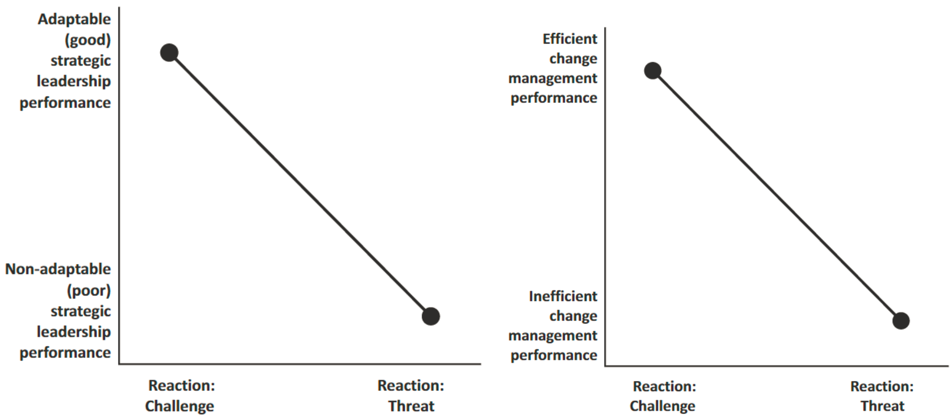
Recently, one of the most interesting areas in the psychophysiological research has been the investigation of the “biophysical model of challenge and threat”, which was originally developed by Blasovich & Tomaka (1996). Vast amount of literature has emerged to support the model and investigate its wide range of applications (see Blasovich 2013) and to reach more objective conclusions, studies linked with predicting actual performance have governed the field to investigate whether the challenging concept of pressure behaviour could have a robust predictor from careful physiological profiling.

In the model, the first part consists of “Challenge”. Individuals experience a sense of challenge when their brains construe they can access the necessary resources -- the skills, the knowledge, the effort, and the materials -- to fulfil the demand. When this state prevails, the sympathetic nervous system accelerates cardiac activity, but the adrenaline dilates vessels, and hence blood pressure remains relatively constant. On the contrast, individuals experience a sense of “Threat” when their brains construe they cannot access the necessary resources to fulfil the demand. When this state emerges, the sympathetic nervous system again accelerates cardiac activity. Nevertheless, in this instance, the adrenal medullar is inhibited, the release of adrenaline diminishes, and hence vessels are not dilated. However, blood pressure alone has never really proved to be an indicator of increased/decreased ability to handle pressure mostly due to fact that it consists of both vascular and cardiac component.

The biophysical model of challenge and threat has already been applied to several contexts, of which some are discussed below. For example, Blascovich et al. (2004) examined the relationship between pre-performance motivational states (i.e., challenge vs. threat) and subsequent performance in athletic competition, finding that players who experienced challenge and had higher cardiovascular challenge markers in the laboratory performed better relative to those who experienced threat. Consequently, Jones and colleagues proposed in 2009 a “theory of challenge and threat states in athletes”, which expanded the biophysical model into sports and speculated about the different context specific emotional states. Additionally, a framework was suggested for sports practitioners to enhance performance through developing the challenge state with the help of physiological measuring of cardiac output and peripheral resistance. In female soccer players, individual cardiovascular reactivity mediates the effects of challenge approach on performance (Chalabaev et al., 2009), which again highlights the importance of physiological profiling.

Moreover, in 2010, Seery and colleagues examined the relationship between cardiovascular markers of challenge/threat and university course performance and found that participants who exhibited cardiovascular challenge markers performed better in the subsequent course than those who exhibited cardiovascular markers of relative threat (Seery et al., 2010). This relationship remained significant after controlling for two other important predictors of performance (college entrance exam score and academic self-efficacy). In addition, pre-task appraisals of challenge states are linked with the physiological markers even with more mild stress environments (Quigley et al., 2002) In addition to performance of athletics and success related to cognitive capability, the physiological index of challenge and threat has predicted also effective attentional control and superior performance during a motor task of laparoscopic surgery (Vine et al., 2013). According to the researchers, the findings may have implications for the training and performance of motor skills in surgery, sports and aviation. The similar results were confirmed by Moore and his colleagues (2012), who found that golf putting performance was successfully predicted by cardiac output and peripheral resistance. Then again, Mendes et al. (2007) showed that the “threat” state literally prepares the body for defeat in a social psychological experiment.

Accordingly, Finnish researchers (collaborators of Caleidocons Ltd.) found in a research project conducted at the University of Helsinki that physiological challenge/threat profile of an individual manager or director (total n=44) matched exactly with their real-life achievements 3-4 months later. Those experiencing the”challenge” when they were under heavy psychosocial pressure succeeded a far better later in strategic leadership and change management, measured by a 360 degree feedback. And vice versa, those experiencing the ”threat” during the pressure were less successful in their work few months later (see figures below).



After all these findings, it is important to emphasize that the “challenge profile” is not always superior to “threat profile”, for some tasks require abilities in which the “threat profile” outperforms the “challenge profile” (Hunter, 2001). In addition, cardiovascular stress reactivity profiles are different in situations where there is constant pressure and performance is based on efficient rational decision-making without emotions evolved, such as is with financial security traders (Lo & Repin, 2003). Ability to cope under heavy or extreme pressure is essential in various occupations, but while under the pressure, people tend to behave differently, both cognitively and emotionally.

Cognition under Heavy Pressure: Attention and Self-Regulation

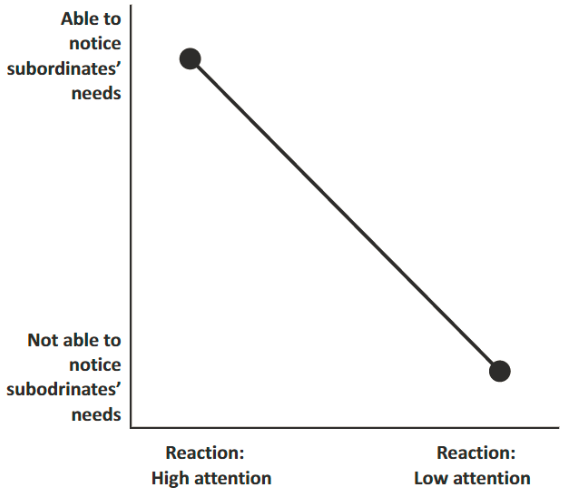
In early 90's, Stephen Porges studied the association between vagal activity and attention (Porges, 1991; 1995) It was also suggested by Porges that vagal activity had links to self-regulation especially during stress. Vagal activity is largely governed by parasympathetic nervous system and it can be non-invasively determined with high frequency (0.12 – 0.40 Hz) fluctuations of heart rate (Berntson et al. 1997). This index can be obtained by using a computational technique called Fast Fourier Transform (FFT) to detrended and appropriately resampled time series of heart rate data. There has been a lot of discussion around heart rate variability and its usability.

Heart rate variability has been linked to sustained attention in ADHD children (Börger et al., 1999), self-regulatory strength and effort (Segerstrom & Nes, 2007), and overall cognitive performance (Elliot et al., 2011). Morgan et al. (2007) used the high-frequency heart rate variability and successfully predicted performance in active duty military personnel enrolled in high intensity military training. It was suggested that by means of sustaining attention, concentrating in the relevant and gaining control of oneself were the keys to success. Interestingly, the heart rate variability predicted the performance better than physical fitness or prior experience. Then again, Goldberg et al. (2007) found that heart rate variability predicted self-control in a setting, in which participants received feedback for an alleged intelligence test. The association remained even after controlling for neuroticism, which is strongly linked to self-control itself. It was hypothesized further on, that the heart rate variability reflected the inhibitory control under a stressful situation.

Lo and Repin (2002) investigated transient market events in 10 securities traders and predicted their success with cardiovascular indices of heart rate, blood volume pulse and electrodermal activity and found that more experienced traders had less reactivity in both of these markers to information surprises. They also speculated in terms of other results that traders who let their emotions get the best of them and do not have the self-regulatory capacity, tend to fare poorly in the markets. Then again, Collet (2005) measured sympathetic influence with electrodermal activity prior a surprising and critical driving situation and predicted whether the person reacted correctly with a calm manouver.

Hudlicka (2002) went a step further by developing an application, in which both parasympathetic and sympathetic activity of an Air Force pilot during a high stress situation (combat task) was measured, and the information was used to modify the content of the messages that were displayed in giving alarm messages. In fact, it has been shown that both cardiac and electrodermal measures are related to rated workload, mental capacity, situational awareness, and performance during in pilots during a flight (Svensson & Wilson, 2002).

Also, in the same study described above, Finnish researchers found that heart rate variability was linked with actual real-life performance of managers/directors (see the figure below). Individuals whose physiological reaction to highly stressful situation were allocating more resources outperformed individuals with less efficient allocation of resources in actual work few months later.



Unfortunately, however, the variability of heart rate has not consistently linked with behavior/performance during intense pressure. Therefore, further validation is still needed.

Emotions under Heavy Pressure: Anxiety and Chronic Stress

Clinical studies have shown that during the psychological state of anxiety, the HPA axes is responding heavily. This is most probably due to its anti-inflammatory effects to protect the human body from the consequences of a stressful event. In literature, anxiety has been found to interact especially with cortisol and heart rate (Tops et al., 2007; Pruessner et al., 1999).

Besides evaluating performance, it is also possible to screen for persons with chronic stress. The number of employees suffering from symptoms of chronic stress were found to be half of the current working force in Finland, and especially persons aged under 35 years were affected (Gabriel & Liimatainen, 2000). Several studies have shown that burnout victims have dysregulated HPA and immunological activity (Sonnenschein et al. 2007, De Vente et al. 2003, Pruessner, Hellhammer & Kirschbaum 1999, Tops et al. 2007).

Given that using only HPA activity as a diagnostic tool for burnout has also been criticized (Mommersteeg et al., 2006), it is vital to use indices of sympathetic activity (Zanstra et al. 2006), since burnout victims have overactive Sympatoadrenal system (Vrijkotte, van Doornen & de Geus 2000), and also lack of habituation of the system to concurrent mental tasks (Zanstra et al. 2006) during working days.

Then again, baseline cortisol / dehydroepiandrosterone sulfate ratio taken in a day of rest in military men predicted performance in a high-intensity captivity-related challenge related to survival training (Taylor et al., 2007), and cortisol itself predicted success in military interrogation scenario for active-duty soldiers enrolled in US army survival school training (Morgan et al., 2001).

Conclusion

One of the reasons why the vast amount of these applied studies has emerged only during the past decade is that heart rate, blood pressure and cortisol all have one thing in common: they are all net results of several underlying mechanisms, which have only lately been able to be measured non-invasively. Heart rate is a result of sympathetic and parasympathetic influence to the heart. Then again, blood pressure can be described as a net result from cardiac output and vascular resistance. Current ambulatory non-invasive devices are, however, able to detect and accurately estimate each of these indices and rapidly offer us detailed knowledge from the human periphery.

The societal benefit from applied studies are to find easy-to-use and reliable applications that would help the individual in evaluating, controlling and alleviating acute stress reactions that are harmful for both short-term performance and long-term performance and health.

References

Arnsten, A. F. (2009). Stress signalling pathways that impair prefrontal cortex structure and function. Nature Reviews Neuroscience, 10(6), 410-422.
Berntson, G. G. (1997). Herat rate variability: origins methods and interpretive caveats. Psychophysiology, 34, 623-648.
Blascovich, J. (2013). 25 Challenge and Threat. Handbook of approach and avoidance motivation, 431.
Blascovich, J., Seery, M. D., Mugridge, C. A., Norris, R. K., & Weisbuch, M. (2004). Predicting athletic performance from cardiovascular indexes of challenge and threat. Journal of Experimental Social Psychology, 40, 683–688.
Blascovich, J. (2008). Challenge and threat. In A. J. Elliot (Ed.), Handbook of approach and avoidance motivation (pp. 431–445). New York: Psychology Press.
Börger, N., van Der Meere, J., Ronner, A., Alberts, E., Geuze, R., & Bogte, H. (1999). Heart rate variability and sustained attention in ADHD children. Journal of Abnormal Child Psychology, 27(1), 25-33.
Blascovich, J., & Tomaka, J. (1996). The biopsychosocial model of arousal regulation. Advances in Experimental Social Psychology, 28, 1–51.
Bremner, J.D., Krystal, J.H., Southwick, S.M. & Charney, D.S. 1995, Functional neuroanatomical correlates of the effects of stress on memory, Journal of traumatic stress, 8, 527-553.
Burleson, M. H., Poehlmann, K. M., Hawkley, L. C., Ernst, J. M., Berntson, G. G., Malarkey, W. B., ... & Cacioppo, J. T. (2003). Neuroendocrine and cardiovascular reactivity to stress in mid-aged and older women: Long-term temporal consistency of individual differences. Psychophysiology, 40(3), 358-369.
Chalabaev, Major, Cury, Sarrazin. (2009). Physiological markers of challenge and threat mediate the effects of performance-based goals on performance. Journal of Experimental Social Psychology, Volume 45, Issue 4, July 2009, Pages 991-994
Christian, L. M., & Stoney, C. M. (2006). Social support versus social evaluation: unique effects on vascular and myocardial response patterns.Psychosomatic medicine, 68(6), 914.
Collet C., Petit C., Priez A., Dittmar A. Stroop color-word test, arousal, electrodermal activity and performance in a critical driving situation. Biological Psychology, 2005, 69, 193-203.
De Vente, W., Olff, M., Van Amsterdam, J. G. C., Kamphuis, J. H., & Emmelkamp, P. M. G. (2003). Physiological differences between burnout patients and healthy controls: blood pressure, heart rate, and cortisol responses. Occupational and environmental medicine, 60(suppl 1), i54-i61.
Dickerson, S. S., & Kemeny, M. E. (2004). Acute stressors and cortisol responses: a theoretical integration and synthesis of laboratory research.Psychological bulletin, 130(3), 355.
Elliot, A. J., Payen, V., Brisswalter, J., Cury, F., & Thayer, J. F. (2011). A subtle threat cue, heart rate variability, and cognitive performance.Psychophysiology, 48(10), 1340-1345.
Gaab J, Rohleder N, Nater UM, Ehlert U. (2005) Psychological determinants of the cortisol stress response: the role of anticipatory cognitive appraisal. Psychoneuroendocrinology. 30, 599-610.
Gabriel P, Liimatainen M-L. (2000) Mental health in the workplace: Introduction. International Labour Office, Geneva, October 2000.
Gillespie, C. F., Phifer, J., Bradley, B., & Ressler, K. J. (2009). Risk and resilience: genetic and environmental influences on development of the stress response. Depression and anxiety, 26(11), 984-992.
Goldberg, L. S., & Grandey, A. A. (2007). Heart rate variability predicts self-control in goal pursuit. European Journal of Personality, 23, 623-633.
Hansen, A., Johnsen, B., & Thayer, J. (2008). Relationship between heart rate variability and cognitive function during threat of shock. Anxiety, Stress & Coping, 9, 1-12.
Hudlicka, E., Mcneese, M., (2002). Assessment of User Affective and Belief States for Interface Adaptation: Application to an Air Force Pilot Task. User modelling and User-Adapted Interaction, v. 12(1), pp. 1-47.
Hunter S. B. (2001). Performance Under Pressure: The Impact of Challenge and Threat States on Information Processing. Ph.D. thesis, University of California Santa Barbara, CA
Jones, A., Beda, A., Osmond, C., Godfrey, K. M., Simpson, D. M., & Phillips, D. I. (2008). Sex-specific programming of cardiovascular physiology in children.European heart journal.
Jones, M., Meijen, C., McCarthy, P. J., & Sheffield, D. (2009). A theory of challenge and threat states in athletes. International Review of Sport and Exercise Psychology, 2(2), 161-180.
Kelsey, R. M., Alpert, B. S., Patterson, S. M., & Barnard, M. (2000). Racial differences in hemodynamic responses to environmental thermal stress among adolescents. Circulation, 101(19), 2284-2289.

Lo, A. and Repin, D. (2002), The Psychophysiology of Real-time Financial Risk Processing,. Journal of Cognitive Neuroscience 14, 323-339
Lupien, S. J., McEwen, B. S., Gunnar, M. R., & Heim, C. (2009). Effects of stress throughout the lifespan on the brain, behaviour and cognition. Nature Reviews Neuroscience, 10(6), 434-445.
Magnusson 5. (2002). Similarities and Differences in Psychophysiological Reactions Between Simulated and Real Air-to-Ground Missions. The International Journal of Aviation Psychology 12(1), 49-61
Maher B. (1966) Principles of psychopathology: an experimental approach. New York: McGraw-HilI.
May, R. W., Sanchez-Gonzalez, M. A., Brown, P. C., Koutnik, A. P., & Fincham, F. D. (2013). School burnout and cardiovascular functioning in young adult males: a hemodynamic perspective. Stress, (0), 1-27.
McEwen, B. S. (1998). Stress, adaptation, and disease: Allostasis and allostatic load. Annals of the New York Academy of Sciences, 840(1), 33-44.
McEwen B.S.; Sapolsky R.M. (1995). Stress and cognitive function. Current Opinion in Neurobiology, 5
Mendes W. B., Blascovich J., Hunter S. B., Lickel B., Jost J. T. (2007). Threatened by the unexpected: physiological responses during social interactions with expectancy-violating partners. J. Pers. Soc. Psychol. 92 698–716
Mizoguchi, K., Yuzurihara, M., Ishige, A., Sasaki, H., Chui, D.H. &. Tabira, T. (2000), Chronic stress induces impairment of spatial working memory because of prefrontal dopaminergic dysfunction. The Journal of neuroscience: the official journal of the Society for Neuroscience, 20, 4, 1568-1574.
Mommersteeg, P., Keijsers, G. P., Heijnen, C. J., Verbraak, M. J., & van Doornen, L. J. (2006). Cortisol deviations in people with burnout before and after psychotherapy: a pilot study. Health Psychology, 25(2), 243.
Moore, L. J., Vine, S. J., Wilson, M. R., & Freeman, P. (2012). The effect of challenge and threat states on performance: An examination of potential mechanisms. Psychophysiology, 49(10), 1417-1425.
Morgan, C., Aikins, D., Steffian, G., Coric, V., & Southwick, S. (2007). Relation between cardiac vagal tone and performance in male military personnel exposed to high stress: Three prospective studies. Psychophysiology, 44, 120-127.
Nagpal, M. L., Gleichauf, K., & Ginsberg, J. P. (2013). Meta-Analysis of Heart Rate Variability as a Psychophysiological Indicator of Posttraumatic Stress Disorder. J Trauma Treat, 3(182), 2167-1222.
Pacak, K., Palkovits, M., Yadid, G., Kvetnansky, R., Kopin, I. J., & Goldstein, D. S. (1998). Heterogeneous neurochemical responses to different stressors: a test of Selye's doctrine of nonspecificity. American Journal of Physiology-Regulatory, Integrative and Comparative Physiology, 275(4), R1247-R1255.
Porges, S.W. (1991). Vagal tone: An autonomic mediator of affect. In I.A. Garber and K.A. Dodge (eds.), The Development of Affect Regulation and Dysregulation. New York: Cambridge University Press, 111-128.
Porges, S. (1995). Orienting in a defensive world: Mammalian modifications of our evolutionary heritage. A polyvagal theory. Psychophysiology 32, 301-318.
Pruessner, J.C., Hellhammer, D.H. &. Kirschbaum, C. (1999). Burnout, perceived stress, and cortisol responses to awakening, Psychosomatic medicine, vol. 61, no. 2,197-204.
Quigley, Karen S., Lisa Feldman Barrett, and Suzanne Weinstein (2002). Cardiovascular patterns associated with threat and challenge appraisals: A within-subjects analysis. Psychophysiology 39: 292-302.
Schommer, N. C., Hellhammer, D. H., & Kirschbaum, C. (2003). Dissociation between reactivity of the hypothalamus-pituitary-adrenal axis and the sympathetic-adrenal-medullary system to repeated psychosocial stress.Psychosomatic medicine, 65(3), 450-460.
Segerstrom, S. & Nes, L. (2007). Heart rate variability reflects self-regulatory strength, effort, and fatigue. Psychological Science, 18, (3), 275-281
Seery, M.D., Weisbuch, M., Hetenyi, M. A., Blascovich, J. (2010). Cardiovascular measures independently predict performance in a university course. Psychophysiology, 47 (2010), 535–539.
Selye, H. (1936). A syndrome produced by diverse nocuous agents. Nature,138(3479), 32.
Shusterman V., Barnea, O. (2005). Sympathetic nervous system activity in stress and biofeedback relaxation. IEEE Engineering in Medicine and Biology Magazine. 24, 52-57.
Snieder, H., Harshfield, G. A., Barbeau, P., Pollock, D. M., Pollock, J. S., & Treiber, F. A. (2002). Dissecting the genetic architecture of the cardiovascular and renal stress response. Biological psychology, 61(1), 73-95.
Sonnenschein, M., Mommersteeg, P., Houtveen, J. H., Sorbi, M. J., Schaufeli, W. B., & van Doornen, L. J. (2007). Exhaustion and endocrine functioning in clinical burnout: an in-depth study using the experience sampling method.Biological psychology, 75(2), 176-184.
Svensson, E. A., & Wilson, G. F. (2002). Psychological and psychophysiological models of pilot performance for systems development and mission evaluation. The International Journal of Aviation Psychology, 12(1), 95-110.
Taylor MK, Sausen KP, Patternt EG, Mujica-Parodi LR, Reis IP, Markham AE, Padilla GA, Taylor DL. (2007). Stressful military training: endocrine reactivity, performance, and psychological impact. Aviat Space Environ Med, 78, 1143-9.

Tops, M., Boksem, M.A., Wijers, A.A., van Duinen, H., Den Boer, J.A., Meijman, T.E &. Korf, J. 2007, The psychobiology of burnout: are there two different syndromes?, Neuropsychobiology, 55, 143-150.
Uchino, B. N., Uno, D., Holt-Lunstad, J., & Flinders, J. B. (1999). Age-related differences in cardiovascular reactivity during acute psychological stress in men and women. The Journals of Gerontology Series B:
Psychological Sciences and Social Sciences, 54(6), P339-P346.
Vedhara, K., Hyde, J., Gilchrist, I. D., Tytherleigh, M., & Plummer, S. (2000). Acute stress, memory, attention and cortisol. Psychoneuroendocrinology,25(6), 535-549.
Vine, S. J., Chaytor, R. J., McGrath, J. S., Masters, R. S., & Wilson, M. R. (2013). Gaze training improves the retention and transfer of laparoscopic technical skills in novices. Surgical endoscopy, 27(9), 3205-3213.
Vrijkotte, T. G., van Doornen, L. J., & de Geus, E. J. (2000). Effects of work stress on ambulatory blood pressure, heart rate, and heart rate variability.Hypertension, 35(4), 880-886.
Zanstra, Y. J., Schellekens, J. M., Schaap, C., & Kooistra, L. (2006). Vagal and sympathetic activity in burnouts during a mentally demanding workday.Psychosomatic medicine, 68(4), 583-590.