Effects of Hong Kong Employees' Workplace Stress on Heart Rate Variability

Doctoral Project

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DEDICATION

This dissertation is dedicated to my God, Christ Jesus, my source of energy, grit, motivation and passion. Without You, this is impossible.

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"Everybody knows what stress is and nobody knows what stress is" Hans Selye, 1976, "The Evolution of the Stress Concept"

"For psychotherapists things are radically different. Their job is to improve the mental functioning of their patients. But how can they tell when their interventions are going wrong or, for that matter, right? Where is the feedback? Most psychotherapists gauge how their clients are responding to treatment not with objective data, but by observing them in clinic. But this data is highly unreliable. After all, patients might be inclined to exaggerate how well they are to please the therapist, a well-known issue in psychotherapy. But there is a deeper problem. Psychotherapists rarely track their clients after therapy is finished. This means that they do not get any feedback on the lasting impact of their interventions. They have no idea if their methods are working or failing in terms of actually improving long-term functioning. And that is why the clinical judgments of many practitioners don't improve over time. They are effectively playing golf in the dark." Matthew Syed, 2015, "Black Box Thinking: The Surprising Truth About Success"

This doctoral project is not just about me. It's dedicated to everyone. It's about you. It's about the stress we have experienced whether or not we are aware of it, it's just there. Here is my special thank you list (No priority of order intended)

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APPROVAL

We, the undersigned, certify we have read this Doctoral Project and approve it as adequate in scope and quality for the degree of Doctor of Psychology.

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ABSTRACT

Research on workplace stress measurements varied without much accuracy and effectiveness. The objective of this study was to introduce a new quantitative assessment tool emWave Pro Plus (Institute of HeartMath) and to compare Heart Rate Variability (HRV) results with the Personal and Organizational Quality Assessment (POQA) and the Perceived Stress Scale (PSS). Eighty-five full-time employees who were working at least 40 hours per week in a large corporation participated in this study. Firstly, significant negative correlations were found between Subjective Stress and HRV measures: Perceived Stress and 5-minute Mean Inter-Beat-Interval (IBI), r = -0.217*; Perceived stress and 5min SDNN, r = -0.255* and Perceived stress and Ln 5min RMSSD, r = -0.282**. Secondly, significant negative correlations were found between age and the HRV measures: 1-minute SDNN ($r = -.235$, $p < 0.01$); 5-minute SDNN ($r = -.290$, $p < 0.01$); 5-minute RMSSD ($r = -.395$, $p < 0.01$); Total Power ($r = -.272$, $p < 0.05$); Very Low Frequency ($r = -.215$, $p < 0.05$) and High Frequency ($r = -.402$, $p < 0.01$). Thirdly, significant negative correlation was found between Normalized Coherence and Relational Tension ($r = -.222$, $p < 0.05$). Additionally, significant positive correlations were found between Emotional Stress and the Mean Heart Rate Range (MHRR), r = 0.216* and between Intention to Quit and 5-minute Ln Very Low Frequency (VLF), r = 0.234*. The research shows promising results and future studies should continue to tap into HRV as an objective measure of mental health and workplace stress.

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CHAPTER ONE

OVERVIEW OF THE STUDY

Cardiovascular diseases are the highest cause of death in the world (World Health Organization, 2014). Many of these deaths may be workplace-related (Chandola et al., 2008). Long hours at work seem to be influencing the increased risks of heart diseases (Kivimaki & Kawachi, 2015). Moreover, researchers from the Standard Working Hours Committee in Hong Kong administered a 2014 survey and coined Hong Kong as "overworked, overstressed and overwhelmed" (South China Morning Post, 2015, para. 1). The Committee reported that "every person in the 23 per cent of our working population who toil for 51½ hours or more per week has clocked up at least 4,958 hours" after two years (South China Morning Post, 2015, para. 2). Stress at work is associated with an increased risk of cardiovascular disease (CVD), but little is known about the conduit that underlies the association (Backe et al., 2012).

Background of the Problem

Defining Stress

According to Selye (1974), he established stress as "the non-specific response of the body to any demand made upon it" (p. 14). In other words, every demand positioned on the body triggers a non-specific demand to regulate and adapt to the challenge, which demands a secondary level of physical and emotional adaptation. The National Institute for Occupational Safety and Health (NIOSH) defined workplace stress as "the harmful physical and emotional responses that occur when the requirements of the job do not match the capabilities, resources, or [the] needs of the worker" (National Institute for Occupational Safety and Health, 1999, p. 7). A stress study over a period of 5 years was conducted (American Psychological Association, 2011) and researchers reported that 70% of Americans pointed out that work was a contributing factor

to stress. Moreover, a study conducted by NIOSH (1999) revealed that 40% of employees indicated that their jobs were very or extremely stressful. This shows that workplace stress happens not just in Hong Kong, but also globally.

Global and Health Issues

Besides Hong Kong and the United States, other developed countries are experiencing workplace stress as an emerging global problem. Canada and the United Kingdom report that workplace stress contributes to diseases, depression, injury and a decrease in organizational productivity (Price, 2004; Ryan & Watson, 2004). In an environment where there's workplace stress, employees inculcate a negative attitude towards their work with a consequent drop in motivation, performance, and efficiency. Moreover, workplace stress triggers three kinds of employee reactions: firstly, there may be physical ailments such as high blood pressure, heart disease and elevated cortisol levels, secondly, psychological effects such as escalated conflict and depression may be triggered, and thirdly, unhealthy coping habits such as excessive consumption of alcoholic beverages may be displayed. Employees exhibit early signs of workplace stress such as a headache, insomnia, difficulty in concentrating, short temper, upset stomach. On the same side of the coin, organizational productivity drops as absenteeism, presenteeism, turnover and sick leave increase.

Workplace stress also impacts businesses financially on a global basis. It is estimated to cost organizations in the United States more than US$300 billion annually in productivity loss, absenteeism, turnover, medical, legal and insurance costs (Rosch, 2001). In Canada, workplace stress costs 6 billion Canadian dollars annually (Price, 2004). Interestingly, United Kingdom reported not in terms of a financial trade-off, but an estimated annual loss of 200 million working days due to illnesses triggered by workplace stress (Ryan & Watson, 2004). Other financial

losses include employee lawsuits with monetary compensations (Rosch, 2001), an increase in employees' compensation and disability claims (NIOSH, 1999). Hence, these reports indicate that workplace stress is an emergent global prevalence. From the 1970s, NIOSH started epidemiological researches on the outcomes of work-related factors in organizations. Researches from NIOSH revealed workplace stress as a workplace safety and health risk. They further reported that all workplace employees will experience workplace stress at some point in time, both in and beyond the workplace. Interestingly, employees react to workplace stress differently. Most employees go to work but do not work at their best, while others resign when overstressed (Willingham, 2008). Similarly, the American Psychological Association (2007) states that "fifty-two percent of employees report that they have considered or made a decision about their career such as looking for a new job, declining a promotion or leaving a job based on workplace stress" (p. 11). Moreover, stressed employees eradicate themselves from working for someone else by starting their own businesses (Hewlett & Buck Luce, 2006).

Assessments

The validity of obsolete tools being used to evaluate workplace stress is questionable as some questionnaires and survey questions contain outdated questions and unrepresented data that cannot accurately reflect today's population of workplace employees. The irony is that in assessing workplace stress, many researchers, business executives and Organizational Development (OD) consultants have been consistently using questionnaires, surveys and clinical instruments that were created and validated more than 25 years ago (Centre for Studies on Human Stress, 2012). Moreover, there are also some questionnaires still in use that were developed over 30 years ago via funding given by the National Institutes of Health (NIH) and NIOSH.

Based on past experiences, there is a global need to improve the quality of the working environment by reducing workplace stress. To accomplish these tasks, new assessment tools that can accurately reflect today's population of workplace employees and businesses have to be put in place. Otherwise, merely providing practical solutions or intervention protocols to organizational challenges cannot truly happen. Historically, the development of valid and reliable measurements is lacking which results in the use of the same old questionnaires, surveys and clinical instruments that are wrapped in new packages (Brookfield, 2005; Morgan, 2006; Weisbord, 2012).

Despite having a lack of accurate measurements of workplace stress, research on stress itself shows that there are two main ways to measure stress: physiological (quantifiable) and perception / psychological (self-report). The most commonly-used measures of physiological stress that are quantifiable are hormonal cortisol indicators (cortisol secretion), galvanic skin response (GSR) and heart rate variability (HRV). Krantz, Forsman, and Lundberg (2004) advocate that biomarkers of stress, such as blood pressure, heart rate and catecholamine and cortisol secretion, reveal the influence of mental stress on many physiological functions. These responses also point to a possible connection between psychosocial stress and many physical health issues (Krantz, Forsman, & Lundberg, 2004). Most research have found physiological stress as the cause of cardiovascular disease (Belkic, Landsbergis, Schnall, & Baker, 2004; Collins, Karasek, & Costas, 2005) which may indicate that a stressful work environment is linked to higher risks of heart diseases. More complex analysis involving the power spectral components of the heart rate can also be used to predict the risk of cardiovascular diseases. They can also be used to predict any risk due to stress (Collins, Karasek, & Costas, 2005).

Heart Rate Variability (HRV)

HRV occurs naturally with a beat-to-beat variability in heart rate and it can be measured by an electrocardiogram. HRV is extensively acknowledged as a measure of neurocardiac function that reveals heart-brain connections and autonomic nervous system (ANS) dynamics (McCraty & Childre, 2010). Hence, HRV is a biomarker of health and wellbeing (Antelmi, 2004). On one hand, a high HRV is associated with lower morbidity and mortality, which is predictor of recovery from myocardial infarction (MI) (Carney et al., 2001). According to Matsuoka et al. (2005), a high HRV is associated with reduced medical morbidity, increased longevity, and promotes higher cognitive functioning. On the other hand, a low HRV is a predictor of a risk for MI and sudden cardiac death which is an indication of poor psychological resilience, behavioral flexibility and the capacity to adapt successfully to the changing demands of the environment (McCraty & Childre, 2010).

There is limited research on how workplace stress can affect heart rate. For example, at the time of preparing this manuscript, PubMed gave only 274 hits on the keywords "job stress" or "workplace stress" and "HRV" or "heart rate", starting from 1974 (Botzum & Dorsey, 1974). Nevertheless, there are researchers who have conducted workplace stress using HRV with industries such as Media Workers in Finland and Poland (Lindholm, 2013; Bortkiewicz, Gadzicka, Szymczak, & Zmyslony, 2012), Police Special Forces in the United States (McCraty & Atkinson, 2012; Andersen et al., 2015), Medical Centers in the United States and Germany (Pipe et al., 2012; Linden, Jackson, Rutledge, Nath, & Lof, 2010; Rieger, Stoll, Kreuzfeld, Behrens, & Weippert, 2014; Borchini et al., 2015), Church Staff in the United States (Bedell & Kaszkin-Bettag, 2010), Fire-fighters in South Korea (Shin, Lee, Yang, Lee, & Chung, 2016), Machinery workers in Brazil and China (Monteze et al., 2015; Li et al., 2012), Airplane

Manufacturing Employees in Germany (Loerbroks et al., 2010), Employees from five companies in Korea (Kang et al., 2015) and Teachers in Taiwan (Chang & Shen, 2011). However, there are no researchers using HRV to assess workplace stress in an actual workplace setting in Hong Kong.

Statement of the Problem

Research on workplace stress measurements varied without much accuracy and effectiveness (Feldman, Greenson, & Senville, 2010; Newman & Beehr, 1979). Moreover, to indicate this as an ongoing problem, from the Penny George Institute for Health and Healing (2012), cardiologist and vice president Courtney Baechler asserted, "even with all of the advancements in medicine, as clinicians, we don't have a good tool to measure and compare people's stress" (p. 1). One of the gaps is the usage of outdated assessments to measure workplace stress (Centre for Studies on Human Stress, 2012). For instance, the previously validated measures on depression (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961), stress (Brantley, Waggoner, Jones, & Rappaport, 1987; Cohen, Kamarck, & Mermelstein, 1983), burnout (Maslach & Jackson, 1981) and self-esteem (Rosenberg, 1965) correspond to a workforce and organizational challenges from former times. Secondly, where workplace stress is concerned, another gap is an extensive use of perceivable measures on workplace stressors that are self-reported (Panari, Guglielmi, Ricci, Tabanelli, & Violante, 2012; Spector & Jex, 1998) without the use of physiological measurements. Nevertheless, more quantitative and qualitative research needs to be conducted on new assessments, to reflect the zeitgeist of the current time, with current and valid metrics.

Purpose of the Study

One purpose of this study is to introduce a new practical assessment, Heart Rate Variability (HRV) to assess employee stress in the workplace. Real-time heart rate measures are practical as an aid to assess workplace stress and disease indicators. Additionally, HRV can be used to assess the different levels of mental stress. The significance of heart rate measures has been accepted historically, and traditionally electrocardiogram machines have been used to measure the heart rate. However, these machines are not practical for workplace environments (Kingsley, Lewis, & Marson, 2005; Lindskog, 2014). Portable HRV devices are the most economical as the devices are small and discrete with the capability to collect and store data easily.

Although non-workplace factors (e.g., poor health, environmental stress, significant life events) can contribute to the development of cardiovascular diseases, this research study will examine the effects of workplace stress on HRV. The current study will correlate heart rate variability with psychometric measures. The HRV outcome measures will be limited to the frequency and time domain values, although various studies have proposed examining other physiological responses such as hormone excretion (Kirsch & Woodbury-Farina, 2014; Krantz, Forsman, & Lundberg, 2004) and oxygen uptake (Astrand & Rodahl, 2003; Kim, Jung, Ryu, Kim, & Lee, 2015). Changes in HRV could possibly be used to investigate the root causes of CVDs. The product of this research will not directly attribute CVDs to HRV, but instead will investigate the potential risk factors in the workplace environment that could lead to CVDs. Other personal factors like age, ethnicity and gender will be recorded, but will not be included in the initial analysis.

Hence, a second purpose of this research study is to explore the correlational ties between HRV quantitative measurements and other captured quantitative data that can help to assess the workplace stress of employees in Hong Kong. This study intends to use the power spectral components of heart rate variability to analyze heart rate data after the employee self-reports his or her level of stress over two scales: one is a Personal and Organizational Quality Assessment (POQA) from Heartmath (Barrios-Choplin & Atkinson, 2000), and the Perceived Stress Scale (PSS) (Cohen, Kamarck, & Mermelstein, 1983). After these assessments have been completed, a correlation between the Heart Rate Variability (HRV) and both POQA and PSS will be conducted. The reason for collecting both self-reported and physiological data is to bring together the strengths of both forms of research to establish a profile of workplace stress that is not solely based on measures of self-report.

Research Questions

Several research questions have been developed to address this study as follows:

- In what way can HRV be used to accurately measure the effects of workplace stress in Hong Kong?
- What are the effects of workplace stress in Hong Kong on HRV?
- In what way does HRV compare with self-reports of stress in Hong Kong?
- What is the overall level of comfort a typical Hong Kong employee experiences?

Theoretical Framework

This research study will employ a quantitative correlational design to assess the relationship between an employee's HRV and the psychometrics derived from Personal and Organizational Quality Assessment (POQA) and the Perceived Stress Scale (PSS). Pearson correlation coefficients and their probabilities for all physiological and psychometric variables

will be obtained using SPSS Version 22.0 (IBM Corp, 2013). The POQA is a validated and normed assessment that provides a broad overview of the participants' emotional stressors and social attitudes, vitality and physical symptoms of stress as well as measures of workplace effectiveness (Barrios-Choplin & Atkinson, 2000). According to Cohen et al. (1983), the PSS measures stress in general and has been empirically validated with workplace employees. Although the validation was done more than 3 decades ago whereby cultural validation may be challenged, HRV will be correlated with the PSS as a secondary analysis.

Significance of the Study

Workplace stress is not just a health issue but it is also a challenging business issue. If business leaders disregard the effect of workplace stress, organizations and employees may face even greater consequences of monetary loss, heart diseases and stress-induced deaths. Global conglomerates have been facing losses greater than US$200 billion per year in productivity losses, increased compensation and lawsuit claims, increased turnover and medical costs. As a matter of fact, a majority of doctor visits by employees are workplace stress-related (American Psychological Association, 2011). Hence, employee stress needs to be addressed beyond the status quo.

Additionally, most of the assessments that are used to measure workplace stress are of a self-reported nature and not up-to-date. Besides the fact that most of these assessments were validated more than three decades ago, most present false positive and obsolete information to business leaders. Business executives, researchers and OD consultants need to put in place new assessment tools that can accurately reflect today's population of workplace employees and businesses. The findings in this research study may provide a modern alternative to measuring workplace stress in the actual workplace by introducing a new quantifiable measurement of HRV

to business executives, OD consultants and researchers as a valid and practical assessment tool. Moreover, the study could be beneficial by providing a solution that addresses global business and health issues in a cost-effective manner.

Limitations and Delimitations of the Study

A limitation in the form of measurement bias might have occurred since the survey data was self-reported, the results depended on the effort and honesty of each participant. Participants in the study might have been reluctant to give socially unacceptable answers in the questionnaires, for fear of being judged or are not self-aware enough to provide accurate responses. This might skew the results and might have caused errors in the correlational analysis. Since the research was on workplace stress, another limitation arising from surrogate information error might occur due to the fact that the stress stemming from the employees might have been non-workplace related, such as family bereavement and loss, relationship breakdown, financial problems, family illnesses, commuting pressures, etc. It was also observed that the age range of the participants seemed to have skewed towards the younger population group of 21-40 which might have led to a design bias limitation. Furthermore, participants that came from four lines of services within the corporation were not equally distributed – Department A (57.6%), Department B (11.7%), Department C (22.3%) and Department D (8.2%), which might have delineated a narrow demographic range of the corporation known as a measurement bias (Shuttleworth, 2009).

According to an article search, this was the first research conducted on the relationship between HRV, POQA and PSS in Hong Kong and using HRV as a potential physiological objective measurement for workplace stress. The sample size (n=85) of HRV measures was relatively large compared to other research studies and according to Clinical & Translational

Science Institute (2017), the total sample size was of a significant level to achieve a power of .80 and an estimated effect size of .30.

Definitions and Key Terms

Heart Rate Variability (HRV): beat-to-beat variations in heart rate, derived from electrocardiogram (ECG) or pulse wave recordings. The HRV wave form can be divided into several different frequency bands using spectral analysis techniques: Very Low Frequency (VLF), Low Frequency (LF), and High Frequency (HF) (Shaffer, McCraty, & Zerr, 2014). The very-low-frequency band (VLF) is the power in the HRV power spectrum range between 0.0033 and 0.04 hertz, which equates to rhythms or modulations with periods that occur between 25 and 300 seconds. Although all 24-hour clinical measures of HRV reflecting low HRV are linked with increased risk of adverse outcomes, the VLF band has stronger associations with all-cause mortality than the LF and HF bands (Tsuji et al., 1994). The low-frequency (LF) band ranges between 0.04 and 0.15 hertz, which equates to rhythms or modulations with periods that occur between 7 and 25 seconds. This region was previously called the "baroreceptor range" or "midfrequency band" by many researchers because it primarily reflects baroreceptor activity while at rest (Malik & Camm, 1995, p. 173-188). The high-frequency (HF) spectrum is the power in the range from 0.15 to 0.4 hertz, which equates to rhythms with periods that occur between 2.5 and 7 seconds. This band reflects parasympathetic or vagal activity and is frequently called the respiratory band because it corresponds to the HR variations related to the respiratory cycle known as respiratory sinus arrhythmia (Armour & Ardell, 1994). It is also noted that the assessment of the overall amount of HRV one has reflects long-term processes such as chronic stress, health status, resilience, etc., which is determined by the one minute deep breathing assessment in this study (R. McCraty, personal communication, November 19, 2017).

MHRR: The MHRR is the Mean Heart Rate Range which is derived from the mean difference between the maximum and minimum heart rate from 6 successive deep breaths at a rate of 6 breaths per minute (10 seconds per respiratory cycle).

Normalized Coherence: Normalized Coherence is a measure of the pattern in the heart's rhythm, which is independent of the amount of HRV, and reflects an orderly and harmonious synchronization among various systems in the body such as the heart, respiratory system and blood-pressure rhythms. The amount of coherence we have in our heart's rhythms can be measured with a monitoring device.

Time Domain Measurements of HRV: Time domain measures are the simplest to calculate and include the mean normal-to-normal (NN) intervals during the entire recording and other statistical measures such as the standard deviation between NN intervals (SDNN). However, time domain measures do not provide a means to adequately quantify autonomic dynamics or determine the rhythmic or oscillatory activity generated by the different physiological control systems. Since they are always calculated the same way, data collected by different researchers are comparable, but only if the recording lengths are exactly the same and the data are collected under the same conditions. Time domain indices quantify the amount of variance in the IBI using statistical measures. The three most important time domain measures are the SDNN, the SDNN index, and the RMSSD.

SDNN: The SDNN is the standard deviation of the normal (NN) sinus-initiated interbeat interval (IBI) measured in milliseconds. This measure reflects the ebb and flow of all the factors that contribute to heart rate variability (HRV). To put it simply, the SDNN is referred to as a marker for how the overall nervous system is functioning — what the patient's number that is being compared to (i.e., what's good, what would be a concern).

RMSSD: The RMSSD is the root mean square of successive differences between normal heartbeats. This value is obtained by first calculating each successive time difference between heartbeats in milliseconds. Then, each of the values is squared and the result is averaged before the square root of the total is obtained. The RMSSD reflects the beat-to-beat variance in heart rate and is the primary time domain measure that is used to estimate the vagally-mediated changes reflected in HRV. While the RMSSD is correlated with HF power (Kleiger, Stein, & Bigger, 2005).

Respiratory sinus arrhythmia (RSA): RSA is heart rate variability in synchrony with respiration, by which the R-R interval on an ECG is shortened during inspiration and prolonged during expiration.

Organization

Chapter 2 provides a literature review of the current information on workplace stress, the history of stress and the measurements used in assessing stress. Gaps in the current understanding of the methods that are used as measurements as well as the knowledge exchanged with contemporary researchers and consultants will be highlighted. Chapter 3 will provide an explanation of the research methodology and methods outlined in this study. Chapter 4 will present the research findings from the collected data. Chapter 5 will include a discussion of the findings and the collected data.

CHAPTER TWO

LITERATURE REVIEW

Historical research on workplace stress measurements varied without much accuracy and effectiveness due to the lack of physiological and quantitative measurements. The purpose of this study is to first of all introduce a new practical assessment, Heart Rate Variability (HRV) to assess the long term effects of employee stress in the workplace in Hong Kong. A second purpose of this research study is to explore the potential correlations between HRV quantitative measurements and quantitative data. An extensive literature review has revealed several areas that have a direct bearing on the current research study. This section offers a synthesis of the findings: a review of the definition of stress from a historical to a modern psychophysiological standpoint, the Autonomous Nervous System (ANS) and the heart, Heart Rate Variability (HRV), components of the heart rate, the factors influencing the power spectrum of HRV, the importance of HRV in assessing workplace stress, heart rate measures and the practical applications of heart rate monitors.

Stress

For decades, stress has been universally associated with triggering and aggravating sicknesses such as cardiovascular diseases (heart disease) and cancer (Lovallo, 2015; McEwen, 1998). Nevertheless, stress is subjective and it is challenging to measure stress due to the perplexing nature of everyday life. While the physiological functions of the body advocate adaptation and homeostasis through their ability to adapt and respond during difficult situations, these same functions can compromise internal stability when they are continuously strained in extreme conditions (McEwen, 1998).

Historical Definition of Stress

Before understanding work-related stress and their different theories, it is important to first explore how its parent construct "stress" has been defined and evolved. By conceptualizing what stress means can help the understanding of workplace stress (Dewe, O'Driscoll, & Cooper, 2012). Historically, there are three main views of stress: Stimulus-based, Response-based and Transaction-based also known as the interaction between stimulus and response (Cox, 1978; Cox & Mackay, 1981; Cummings & Cooper, 1998; Dewe et al., 2012; Shahsavarani, Abadi, & Kalkhoran, 2015).

The stimulus-based model postulates stress as an independent variable where stimulus characteristics such as the environment are considered as distressing or disruptive in some way (Cox, 1978; Cox & Mackay, 1981; Sutherland & Cooper, 2000). The stimulus-based model incorporates Hooke's Law of Elasticity from physics where the load or demand known as the "stress", when exerted on the metal triggers a strain that results in deforming the metal. According to Hooke's law, if the strain produced by the stress falls within the elastic limit of the material, the metal will restore to its original position when the stress is removed. Otherwise, permanent damage will happen if the strain is greater than the given elastic limit. Transferring this analogy to human beings, different individuals will have different breaking points. In other words, human beings are able to bear certain levels of stress, but once the limitation level of stress is exceeded, permanent physiological or psychological damage will occur (Cox, 1978). The stimulus-based model is shown in Figure 1.

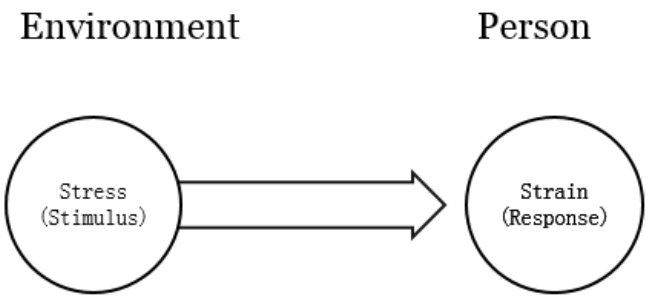

Figure 1: The stimulus-based model of stress. The figure shows that the stress is considered in the stimulus-based model as an independent variable and the main distressing stimulus characteristic is the environment. Retrieved from (Cox, 1978).

Similarly, Papathanasiou, Tsaras, Neroliatsiou, and Roupa (2015) purport to show the stimulus-based model as any mental or physical load that is straining one's body which leads to his or her body undergoing physiological changes. This model sees stress as a stimulus, life events or stressors, either positive or negative that strain the adaptation capacity of an individual, causing physiological and psychological tensions that lead to health problems (Papathanasiou et al., 2015). Rating scales such as the Holmes and Rahe's Social Readjustment Rating Scale (SRRS) were developed based on this model. The SRRS hypothesized that people with high scores in the SRRS would view major life changes having a very stressful impact on them, and they stand a higher chance of experiencing physical or mental illness (Holmes & Rahe, 1967; Schell, 1997; Henry & Stephens, 2013). From a workplace stress perspective, Muchinsky and Culbertson (2016) categorize the eight workplace stressors that can be part of this stimulus-based model:

1. Physical Stressors – Stressful aspects of the environment, such as aversive working conditions.

2. Task-related stressors – Aspects of one's task that create stress, such as interruptions, monotony, or feeling like there is too much to do in too little time.

3. Role stressors – Stressful aspects associated with one's role, including role conflict, role ambiguity, and role overload.

4. Social stressors – Interpersonal aspects that cause stress, such as conflicts with one's boss, bullying, and sexual harassment from a co-worker.

5. Work schedule-related stressors – Aspects about one's work time arrangement that create stress, such as shift work and working overtime.

6. Career-related stressors – Stress-inducing aspects related to one's livelihood, including layoffs, unemployment, and lack of career opportunities.

7. Traumatic events – Major incidents that cause stress, such as exposure to danger, natural disasters, and workplace homicide.

8. Stressful change process – Stressors resulting from huge changes, such as mergers and acquisitions or the widespread implementation of new technology.

As the stimulus-based model believes that the average amount of effort needed to overcome an event indicates a suitable index of the severity of stressor. However, antagonists of this model claim that individual differences among various individuals are neglected and yet, individual differences can lead to different perceptions of the same event (Santorious, Polansky, Rutter, & Holland, 2013; Schwarzer, 2010).

In a Response-based model, stress is postulated as a response with the focus on the manifestation of stress. Also, stress is treated as a dependent variable (Cox, 1978; Cox & Mackay, 1981; Sutherland & Cooper, 2000). The concept of stress as a response was first introduced by Selye (1956) where he defined stress as a basic reaction of a person to any demand or pressure. Seyle was not interested in the nature of the stressor but he was interested in the physiological response and the progression of diseases. He further developed this idea into the

General Adaptation Syndrome (GAS) theory where he proposed that different types of stimuli would result in similar responses as shown below (Cox & Mackay, 1981; Sutherland & Cooper, 2000; Papathanasiou et al., 2015).

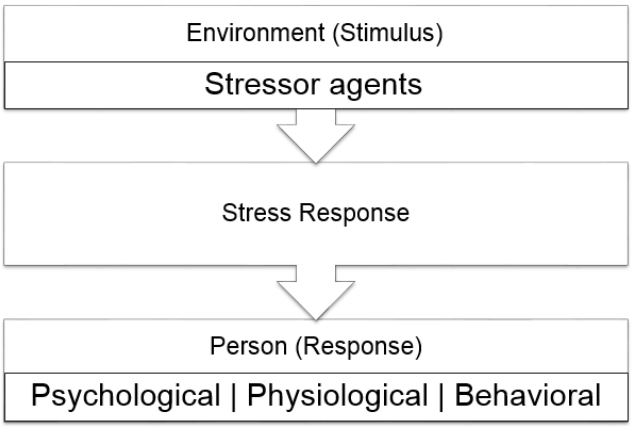

Figure 2: A response model of stress. The figure shows that in the response model the stress is considered as the dependent variable and the main focus is shifted to its manifestation. Retrieved from (Sutherland & Cooper, 2000). Used with permission.

Hans Selye, an endocrinologist, also known as the father of stress research, learnt that a wide range of stimuli like exposure to extreme temperatures, physical injury, and injection of toxic substances resulted in tissue damage in laboratory rats (Schell, 1997; Wainwright & Calnan, 2002). Selye found the rats' cortex of the adrenal gland became enlarged, their thymus and lymphatic structures became involute and deep-bleeding ulcers developed in the stomach and intestines. Hence, Selye called this non-specific response to these harmful stimuli the General Adaptation Syndrome (GAS).

On the same side of the coin, Sir William Osler in 1910 discovered a relationship between angina pectoris, a form of heart disease and a frantic pace of life (Cartwright & Cooper, 1997). Cannon in the early 1900s described an emergency response of an individual when he or she was confronted with a threat or danger. This response prepares the individual to respond to a

peril either by facing it or by eluding it. This response has become known as the "fight" or "flight" response (Quick, Quick, Nelson, & Hurrell, 1997; Wainwright & Calnan, 2002).

According to Cotton (1990), the fight and flight response involves the provocation of the autonomic nervous system (ANS), which is associated with the emission of adrenaline by the adrenal glands. The sympathetic aspect of the ANS mobilizes a number of reactions throughout the body as shown in Table 1 below.

Organ	**Effect**
Eye	Pupil dilates; ciliary's muscle relaxes
Glands – including • Nasal • Lacrimal • Parathyroid • Submaxillary • Gastric • Pancreatic	Vasoconstriction and slight secretion
Sweat glands	Copious sweating
Heart muscle	Increased rate, increased force of contraction
Lungs: Bronchi Blood vessels	 Dilated Mildly constricted Decreased peristalsis and tone in lumen
Gut	Increased sphincter tone
Liver	Glucose released
Kidney	Decreased output

Blood	Coagulation increased, glucose increased
Basal metabolism	Increased up to 100%
Adrenal cortical secretion	Increased
Skeletal muscle	Increased Strength
Piloerector muscles	Excited

Table 1: Examples of the effects of the autonomic (sympathetic) arousal on organs. Note: The table describes the effects that are generated by the autonomic (sympathetic) arousal on the different organs. Retrieved from (Cotton, 1990).

Murphy (1996) also advocates that when an individual deals with danger, the fight and flight response will take account of "elevated heart rate and blood pressure, a redistribution of blood flow to the major muscle groups and the brain and away from the distal parts, and a decrease in vegetative functions". Hence, Selye creatively incorporated some of Cannon's ideas into his physiological model of GAS and he was more interested in what would happen to an individual if he or she could not cope with the stressor with a fight or a flight response (Cotton, 1990).

GAS has three phases, which are rooted on the hypothesis that the body has a normal level resilience to stress. In the first phase (The Alarm Reaction), there are two sub-phases of how the body deals with the stressor. The body will try resisting the stressor (Shock Stage) and will trigger an initial alarm before returning to its normal level (Counter Shock Stage). The first phase is also known as the fight or flight response that prepares the body for immediate action. This phase is activated when the individual is exposed to continuous or excessive stress (Schell, 1997; Cotton, 1990; Carson, Butcher, & Mineka, 2000; Seaward, 2015). During the shock stage, the body exhibits signs of distress such as loss of muscle tone, decreased body temperature and decreased blood pressure. During the Counter Shock Stage, the body is associated with the

release of adrenaline and noradrenaline as it ensures that energy is readily available. The pulse rate and blood pressure will rise with a corresponding increase in blood circulation throughout the body thereby stimulating the central nervous system (Schell, 1997).

In the second phase, if the body's resistance remains high, resistance will drop rapidly before the final phase of exhaustion. The second phase is not as intense as the first phase, but certain hormones are released which cause structural and chemical composition changes in the body (Seaward, 2015). According to Schell (1997), there will be an increase in cortisol secretion with concomitant heightened metabolism, increased muscle strength, decreased swelling and inflammation and decreased immunity. Although this phase encourages an individual to cope and to adapt, yet, the capacity for him or her to resist the stressors is limited. Resources in the body are depleted and the body's defense mechanisms will weaken if the stress is not removed. Schell further mentions that the resistance phase is involved with the development of psychosomatic disorders, gastric ulcers, hypertension, colitis, asthma, migraine headaches and arthritis in certain circumstances.

In the final phase, bodily systems will have been depleted due to prolonged resistance and the body becomes susceptible to diseases and death (Seaward, 2015). In other words, when the stressor is excessive and prolonged, the individual's adaptive resources are depleted. Prolonged high levels of cortisol start to have detrimental effects with the exhibition of psychological, physiological and behavioral maladaptation such as chronic depression, lowered resistance to infection and alcoholism. In most severe cases, death may occur (Schell, 1997). The General Adaption Syndrome (GAS) is shown in Figure 3.

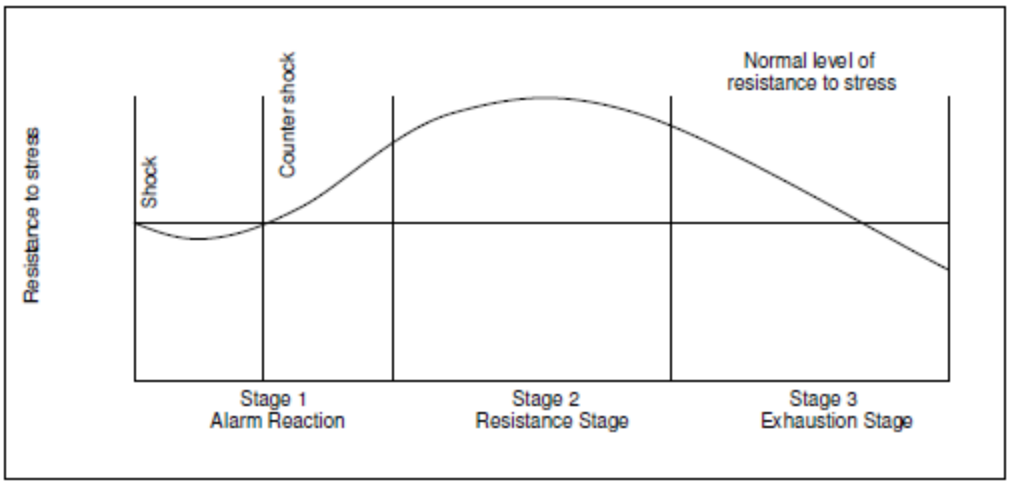

Figure 3: The General Adaptation Syndrome (GAS). The figure illustrates the resistance to stress on the different phases of the General Adaptation Syndrome. Retrieved from (Schell, 1997).

Selye's GAS has been criticized as having neglected the psychological impact of stress on the individual and the individual's capacity to recognize stress and to respond in ways that can change his or her situation (Cartwright & Cooper, 1997). Nevertheless, the response-based model with Selye's GAS has paved the way for modern physiological theories of stress (Halbern, Gallagher, & Kenny, 2014; Schwarzer & Schulz, 2003).

The third model is known as the transactional model of stress which takes into account the role of perceptual and cognitive characteristics, also known as the psychological model of stress. This model is essential in explaining individual differences with regard to their responses to stress (Cox & McKay, 1981). Two variations of the transactional model will be discussed, namely Lazarus's and Cox's models. A psychological model of stress is shown in Figure 4.

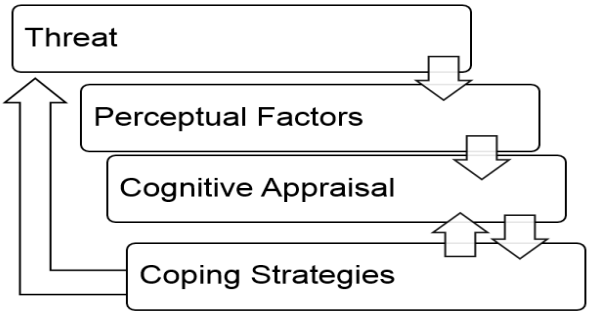

Figure 4: A psychological model of stress with the emphasis on perceptual and cognitive processes. The figure illustrates the cooperation of the threat, perceptual factors, cognitive appraisal and coping strategies in the psychological model. Retrieved from (Cox and Mackay, 1981).

Lazarus and Folkman (1984) criticize the other two models, stimulus model and response-based model as treating people like machines. Lazarus and Folkman believe that people have the capacity to think, evaluate and then react. They affirm that thinking can make stress either better or worse and later on described stress as "a particular relationship between a person and the environment that is appraised by the person as taxing or exceeding his or her resource and endangering his or her well-being" (Lazarus & Folkman, 1984, p. 19). In other words, according to Glanz, Rimer, and Viswanath (2015), if an individual views the situation as stressful, it is due to his or her cognitive appraisal of the environment and Lazarus' transactional model of stress is based upon the observation that people can appraise the same event differently.

Lazarus and Folkman (1984) have identified three kinds of cognitive appraisal: primary, secondary and reappraisal where primary appraisal consists of the judgment that an encounter is irrelevant, benign-positive, or stressful. Secondary appraisal refers to a judgment concerning what might and can be done. Reappraisal is when the appraisal is changed based on new information from the environment and/or from the individual. Hence, stress is viewed as a process between the individual and his or her environment in which threat and coping play a

role. Questions an individual may ask are "What choices do I have?", "Can I implement a particular option?" and "Will it work?" (Wainwright & Calnan, 2002, p. 61). Because of this, we can also understand from Omdahl (2014) that Lazarus has developed an interaction theory where the primary appraisal process determines whether the event represents a threat to a person. The person would then perceive the event as either irrelevant, positive to well-being or negative to well-being. If it is a negative appraisal, it will lead to a secondary appraisal process where the person will assess his or her coping resources which include environmental factors, social support, help, knowledge or skills to reduce the threat. Furthermore, appraisals of potentially stressful events are influenced by the controllability of events or the predictability of events. Events that are uncontrollable or unpredictable will be more stressful to the person. The process of appraisal explains why some individuals are able to cope or even thrive under stressful conditions while others won't. Recently, the European Agency for Safety and Health at work has adopted this view in its definition: "Work-related stress occurs when the demands of the job exceed a worker's ability to cope with them. It is one of the most important outcomes of a poor psychosocial work environment — not least because workers experiencing prolonged stress at work may go on to suffer serious mental and physical health problems" (EU-OSHA, 2013, p. 4). Furthermore, the risk of workplace stress is increased by disproportionate demands that is beyond an employee's ability to cope with, low support from management and co-workers, poor social support, psychological or sexual harassment such as "victimising, humiliating, undermining or threatening behaviour of supervisors or colleagues towards an employee or [a] group of employees", unfair treatment in the form of "distribution of work, rewards, promotions or career opportunities", ineffective communication, poor setting of boundaries between work and non-work commitments, etc.(EU-OSHA, 2013, p. 5).

Cox and MacKay's transactional model of stress puts forward another important psychological aspect of stress where they define stress as an individual phenomenon based on the "result of a transaction between the person and his [or her] situation" and transaction is the emphasis on "the active and adaptive nature of the process" (Cox & McKay, 1981, p. 101) . Hence, stress is "part of a complex and dynamic system of transactions between the person and his [or her] environment (Cox, 1978, p. 18). We learn from Cox and MacKay's model that it includes both response-based and stimulus-based aspect of stress and that stress is "an individual perceptual phenomenon rooted in psychological processes" (Cox, 1978, p. 18). Another emphasis of this model is the cyclical feedback aspect of the system that is non-linear with five stages.

Cox (1978) describes the first stage as representing "the sources of demand relating to the Person" and it forms part of the individual's environment (p. 19). These demands are either external, derived from the environment, or internal in the form of psychological and physiological needs, the fulfilment of which determines the individual's behavior. The second stage consists of the individual's perception of the demands and his or her ability to cope with the demands. Cox states that "stress may be said to arise when there is an imbalance between the perceived demand and the person's perception of his capability to meet the demand" (p. 18). It is important to realize that the important balance or imbalance is between the perceived demand and the individual's perceived capability and not necessarily between the demand and the individual's actual capability. The individual's cognitive appraisal of the potentially stressful situation and his or her capability to cope is important here. When a high demand is made on an individual, he or she will not experience stress until he or she has reached his or her limitations. At this point, the individual realizes that he or she cannot cope anymore and then experiences

stress due to the recognition of his or her limitations and the imbalance between the demand and capability. This imbalance will be experienced on a subjective or emotional level, coupled with changes on the physiological level with cognitive and behavioral attempts to "reduce the stressful nature of the demand" (p. 20). The third stage is associated with the psychophysiological stages, which correspond to the response to stress. Cox feels that "these responses are sometimes thought of as the end point of the stress process" and "should be regarded as methods of coping available to the person" (p. 20). The fourth stage which Cox feels is frequently ignored and is "concerned with the consequences of the coping responses", whether actual or perceived (p. 20). The fifth and last stage of the model revolves around feedback and is found to occur at all of the other stages determining the outcome at each of the stages. Hence, Cox states that "inappropriate and ineffective response strategies will invariably prolong or even increase the experience of stress" (p. 20). In other words, if inappropriate coping occurs at this point it can result in further physiological and psychological damage. This model, according to Cox, "treats stress as an intervening variable, the reflection of a transaction between the person and his environment" and "it is part of a dynamic cybernetic system" (p. 20). The transactional model of stress described by Cox and Mackay (1978) can be summarized as follows:

1. The situation starts with a demand for action of some kind.
2. The person perceives (accurately or not) this demand.
3. The person has the capability to meet the demand.
4. The person perceives (accurately or not) his or her capability.
5. The person cognitively appraises the match between the perceived demand and the perceived capability.
6. Any perceived imbalance in the lack of capability to meet the demand is felt as stress.

7. The person experiences an emotional response to this.

8. There is also a stress response.

9. There is a felt physiological response.

10. There is also a psychological stress response.

11. The psychological response includes a behavioral response, which feeds back into the original demand and cognitive appraisal.

12. The psychological response also includes a cognitive defense, which feeds back into the cognitive appraisal.

Modern Psychophysiological Theories of Stress and the Risk of Disease

Historical definitions of stress have paved the way for a working definition of stress. A working definition of stress states that stress is the relationship between a person and his or her environment that is appraised, or assessed, to be overwhelming and exceeding his or her resources, thus leading to a potential harm or loss (Lazarus & Folkman, 1984). Additionally, the concept of *Perceived Stress*, is the cognitive appraisal of events or circumstances that an individual interprets as stressful or harmful (Folkman, Lazarus, Gruen, & Delongis, 1986).

In 1950, Selye renamed the three phases of GAS as the "biological stress response" and it was the turning point for the integration of "stress" and "physiology" (Selye, 1950). Selye continued to improvise his physiological stress response model and consequently defined stress as "the non-specific adaptive response of the body to any demand made upon it" (Selye, 1976; Selye, 1973, p. 692). Furthermore, Selye refined his stress concept to distinguish between "stress" and "stressor" where the former is the "response to the stressor", while the latter is "stress-producing factors". A stressor is constituted by a variety of factors that affect one's perception and interpretation of the situation, which varies according to individual differences

such as genetics, gender and developmental stage (McEwen & Stellar, 1993). Despite the differing factors between individuals, Selye noticed that the response to the stressor or the physiological stress response was quite analogous across individuals regardless of the type of stressors one experienced. Selye stated that "The problems [people] face are totally different, but medical research has shown that in many respects their bodies respond in a stereotyped manner with identical biochemical changes, meant fundamentally to cope with any type of increased demand upon the human machinery. The stress-producing factors technically called stressors are different, and yet they all produce essentially the same [physiologic] stress response. This distinction between stressor and stress was perhaps the first important step in the scientific analysis of that most common [physiologic] phenomenon that we all know only too well from personal experience." (Selye, 1973, p. 692). In other words, post-Selye researchers can now study the physiological stress response in an integrated and systematic manner and examine how and when the physiological stress response fails or responds inadequately as well as what the effects are on the human body which can be accountable for the precipitation of a disease (Reading, 2015).

Hence, beyond historical views of stress, modern psychophysiological theories of stress agree that positive stress increases and exercises the mental and physical capacity of a person, but negative stress would cause a functional decline and will induce symptoms of distress leading to diseases (Lindholm, 2013). There are mainly three modern psychophysiological theories linking stress and the risk of diseases: the Cognitive Activation Theory of Stress (CATS), the Allostatic Load Theory of Stress (ALTS) and the Resilience Theory of Stress (RTS).

Cognitive Activation Theory of Stress (CATS)

According to Fritz and Crain (2016), CATS is a psychobiological theory where cognitive evaluations of situations and consequences will determine the physiological and psychological consequences of stress. In other words, the psychobiological consequences of cognitive activities can be explained by increases in brain activation known as "arousal – wakefulness", and the psychological and physiological associations of arousal. CATS postulate the activation or arousal requirement for detecting and controlling stressors, which is associated with increased strain over time if a person does not readily have chances for rest and recovery. Hence, inadequate recovery from stressors may trigger the development of a chronic strain due to prolonged episodes of activation (Fritz & Crain, 2016).

Meurs and Perrewe (2011) describe the stress response to stressors as being conceptualized as a generic alarm in a homeostatic system, producing general and unspecific neurophysiological activation from one level of arousal to a higher level of arousal. An example provided by Meurs and Perrewe is that of a person when facing a potentially dangerous situation or dealing with a small or a big problem, the alarm or stress response is meant to be healthy and necessary for performance, whenever a person sees a discrepancy between what is desired and what is reality. Interestingly, the person will associate a possibility for alarm removal and the stimulus. In other words, if a person has control and expects a desired outcome, the arousal is minimal, the alarm will not be activated and stressors will not be felt psychologically or physiologically (Meurs & Perrewe, 2011). However, there are circumstances when the arousal level becomes too high for adequate performance, and examples include lack of rest under prolonged activity or being overwhelmed with information (Fritz & Crain, 2016). Fritz and Crain further postulate that cognitive activation may lead to pathology through well-established

pathophysiological mechanisms. Moreover, cognitive activation is associated with problem solving, rumination and worrying about work or non-work related that inhibits employees from entering a calm mental state that is essential for falling asleep, staying asleep and perceiving an acceptable level of sleep. Hence, CATS suggests that reducing the mental activity is vital for rest and recovery (Fritz & Crain, 2016). On the same side of the coin, Lindholm (2013) states that vigilance is increased and bodily functions like the circulatory system is activated whenever a person experiences a prolonged cognitive activation, also known as the fight or flight response. If a person experiences a threat or lacking basic needs, homeostasis is disturbed and reactions against the functional ability maintenance occurs. Physiological effects such as the increase of heart rate, blood pressure, muscle tension and alertness occur. From a workplace stress perspective, prolonged fight or flight responses at work is activated by acute high workloads and repeated demands of work which typically leads to muscle pain, tiredness and mood changes. The problem is that there are no specific indicators between appropriate and inappropriate adaptation to workplace stress. Absence from work may take place. Furthermore, Lindholm proposes that "psychobiological sensitization within neural loops maintained by sustained activation predisposes to chronic diseases. The autonomic nervous system (ANS) and hypothalamic-pituitary-adrenal (HPA) axis are important pathways leading to positive adaptations, but can also cause negative health consequences" (Lindholm, 2013, p. 20).

Similarly, the current literature has also established the ANS and the HPA pathway (see Figure 5), as part of the neuroendocrine system, are main contributors of the body's interpretation of stressors and the physiologic responses to the stressor. The ANS and the HPA pathway play major roles in promoting physiologic adaption, or allostasis, but problems arise when these pathways are overactive or underactive (McEwen, 1998). The first physiologic

mechanism that is activated during the stress response is the ANS. Biomarkers of the ANS stress response include heart rate, blood pressure, and Heart Rate Variability (HRV) changes (Rice, 2012; McCorry, 2007).

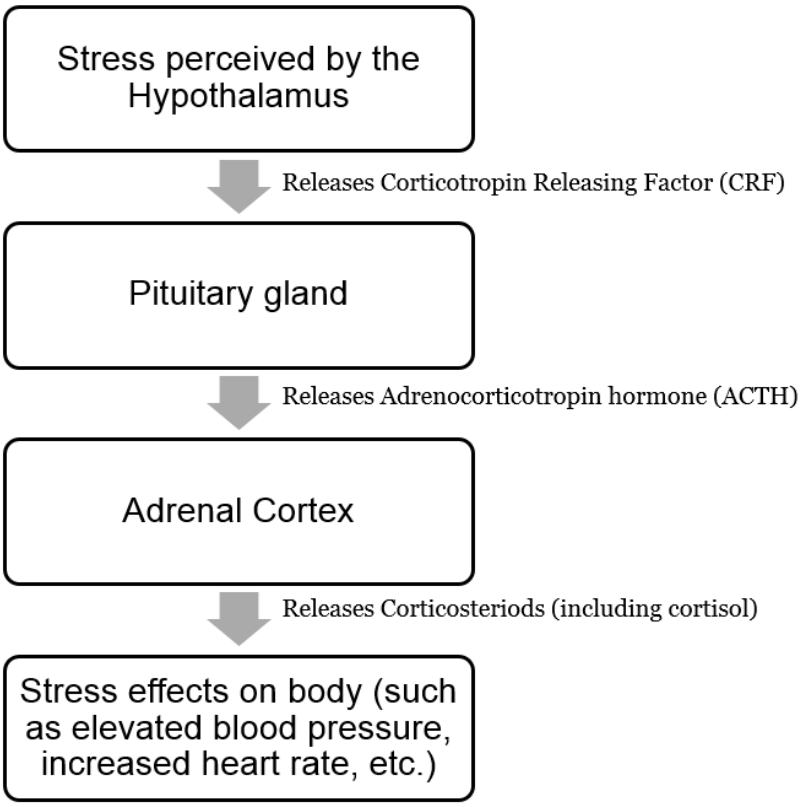

Figure 5. Diagram of Hypothalamic-Pituitary-Adrenal (HPA) Stress Axis. The figure illustrates the mechanism of the influence of stress on the human organism through Hypothalamus, Pituitary gland and Adrenal Cortex and the respective releasing of hormones and factors by each of them. Retrieved from (McEwen, 1998). Used with permission.

Allostatic Load Theory of Stress (ALTS)

Having a prior understanding of the term “allostasis” will help one to understand what ALTS is. Sterling and Eyer (1988) developed the concept of “allostasis” which literally means “maintaining stability (or homeostasis) through change" to describe how the cardiovascular system adjusts to resting and active states of the body and has been used to describe how the physiological factors of the human body co-vary at the same time whenever there is any modification of behavioral or psychological state of an individual. With the intention of sustaining a healthy functioning of an individual, Seeman, Singer, Rowe, Horwitz, and McEwen (1997) put forward the claim that “Allostasis emphasizes the constant dynamism of internal physiologic systems, stressing that healthy functioning requires ongoing adjustments of the internal physiologic milieu, with physiologic systems exhibiting fluctuating levels of activity as they respond and adapt to environmental demands. This dynamic conceptualization of internal physiologic regulation contrasts with the earlier concept of homeostasis, which had a more static view of optimal functioning emphasizing the importance of maintaining constancy of the "milieu intérieur" as a hallmark of healthy functioning.” (p. 2263). It is worth noting that both terms, allostasis and homeostasis have their usages in human physiology, with allostasis being an indispensable component of the body to be capable of maintaining homeostasis. Hence, allostasis is a more suitable term to describe an individual’s physiological systems such as the cardiovascular system, the immune system, the autonomic and central nervous system and even the metabolic machinery which require operating within a set range in order to sustain healthy functioning (McEwen, 1998). To put it simply, when the body is under stress or has to meet a challenge of any kind, allostasis coordinates all the internal functions to bring the body back to homeostasis. Consequently, there are two possibilities in which the allostatic load occurs:

Firstly, the inability and failure of these systems to turn-on or shut-off the response function and operate within their normal ranges over a prolonged period of time. Secondly, after extreme wear and tear that the body experiences due to repeated cycles of the body attempting to maintain allostasis. Moreover, ALT has been hypothesized as a mechanism leading people to disease (McEwen & Stellar, 1993; McEwen, 1998).

To exemplify this better, McEwen in a review paper published in 1998 in the New England Journal of Medicine titled "Protective and Damaging Effects of Stress Mediators" provided the following illustration that demonstrates how "stressors" and "perceived stress" interact to the concepts of "allostasis" and "allostatic load" as shown in Figure 6 below (McEwen, 1998). In the illustration, concepts of allostasis and allostatic load are described as "a cascade of cause and effect that begins with the primary stress mediators leading to primary effects and then to secondary and tertiary outcomes" (McEwen & Seeman, 2009, para. 6). The primary stress mediators of allostasis include "adrenal steroids and catecholamines..but also

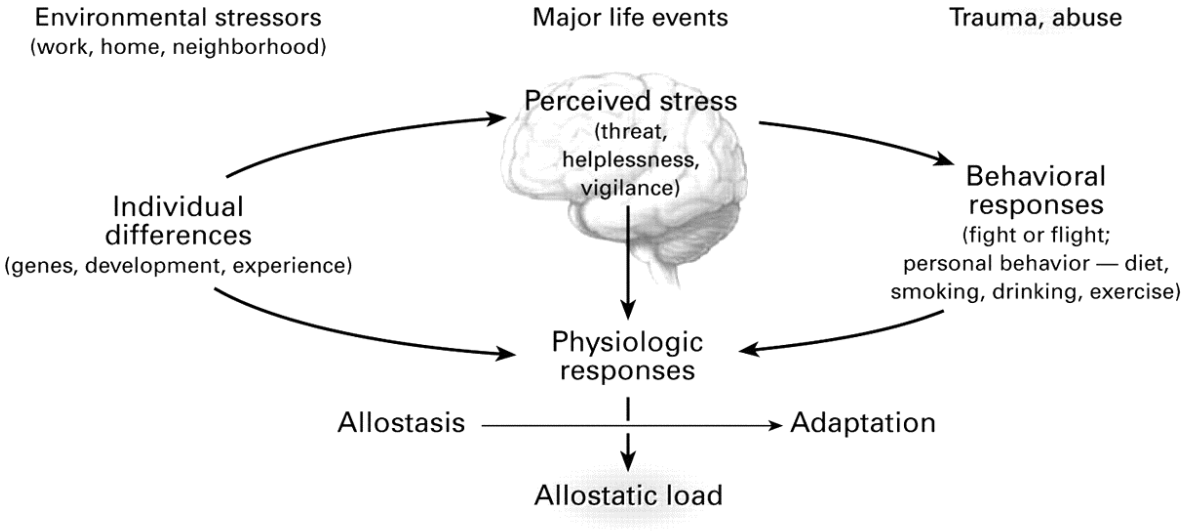

Figure 6: The Stress Response and Development of the Allostatic Load. The figure illustrates how the allostatic load is developed under the influence of physiologic responses, whose mechanism is explained by the perceived stress, individual differences, behavioral responses. Retrieved from (McEwen, 1998). Used with permission.

other hormones like DHEA, prolactin, growth hormones and the cytokines related to the immune system, as well as local tissue mediators like the excitatory amino acids" (McEwen & Seeman, 2009, para. 10). This further leads to the "primary effects [such as] cellular events, like enzymes, receptors, ion channels or structural proteins induced genomically or phosphorylated via second messenger systems, that are regulated as part of allostasis by the primary mediators" (McEwen & Seeman, 2009, para. 24). Secondary outcomes include the "integrated processes that reflect the cumulative outcome of the primary effects in a tissue/organ specific manner in response to the primary mediators, often reflecting the actions of more than one primary mediator, including the ones described above as well as others not yet measured" (McEwen & Seeman, 2009, para. 27). Consequently, the tertiary outcomes "are the actual diseases or disorders which are the result of the allostatic load that is predicted from the extreme values of the secondary outcomes and of the primary mediators" (McEwen & Seeman, 2009, para. 30). McEwen and Stellar (1993) also proposed allostatic load to represent "the cost of chronic exposure to fluctuating or heightened neural or neuroendocrine response resulting from repeated or chronic environmental challenge that an individual reacts to as being particularly stressful" (p. 2093) and "can accumulate, and the overexposure to neural, endocrine, and immune stress mediators can have adverse effects on various organ systems, leading to disease" (McEwen & Seeman, 2009, para. 6).

McEwen (1998) also emphasized four proposed conditions that can lead to an experience of allostatic load (see Figure 7). In the first condition, it involves any individual who is frequently exposed to new stressors. Although the individual experiences a normal stress response, he or she is experiencing more frequently than he or she should ("repeated hits"), hence, he or she wears out his or her physiological systems faster than someone who is

experiencing less frequent new stressors. In the second condition, it shows the inability of the physiological system(s) to terminate the stress response after being aroused by the stressor ("prolonged response"). The individual experiences an abnormal stress response such that when his or her stress response is aroused by the stressor, it fails to turn off as swiftly as it should. As for the third condition, the individual experiences insufficient adaptation to the stressors of the same type ("lack of adaptation"). Similarly, the pattern of physiological reactivity here is similar to the pattern of those who are exposed to frequent new stressors as in the first condition. The difference in this case is that the stressor in the third condition is not new. However, instead of slowing any adaptation such as learning to deal with the stressor, he or she repeatedly exhibit strong stress response despite being repeatedly exposed to the same stressor. The final condition is an ("inadequate response") by the allostatic system. Since the human body is one huge system that encompasses a multiple of subsystems that sustain the bigger system, any individual that displays an insufficient stress response may experience allostatic load as the failure to support an initial sufficient stress response which consequently leads to a torrent of inadequate responses of other interconnected regulatory systems. If the individual in all four conditions experiences allostatic load, he or she will then experience the "wear and tear that results from chronic overactivity or underactivity of allostatic systems" (p. 171). This experience will worsen the individual's immune system, the cardiovascular system, the metabolic system, the brain and the central nervous system, causing him or her to experience further aversive lifestyle that is linked to physiological system failure. Hence, having a higher level of allostatic load correlates to a higher possibility of one's susceptibility to disease and disability. Furthermore, McEwen and Stellar (1993) describe how allostatic overload results in permanent tissue damage, changes in peripheral tissues, altering cerebral cortex functioning, deteriorating dendrites on neurons,

suppressing the creation and proliferation of new neurons and permanent loss of pyramidal neurons.

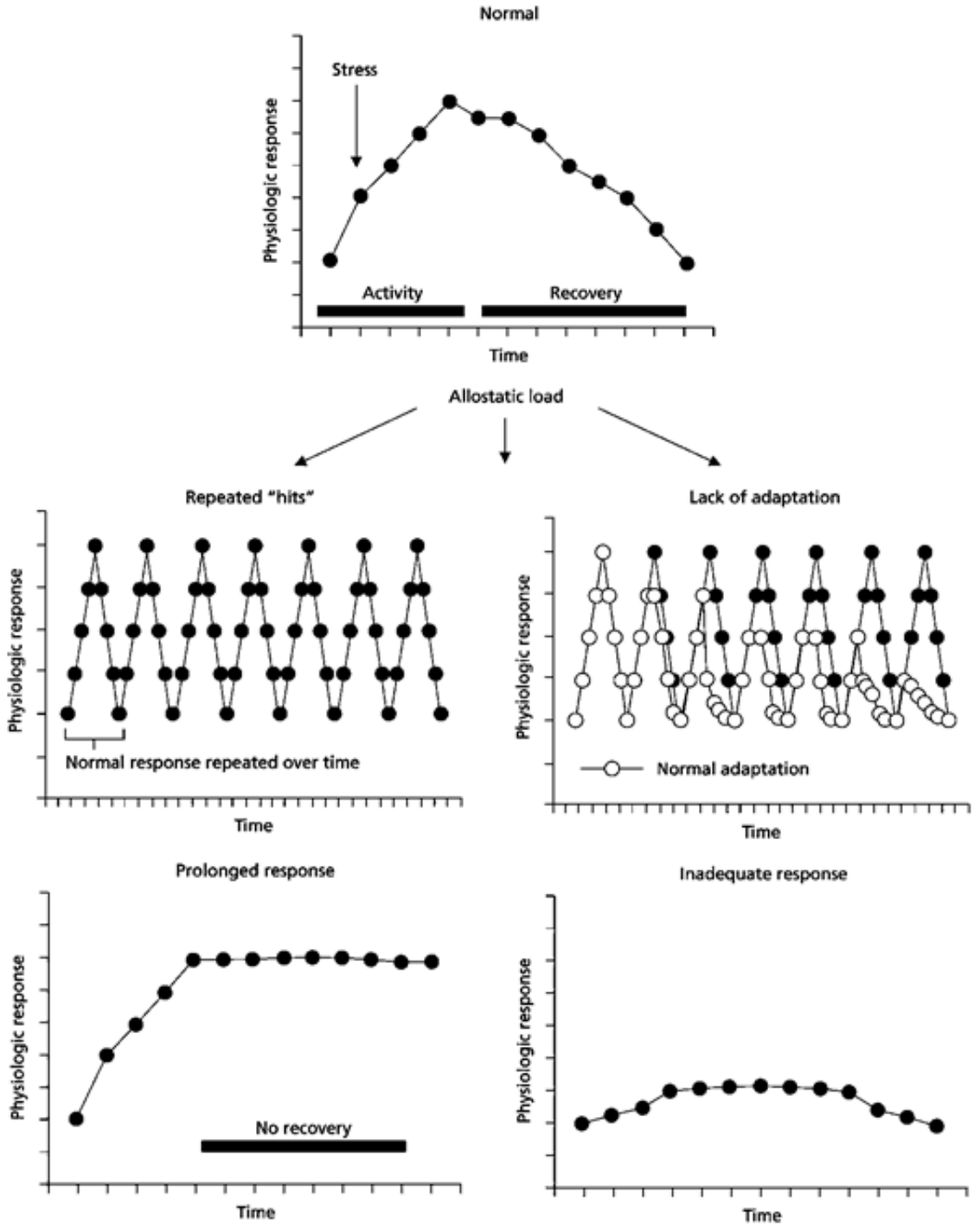

Figure 7: Four Conditions Leading to the Allostatic Load. The figure illustrates that such conditions as the repeated hits, lack of adaptation, prolonged response and inadequate response will lead to the allostatic load. Retrieved from (McEwen, 1998). Used with permission.

McEwen (2003) also refers to the allostatic load as the price one must pay to accommodate stress and as the cost of adaptation. From this perspective, long-lasting pathology can result when hormones like adrenalin and glucocorticoids or cell-signaling proteins are persistently elevated, or when minor stressors accumulate (McEwen, 1998). The allostatic load can accrue from psychological pressures when we try to juggle too many requirements, meet too many deadlines, solve intractable problems, or suffer from psychological abuse.

We can also learn from Lindholm (2013) that whenever the body experiences stress, the ALTS postulates that organisms within the body change themselves to bring the body back into adaptation. Physiological mechanisms regulate the stress by either increasing or decreasing activities. Continuous adaptation is therefore known as the "allostatic load". The repeated taxing of the homeostatic mechanisms from CATS challenges the allostatic load. Workplace stress may play a significant role in the allostatic burden where "physiological mechanisms are sensitized or exhausted by reaction to the load and the symptoms are experienced as harmful" (p. 20). Moreover, the ALTS "emphasizes the significance of hormonal regulators, especially glucocorticoids and catecholamines, and the brain in protecting any harmful effects of stress. [ALTS] is useful when assessing the health effects of chronic stress. [ALTS] is expressed in terms of neuroendocrine immune, metabolic and cardiovascular system functioning. [ALTS] has been used in many studies to evaluate mental stress in the development of cognitive disorders, diabetes, cardiovascular diseases and depression" (p. 20). Edna Foa and her colleagues have shown that brief exposure to moderate stress can be protective, restoring homeostasis so that the body can recover. Moreover, exposure to moderate stress alleviates symptoms associated with anxiety disorders in humans (Foa, 2011; Foa & Kozak, 1986). On the contrary, chronic stress challenges the internal systems that are important to maintain homeostatic balance and may

cause irreversible physiological and psychological damage (McEwen, 2012; Sterling & Eyer, 1988). Furthermore, research has shown that chronic stress and anxiety disorders, including post-traumatic stress disorder (PTSD) indicate similar processes in their etiology (Foa, 2011). When stressors are persistent, the coping mechanism may break down and become modified as the organisms within the body strive to adapt (Cabib, Campus, & Colelli, 2012).

Stressful events are either predictable or unpredictable due to past learning and their predictability affects the extent to which the stressful events are experienced as stressful (Atlas & Wager, 2013). When an event is relatively stable and predictable, normal regulatory processes in the body will maintain stability through homeostatic mechanisms (Ramsay & Woods, 2014). Otherwise, when an event is unpredictable, the body may perceive it as potentially harmful or overwhelming and stressful, which requires a surplus of energy or vigilance. When this happens, psychological and physiological systems are more aroused and extra resources are required (McEwen & Wingfield, 2010). A laboratory experiment conducted on rats by Laudenslager, Ryan, Drugan, Hyson, and Maier (1983) reveals that unpredictable shock causes immune suppression while avoidable shock does not. Hence, predictability via a sense of control and feedback allows an organism to reduce its level of arousal, while the rate of the required response, when made very high, overrides the factors (Levine & Wiener, 2016).

In reviewing the psycho-pathological effects of the allostatic load throughout one's life span, Juster et al. (2011) propose that the allostatic load theory "goes beyond traditional stress–disease theories toward the advancement of person-centered research and practice that promote not only physical health but also mental health" (p. 725). Lovallo (2015) describes ALTS as the pathophysiology of an overworked ANS and HPA pathway. During the allostatic load, the ANS and/or the HPA pathway may fail to turn off or fail to respond during a stressful experience,

which leads to other body systems overreacting and over-secreting hormones and neurotransmitters such as cortisol (Lovallo, 2015, McEwen, 1998). Cortisol, known as the stress hormone, is released when an event is seen as stressful or is potentially harmful to one's well-being. Cortisol is beneficent as it helps to mobilize the energy for a person to cope with the stressors. However, prolonged or excessive cortisol production leads to a reduced immune response, cancers and premature aging amongst other negative health outcomes (Aschbacher et al., 2013).

Lindfors, Lundberg, and Lundberg (2006) in their research study found that middle-aged women tend to have cognitive and physical impairment among those with a high allostatic load. Moreover, research from MacArthur Studies of Successful Aging have revealed that higher allostatic load scores, independent of sociodemographic and other health status risk factors, are associated with poorer cognitive and physical functioning, together with an increased risk of cardiovascular disease in a group of older men and women (Seeman et al., 1997; Seeman, McEwen, Rowe, and Burton, 2001; Karlamangla, Singer, and Seeman, 2002).

Chen, Redline, Shields, Williams, and Williams (2014) carried out a study using data from the National Health and Nutrition Examination Survey (NHANES) and discovered that high allostatic load scores were significantly associated with sleep apnea, sleep apnea symptoms, insomnia component, short sleep duration, and diagnosed sleep disorder among US adults. Comparable findings can also be found among high-risk subgroups such as chronic fatigue syndrome patients where a high level of the allostatic load was significantly associated with overall deteriorating health, increased bodily pain, poorer physical functioning and greater general symptom frequency and intensity (Maloney et al., 2006; Goertzel et al., 2006).

Mattei, Demissie, Falcon, Ordovas, and Tucker (2010), from the Boston Puerto Rican Health Study found that increasing categories of allostatic load scores were significantly associated with increased odds of abdominal obesity, hypertension, diabetes and self-reported cardiovascular disease and arthritis among a minority group of Puerto Ricans living in the United States. Moreover, Parente, Hale, and Palermo (2013) found that having a history of breast cancer was associated with an elevated allostatic load among black women when compared with white women.

Among children, Johnston-Brooks, Lewis, Evans, and Whalen (1998) have identified comparable findings with the allostatic load as an underlying mechanism in the link between chronic stress and health in children. Other researches show that young women who have higher allostatic load indexes have earlier menarche, which may indicate a sign of increased personal stress among those women (Allsworth, Weitzen, & Boardman, 2005). Bahreinian et al. (2013) found that a high allostatic load amongst boys was associated with an increased likelihood of prevalent and new-onset asthma.

We can therefore see that there is an extensive list of negative health outcomes that are associated with high levels of allostatic load. Furthermore, if the components of the allostatic load are examined, any failure of one or more of the human physiological systems to operate within their set ranges, numerous adverse health events can occur. For instance, chronic activity or inactivity of the cardiovascular system can lead to hypertension, incident strokes and myocardial infarctions (Seeman, Epel, Gruenewald, Karlamangla, & McEwen, 2010). A failure of the metabolic system can lead to obesity, diabetes and atherosclerosis. A breakdown of the immune system can lead to inflammatory and autoimmune disorders, while inadequate functioning of the brain and the central nervous system can lead to neuronal atrophy and death of

nerve cells. Although the researches have revealed that a high allostatic load is associated with negative health outcomes, we also learn from Karlamangla, Singer, and Seeman (2006) that reductions in allostatic load levels are associated with a reduced mortality risk.

To conceptualize better, Mauss, Li, Schmidt, Angerer, and Jarczok (2015) provide a summary of the stress-regulating process from a homeostasis to an allostatic overload in Figure 8 as shown below. Recent research indicates that the primary effects and pathophysiological processes on mitochondrial level could potentially be measured. Similarly, Read and Grundy (2012) provide the three stages of stress mediation in Figure 9 to show that specific biomarkers

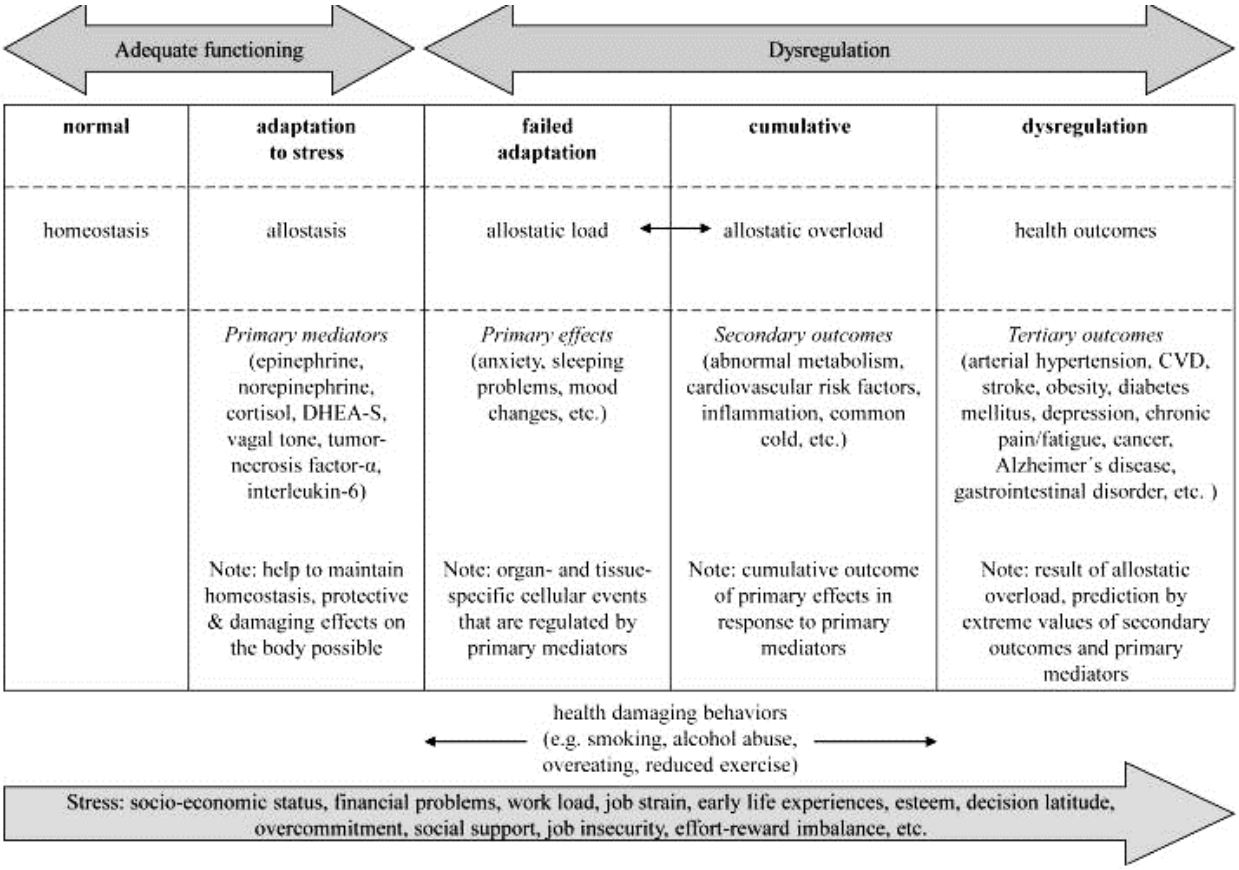

Figure 8: Stress-regulating process from homeostasis to allostatic overload (DHEA-S: Dihydroepiandrosterone sulfate, CVD: cardiovascular disease). The figure illustrates the consequences of each stage of the process for the human body. Retrieved from (Mauss et al., 2015). Used with permission.

can be used to measure the allostatic load. At this stage, it is still unclear regarding the best combination of biomarkers that can be used to measure the allostatic load, and discussions on deriving the composite score of the overall allostatic load index will not be discussed here.

Where the Allostatic Load Index is concerned, Mauss, Jarczok, and Fischer had carried out two research studies in 2015 and 2016 to confirm that there was a positive association between the Allostatic Load Index and the workplace stress of German Industrial employees. They designed the Allostatic Load Index as a composite of five variables (diastolic blood pressure, glycosylated hemoglobin, low-density lipoprotein, waist circumference and heart rate variability (HRV)) which were used to assess the biological wear and tear of workplace employees exposed to workplace stress. They postulated that the Allostatic Load Index of these five variables could be used as an indicator for stress in an organizational setting (Mauss, Jarczok, & Fischer, 2015; Mauss, Jarczok, & Fischer, 2016). Mauss et al. affirm that a high Allostatic Load Index is positively linked to various adversarial health conditions such as cardiovascular diseases and impaired mental health. Hence, HRV is an important biomarker (primary mediator of neurophysiologic pathway) that can be used to measure stress.

Therefore, it is worth noting that vagal activity measured by heart rate variability (HRV), as a biomarker, may be an easily assessable and accessible primary mediator (Jarczok et al., 2013; Thayer & Sternberg, 2006; Weber et al., 2010; Fischer & Thayer, 2006; McCaffery et al., 2012; Mauss, Jarczok, & Fischer, 2015; Mauss et al., 2016), although some researchers claim that it has been defined as a cardiovascular secondary outcome and not as a primary mediator (Juster, Moskowitz, Lavoie, & D'Antono, 2013). Figure 10 shows the biomarkers used in calculating the Allostatic load Index in working populations and the use of Heart Rate Variability as a biomarker to measure the Neurophysiological type of Primary Mediators.

Stress mediation	System	Biomarker
Primary mediators	Neuroendocrine	Epinepherine, norepinephrerine, dopamine, cortisol, dehydroepiandrosterone (DHEAS), aldosterone
Secondary outcomes	Immune	Interleukin-6, tumor necrosis factor-alpha, c-reactive protein (CRP), insulin-like growth factor-1 (IGF-1)
	Metabolic	HDL and LDL cholesterole, triglycerides, glucosylated hemoglobin, glucose insulin, albumin, creatinine, homocysteine
	Cardiovascular and respiratory	Systolic blood pressure, diastolic blood pressure, peak expiratory flow, heart rate/pulse
	Anthropometric	Waist-to-hip ratio, body mass index (BMI)
⬇	⬇	⬇
Tertiary outcomes	Poor subjective health, disability, cognitive decline, cellular aging, diseases, death	

Figure 9: Stress mediation, systems, and biomarkers that are used to measure the Allostatic Load. The figure illustrates the human systems that are included in the stress mediation, as well as the biomarkers of each system that are activated in this process. Retrieved from (Read and Grundy, 2012).

Group	Type	Biomarker	Description	Threshold ranges reported
Primary mediators	Neuroendocrine	Cortisol (urine)	Adrenal glucocorticoid and indicator of HPA-axis activity	24.83–25.6 µg/g creatinine 60.0 µg/l 418.5 nmol/l
		Cortisol (saliva)		10.7 ng/ml 410.4–839.8 nmol/l
		DHEA-S (µg/dl)	Adrenal hormone and functional HPA-axis antagonist	13.3–51.5
		Epinephrine (urine)	Adrenal and brain catecholamine as neurotransmitter and indicator of sympathetic nervous system activity	4.75–9.0 nmol/l 5.55 µg/g creatinine
		Norepinephrine (urine)	Brain catecholamine as neurotransmitter and indicator of sympathetic nervous system activity	64.0 µg/g creatinine 173.0 nmol/l
	Neurophysiological	Heart rate variability (SDNN, standard deviation of beat-to-beat intervals) (ms)	Physiological phenomenon of variation in the time interval between heartbeats measured by the variation in beat-to-beat intervals	118
	Anti-inflammatory	TNF-α (pg/ml)	Cytokine affecting inflammation, tissue repair, immune defence, and lipid metabolism; increased in obesity	1.44–2.2

Figure 10: Biomarkers used in calculating the Allostatic Load Index in working populations and Heart Rate Variability is used as a biomarker to measure the Neurophysiological Type of Primary Mediators. The figure illustrates the threshold values of the biomarkers, which are used in the calculation of the Allostatic Load Index. Retrieved from (Jarczok et al., 2013). Used with permission.

A review of the literature has shown that up to now, there have been no serious attempts to develop interventions that can methodologically decrease the allostatic load in any population or high risk groups, let alone workplace employees. Moreover, there's no detection of an exhaustive set of the determinants of the allostatic load. Nevertheless, the potentially modifiable risk factors and workplace stressors as the perspective field for the investigation of the determinants of the allostatic load may be identified.

Resilience Theory of Stress (RTS)

Resilience is the ability of a person to reinvigorate beyond his or her workplace situation, acclimatize better than expected and continue to survive and thrive in his or her workplace (Wagnild & Young, 1993; Taylor & Reyes, 2012). Resilience is very much connected to ALT as according to RTS, the more adaptable a person is with any environmental change, the more he or she is able to maintain the allostatic load within a normal range without exhausting internal resources to an excessive degree. Whether a person is adaptable depends on a multi-faceted

sense of responsiveness in genetic conditions such as early life stress (Howell & Sanchez, 2011), aging (Bloss, Morrison, & McEwen, 2011), learning experiences (Cabib et al., 2012; Karatsoreos & McEwen, 2011) and drug use (George, Olivier, Le Moal, & Koob, 2012). On the contrary, whether the demand is greater than one's available resources may depend on the changeable factors such as ability, socioeconomic status, and social position. These variances affect energy outflow and the efficiency and effectiveness in meeting demand requirements (McEwen, 1998).

Contributions from Richardson, Neiger, Jensen, and Kumpfer (1990) and Richardson (2002) describe the resiliency process where it begins with a state of "biopsychospiritual homeostasis", or a "comfort zone", where a person is in balance physically, mentally and spiritually. Disruption from this homeostatic state happens if an individual has inadequate resources (i.e., protective factors) to safeguard himself or herself against adversities, life events or stressors. Once an individual experiences a homeostatic disruption, he or she will adjust and begin the reintegration process. This process leads to one of four outcomes: 1) Resilient Reintegration, where disruption leads to the attainment of additional protective factors and a new, higher level of homeostasis; 2) Homeostatic Reintegration, where disruption causes people to remain in their comfort zones, in an effort to "just get past" the disruption; 3) Reintegration with loss (where disruption leads to the loss of protective factors and a new, lower level of homeostasis); and 4) Dysfunctional Reintegration, where disruption leads to people resorting to destructive behaviors such as substance abuse.

Emotional Nature of Stress

According to the Merriam-Webster dictionary, the word "emotion" originates from the emovēre, denotes to move (Merriam-Webster, N.D.). Emotions are adaptive representations of

physiological arousal, cognitive processes, facial and bodily expressions, and specific behavioral responses that are crucial for survival and reproduction (Gerrig, 2013; Carlson & Birkett, 2017).

A literature search on emotions returns various perspectives on emotions. Frijda (1988) suggests that emotional responses are subjective experiences that entail elements of pleasure or pain. Conversely, Carlson & Birkett (2017) oppose that emotions are not subjective experiences but behaviors. Although both of them have differing definitions of emotions, they agree that emotions result from how an individual subjectively appraises in either positive or negative way toward their external environment (Frijda, 1988; Carlson & Birkett, 2017). Results from a recent study have been found consistent with appraisal theories. Emotions such as anxiety/fear and positive emotion are determined by the level of importance and self-confidence on examinations appraised by the students (Schmidt, Tinti, Levine, & Testa, 2010).

According to Carlson & Birkett (2017), an emotional condition such as fear, comprises of three components: Behavioral, Autonomic, and Hormonal. First, muscular movements are necessary for appropriate responses to a situation denotes the behavioral component. For instance, a mother runs towards her child when she saw a massive vehicle in the distance is approaching with no intention of stopping. Second, the activation of the sympathetic system provides a surge of energy by increasing the heart rate, glucose and blood flow for vital movements are the working of the autonomic component. Third, the autonomic responses are supported by the hormones component where it supplies steroid hormones from the adrenal cortex. Associating the autonomic system and emotions, the James-Lange theory suggests that emotion is derived from the feedback of autonomic arousal and skeletal actions. Studies have found to be consistent with this theory in which individuals with impairment in their autonomic

responses feel less emotional, and they tend to describe their emotions in the cognitive aspect (Kalat, 2007).

Karl Pribram Model: The Role of Familiarization

In Pribram's model, he postulates that memories or stable patterns of activity are formed and maintained in the neural architecture of the brain as we gain experience either internally through self-regulation or externally with the environment (Pribam & Melges, 1969). Stable patterns such as "breathing, eating, drinking, sleeping, alerting, sexual, and other behaviors" are evaluated, updated and modified as a person encounters new experiences and learn how a certain action leads to specific results (McCraty, 2003, p. 95). Internal and External inputs are compared to this stable pattern. If there's a mismatch between the input and the stable patterns, a person senses a feeling of "novelty". This stability becomes a reference point for current and future evaluation and it is the amygdala that determines what is familiar and what is not. Hence, when a person has a stable pattern of chaos or calmness, any mismatch from internal or external inputs will require the person to make intrinsic or extrinsic adjustments in order to remain in the familiar territory (McCraty, 2003).

Significance of the Afferent Feedback

Traditionally, researchers and scientists approach the study of communication pathways of differing emotions between brain and body from a rather one-sided perspective, with the focus to be primarily on the body responses to the brain's commands (McCraty, 2003). McCraty states the critical role is played by afferent neural signals that send feedback from the body to the brain. This afferent feedback from bodily organs affect overall brain activity and exert a measurable influence on cognitive, perceptual and emotional processes. McCraty further postulates that the heart sends more signals to the brain (afferent connections) than the brain to the heart (efferent

connections). In other words, the afferent input to the brain from the heart can either inhibit or facilitate cognitive ability which in turn affects one's perception and motor activity.

From the research of McCraty et al. (1998), the changing pattern of afferent information generated by the cardiovascular system significantly influences the perception and emotional experience.

Psychophysiological Perspective of Emotions

From the perspective of R. McCraty, the emotional nature of stress is the primary issue related to work stress (personal communication, November 20, 2017). Although stress research has been conventionally in favor of the cognitive processes that influence the perception of stress and how the body physiologically reacts to it, little emphasis has been given to the emotional system of the stress process (McCraty & Tomasino, 2006). McCraty and Tomasino claim that from a psychophysiological standpoint, it is the emotions triggered in response to the cognitive perception that is more threatening than the cognitive perception itself which makes emotions the primary source of stress. To put it more succinctly, McCraty and Tomasino describe how feelings such as "anxiety, irritation, frustration, lack of control, or hopelessness – that are truly what we are experiencing when we describe ourselves as "stressed." All of the above examples of "stressors" – whether minor inconveniences or major life changes – are experienced as "stressful" to the extent that trigger emotions such as these (p. 5). Hence, most of the time, it is the unmanaged emotions that fuel the sustenance of stress and additionally, emotions trigger the physiological changes of the body's systems and organs such as the autonomous nervous system and hypothalamic-pituitary-adrenal axis (HPA).

The amygdala in the limbic system has been associated with emotion where studies have demonstrated that stimulation or lesion of the amygdala can trigger or decrease autonomic

responses such as fear and anxiety (Carlson & Birkett, 2017). Research has shown that other brain areas also have effects on emotion. For instance, the activation of the insular cortex is associated to disgust, and the damage to ventromedial frontal cortex impair decision making and behavioral control and thus more susceptible to anger and aggression (Carlson & Birkett, 2017; Kalat, 2007).

McCraty and Tomasino (2006) further conceptualize stress as an "emotional unease" where "the experience of which ranges from low-grade feelings of emotional unrest to intense emotional turmoil" (p. 5). This concept of "emotional unease" does not merely respond directly to external events but continues via an internal rumination of internal emotional process such as "recurring feelings of agitation, worry, and anxiety; anger, judgmentleness, and resentment; discontentment and unhappiness; insecurity and self-doubt" without any external event or current stressor (p. 5-6). In other words, an emotional experience can be consciously or unconsciously induced externally or internally. Consequently, the familiarity of the emotional experience becomes a defining part of the person's self-identity.

Workplace Stress

With a historical underpinning of the parent construct of "stress" and the modern psychophysiological theories of stress, Babatunde (2013) epitomizes stress as "perceived in terms of general physiological and psychological reactions that provoke adversarial mental or physical health conditions when a person's adaptive capabilities are overextended" (p. 73). However, it is still tricky to delineate a unitary definition of stress due to the varied nature and perception of stress experiences in the workplace as well as its impact on the organization (Dewe & Trenberth, 2004). Nevertheless, an attempted definition of workplace stress is the

"discrepancies between the physiological demands within a workplace and the inability of employees to either manage or cope with such work demands" (Babatunde, 2013, p. 73).

The varied nature and perception of stress is exemplified from literature that shows stress being either a stimulus, or a response, or a stimulus-response combination, also known as a transactional relationship between one or more individuals and the environment, leading to an initiative towards a physiological standpoint. Hence, Selye (1974) defined stress as "the nonspecific response of the body to any demand upon it" and this has a high propensity of distracting the normal homeostatic regulatory, physiological functioning of the individual (p. 14). Prior to this, Selye originally distinguished between the concept of "Eustress" and "Distress", where "Eu" is a Greek word meaning "good" which places "eustress" as positive responses to external stressors. On the other hand, "Distress" is coined as responses to stressors that are evaluated as undesirable and oppositional to the well-being (Colligan & Higgins, 2005). At first glance, it may seem that the former "Eustress" is good stress while the latter "distress" is bad stress. However, Selye argues that regardless of whether the response of an individual is of "Eustress" (beneficial) or "Distress" (harmful) nature, physiologically, the individual will still undergo the same "general metabolic processes for the purpose of either preparing reactive secretions to combat, accommodate or remove stressful circumstances" (Babatunde, 2013, p. 74).

Furthermore, even within the "interactional" theory of stress, Michie (2002) states that stress is an interaction between a person and the sources of demands that undermine wellness. This approach paints the picture that stress could be overwhelming, changeable, ambiguous and sometimes unfamiliar and is subjective. However, Cooper & Cartwright (1997) describe "stress as the consequences of a structural lack of fit between the needs and demands of the individual and his/her environment" (p. 7).

Therefore, there has been a lack of a consensual definition of stress over the years and a lot of models have been made since then, within the diverse context of stress research and beyond. Workplace stress models that have been formulated are the Person-Environment-Fit model (French, 1973), Job Characteristics Framework (Hackman and Oldham, 1980), Job Demand-Control Support Model (Karasek, 1979), Effort-Reward Imbalance Model (Siegrist, 1996), and the Transactional Theory of Psychological Stress and Coping (Lazarus & Folkman, 1984). According to Mark and Smith (2008), these are the models that have gained supremacy over the decades in scaffolding workplace stress research and practice even though empirical evidences and popularity are lacking. Within these models, the most theoretically influential model is the transactional theory of psychological stress and coping.

Per Lazarus and Folkman's (1984) transactional theory of psychological stress, when applied to the context of workplace stress, it examines the relationship between employees and their work environment or working conditions that are appraised as health risks. However, Mazzetti and Blenkinsopp (2012) found that the transactional model embraces variables such as subjective perceptions and the potential influence of individual differences in assessing stress responses. Hence, a limitation of the transactional model is the difficulty of empirically assessing the immense variations of how people respond and cope under stressful conditions. Taking into account that the quantitative studies of workplace stress provided only data about static moments in time they had often been criticized previously. Moreover, Mazzetti and Blenkinsopp criticized the transactional model as incompatible with historically preferred method such as self-reported surveys and questionnaire designs approaches because of their inability to consolidate the full extent peoples' fluctuating and subjective stress experiences. Typically, surveys consist of a series of quantitative questions linked to particular measurement

variables such as emotional and physical effects. After all, self-reported measurements themselves have particular shortcomings. There are mixed views towards the use of stress-related surveys. First, researchers disagree regarding a preference for empirically quantitative surveys or interpretive qualitative surveys. Some researchers point out that empirical survey measurements are the most valid method of assessment over the interpretive surveys (Frew, 1974; Kohler & Munz, 2006). On the other hand, some researchers claim that qualitative measurements are better due to their deeper insight into the personal and subjective stress experiences (Bellarosa & Chen, 1997; Frew, 1974; LaMontagne, Keegel, & Vallance, 2007; Schmidt-Wilk, Alexander, & Swanson, 1996). Other researchers claim that surveys, regardless of whether they are quantitative or qualitative, are ineffective measurements (Raitano & Kleiner, 2004). Nevertheless, self-reported surveys will still be around as a major research method for getting individual perceptions of stress and its effect. After all, Lazarus (1990) has argued that the best method to measure effectiveness is by using a mixed method of both empirical and interpretive surveys which gives the researcher a well-rounded picture of participants' experiences and state.

According to Babatunde (2013), there are many definitions of workplace stress. One may define workplace stress as pressure from the environment or as the internal strain of an employee. Also, it can be defined as some form (interactional or transactional) of the simultaneous influence of individual and external factors. Different stress models aggravate the problem of having a definition that has an integrated meaning of workplace stress. Also, newer forms of workplace stress are constantly developing largely due to the accelerated development of technologies, the growth of the global competition and the intensifying of the processes of automation. All of them increase the level of workplace stress, leading to negative health

outcomes of the different localities. At this juncture, a general review is important to consider the factors that contribute to workplace stress.

After reviewing a massive amount of workplace stress literature, McVicar, Munn-Giddings, & Seebohm (2013) have found that the major sources of work stress (see figure 11) have to do with the content and context of work. To elaborate more, stress experiences originating from the content of work are often associated with factors intrinsic to the workplace role as shown in figure 11. In this category, the employee is found to be struggling with the job characteristics that trigger an operational inadequacy between demands and the employee's competence to cope with such demands. Several features within the workplace have been identified to have the potential of producing negative organizational and extra-organizational outcomes which repeatedly pose a threat to the employee's mental and physical well-being. Firstly, there are factors unique to the content of the workplace role (see figure 11) such as workload (either overload or under load), extreme work pace (time pressures), lack of job meaningfulness, low work autonomy, external disturbances such as noise, overcrowding and toxic work systems (poor working conditions). All these examples pose threats to employee's health and well-being.

Secondly, referencing figure 11, Michie (2002) states that both organizational and extra-organizational outcomes may be generated from the second category workplace stressors, which focus on how stress is induced by the role and responsibility that an employee holds within the organization. For instance, managerial roles that are given higher levels of responsibilities but

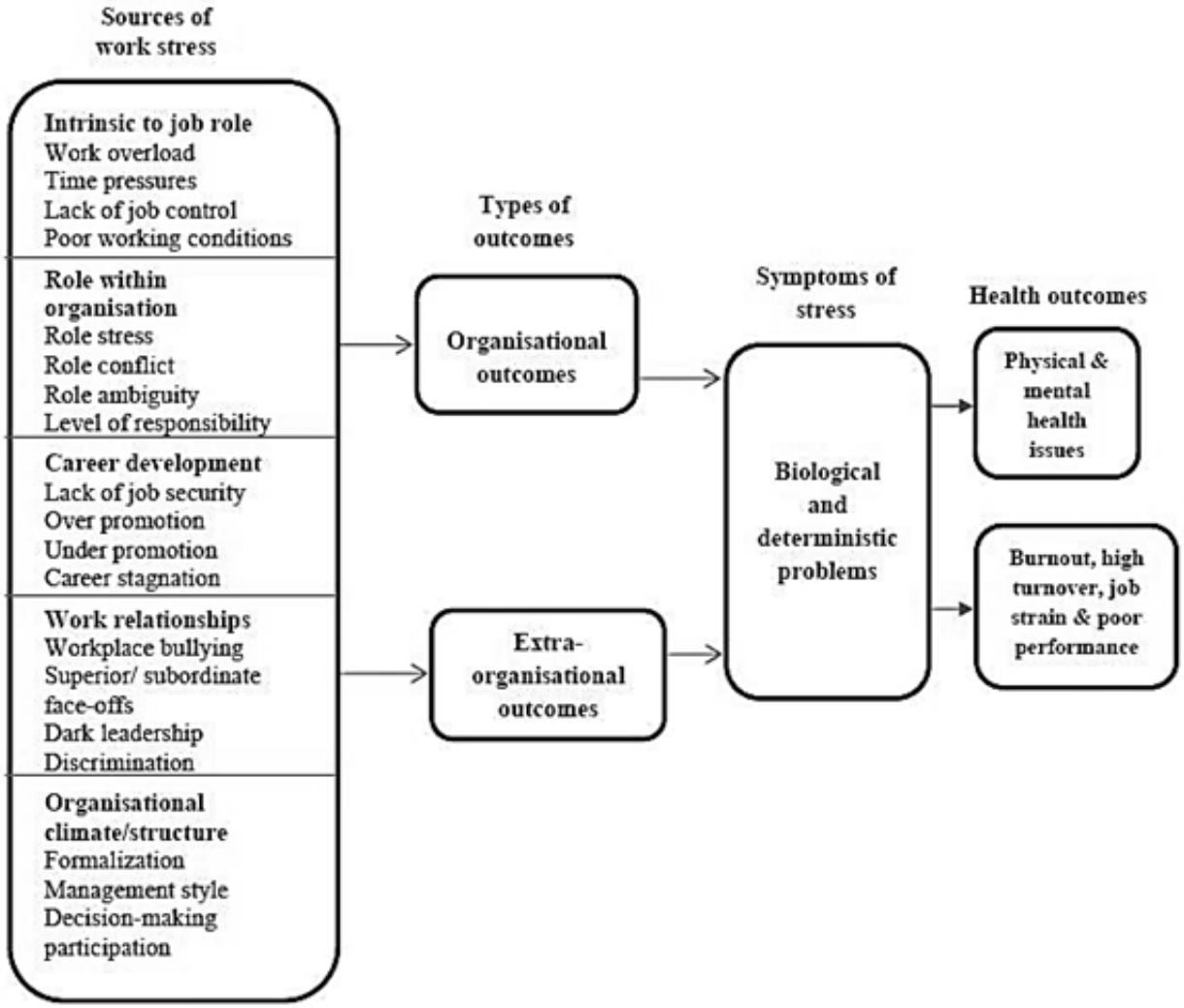

Figure 11: Sources of workplace stress and their related outcomes. The figure in details describes how different sources of stress are transformed into health outcomes. Retrieved from (McVicar et al., 2013).

without clear delineation of role boundaries or where non-managerial employees are required to succumb to multiple demands from superiors and others within the organization in a simultaneous and impractical manner. When this happens, such employees experience role stress due to role ambiguity and role conflict. Role ambiguity is described as a situation where the employee perceives lack of role clarity and significant information that is required to perform his or her role appropriately, while role conflict happens when job demands and expectations from employees' superiors, colleagues and even the organization are incompatible and

incoherent (Ackfeldt & Malhotra, 2013). Thirdly, the contextual stressors are related to career development. This includes lack of job security which triggers stress-related issues that negatively influence the employee's sense of well-being and the obligation to work. Other stressors include over promotion or under promotion and career stagnation of the employee. Moreover, the employee is often expected by modern organizations to constantly adapt and change with technology in order to improve workplace performance and sustain competitive advantage.

Therefore, a high employee turnover may induce non-permanent contracts and contingent work arrangements, causing outcomes such as downsizing, outsourcing, delayering, mergers and acquisitions, restructuring and re-arranging work (Kossek, Kalliath, & Kalliath, 2012). The absence of career growth, especially for those with high potential is a strong stressor. Even if the employee receives a good salary in his or her position, after some time he or she will be demoralized because he or she will understand that the peak of his or her career has been reached and there is no point to make an effort for future progress. Constant changes in the working lives of employees have generated stressful working environments which result in low job autonomy, job insecurities, poor promotional prospects and even situations where the employee is "stuck in a position with no opportunity for advancement" (Colligan & Higgins, 2005).

The fourth category, work relationships, with sources such as workplace bullying, superior-subordinate face-offs, dark leadership and discrimination adds to the contextual aspect of workplace stress within the workplace environment (Dillard & Fritz, 1995). Dillard & Fritz, (1995, p. 12) further described how consequences ranging from "passive to active dislike, animosity, disrespect, or destructive mutual interaction" may occur within the workplace. Therefore, workplace stress, burnout, personal injuries and negative turnovers consequently

result in lose-lose situations between the employees and the organization. The final category relates to stress-induced reactions originating from the organizational structure and climate. In this category, one of the main features of the structure of most organizations is formalization, which refers to the extent to which roles within the organization are standardized and the extent to which the content of work is steered by rules and regulations. When job roles are formalized to a great extent, there may be little autonomy for employees to effectively and efficiently execute work demands because formalization creates rigid procedures and rules of engagement. There is the likelihood that employees will experience high stress originating from inappropriate locus of control needed for work demands. In a similar vein, the corporate climate revolves around the collective perceptions of employees on various aspects of organizational work-life. This includes business objectives that drive high performance, primacy in HR policies and best practices, leadership style, work design, technology, employee engagement, communication systems, motivational conditions, reward mechanisms, working conditions etc. Consequently, occurrences of role stress comprising role conflict and role ambiguity, distorted communication flows, fragmented job characteristics, poor pay, job insecurity and low social value to work arising from a set of properties within a corporate climate are predictors that can produce negative organizational and extra-organizational outcomes.

All listed sources of the stress lead to organizational outcomes and extra-organizational outcomes, which cause such symptoms of stress as biological and deterministic problems. Finally, two types of the health outcomes are caused. The first type includes physical and mental health issues, while the second type includes burnout, high turnover, job strain and poor performance. Therefore, the conducted review of the literature shows that five groups of sources of stress have a negative influence on organizational outcomes, as well as on extra-organizational

outcomes. Work-related stress generates an increasing concern for business because of its negative influence on the profitability of organizations and their reputation (Kelloway, Teed, & Kelly, 2008). Siergrist (1996) states that the manifestation of organizational outcomes is demonstrated through the effort-reward imbalances. In other words, poor performance results are explained by the difference between the efforts of employees and their salaries (Kinman & Jones, 2008). When the employee feels the overloading at the workplace lasts a long time, and yet he or she does not receive the bonuses, or increased salary and promotion, stress and strong negative emotions may occur. We can note the conception of the effort-reward imbalances corresponding with the theory of the social exchange theory. This theory assumes that the rational person always compares his efforts with the expected results from them. Therefore, the misbalance between the efforts and results will eventually lead to the negative health consequences. The topic of the workplace stress is strongly related to the topic of the balance between work and personal life. The constant stress decreases the performance of the worker and he is forced to make up some work at home. Even when he does not make up work at home he thinks about work. That is why the misbalance is growing. Greenhaus & Beutell (1985) show that the growth of the misbalance occurs because of the conflict of the role of the worker and the role of the family man. Messersmith (2007) further postulates that the conflict of roles may grow into time-based (i.e., appropriateness in time devoted to each role demand), strain-based (i.e., strain originating from one role makes it difficult to meet the expectations of another role) and behavior-based conflict (i.e., the idea that patterns of behavior required in one role may be in dissonance with the desired characteristics of another role). In spite of the fact that the conflict between work and personal life is manifested in two directions, this paper is focused on the influence of the work, including workplace stress, on the employee's personal life.

A Summary of Stress and Workplace Stress

After reviewing the literature on Stress and Workplace Stress, below is a summary:

- Stress: Perceived in terms of general physiological and psychological reactions that provoke adversarial mental or physical health conditions when a person's adaptive capabilities are overextended
    - Stimulus-based: Stress as a stimulus, life events or stressors, either positive or negative that strains the adaptation capacity of an individual
    - Response-based: Stress as a response where the manifestation of stress is the main focus such as a person's basic reaction to any demand or pressure.
        - Influenced Selye's General Adaption Syndrome
    - Transaction-based: Based upon the observation that people can appraise the same event differently
- Modern Psychophysiological Theories of Stress
    - Selye renamed GAS to "biological stress response" which is a stepping stone to the integration of "stress" and physiology", which further fuels the three major modern psychophysiological theories that link stress and diseases
        - Cognitive Activation Theory of Stress (CATS): Cognitive evaluations of situations and consequences will determine the physiological and psychological consequences of stress
        - Allostatic Load Theory of Stress (ALTS): The theory of how "stressors" and "perceived stress" interact to give rise to the concepts of "allostasis" and "allostatic load", where actual diseases and disorders are the result of the allostatic load

        - Resilience Theory of Stress (RTS): The ability of a person to reinvigorate beyond his or her workplace situation, to acclimatize better than expected and to continue to survive and thrive in his or her workplace

- Emotional Nature of Stress
    - Karl Pribram Model: The Role of Familiarization - any mismatch from internal or external inputs will require the person to make intrinsic or extrinsic adjustments in order to remain in the familiar territory
    - Significance of the Afferent Feedback: Afferent neural signals send feedback from the body to the brain
    - Psychophysiological Perspective of Emotions: the emotions triggered in response to the cognitive perception that is more threatening than the cognitive perception itself which makes emotions the primary source of stress
- Workplace Stress
    - A working definition: Discrepancies between the physiological demands within a workplace and the inability of employees to either manage or cope with such work demands
    - A general review is utilized to consider factors that contribute to stress within the workplace.
        - Workplace stressors such as workplace content or context (see Figure 11)
            - directly impacts the organizational outcomes or extra-organizational outcomes
            - biological and deterministic problems as the symptoms
            - Physical and Mental health issues

- Burnout, High turnover, job strain and poor performance

Measuring the heart rate as a way to assess the risk of contracting cardiovascular disease

We learn from research that certain sectors of the working population are at a higher risk of contracting cardiovascular diseases due to workplace stress, that is, physical, psychological or mental strain induced by higher job demands being placed on the employees (Collins et al., 2005). These high levels of physical and mental strain could lead to adverse physiological conditions such as higher blood pressure, increased heart rate, excessive perspiration and higher oxygen intake. An inevitable reaction towards sustained power and endurance over repetitive physical, psychological and mental activities is the increased heart rate. The increased heart rate can bring stress to the point of a heart failure. Ergonomics is interested in finding out how workplace stress can affect heart rate and also whether certain components of the heart rate measurements such as power spectral components of HRV can be used to predict the risk of diseases (Collins et al., 2005). Examples of daily workplace scenarios where physiological stress is inherent are the working conditions in terms of long working hours, shift schedules, postural distortions and physical working conditions like heat, vibrations and noise (Semmer, Meier, & Beehr, 2016). Psychological stress could be induced by the work itself (such as what the employees have to do, how interesting the work is to the employees and how much the employees like doing) and the social relationships at work in terms of treatment by others, intensity of interpersonal conflict and social support (Semmer et al., 2016). Other psychological stressors may include incivility of workplace employees (Leiter, 2016), personality differences such as variation in communication styles (Cavaiola & Lavender, 2000) and personal biases learnt over the course of each employee's lifespan (Leiter, 2016). Incivility at the workplace could include the upward, downward or horizontal power domination (Leiter, 2016). For

instance, a subordinate may talk to a boss in a way which people shouldn't talk to their bosses or a co-worker who receives incivility will have a high chance of behaving uncivilly to his or her other co-workers in reciprocal (Leiter, 2016). We learn from Giorgi, Shoss, and Leon-Perez (2015) that incivility like workplace bullying creates workplace stress that could lead to health-related problems such as anxiety, depression, PTSD, etc. Distresses at work may also arise from employee's personal biases that are learnt over the course of his or her lifespan. These may include negative self-worth such as the fear of being rejected by co-workers and lacking trust such as being afraid of building secure attachments with other co-workers and refraining from cooperation (Leiter, 2016). Since heart rate is extremely sensitive to different kinds of stress, measuring heart rate and monitoring it can be a good way to assess the risk of contracting cardiovascular disease (Chandola et al., 2008).

The Autonomous Nervous System (ANS) and the Heart

The Autonomous Nervous System (ANS) regulates all the major organs, including the heart. The primary influences on heart rate are markers of parasympathetic or sympathetic activity. The sympathetic influence on heart rate is mediated by the release of epinephrine and norepinephrine. During episodes of stress, the sympathetic component of the ANS increases cardiac output. The release of norepinephrine following the sympathetic neural stimulation of the cardiac control center causes an increase in both the heart rate by increasing the frequency of spontaneous depolarization of the sino-atrial (SA) node and the strength of cardiac contractions and thus stroke volume (Gordan, Gwathmey, & Xie, 2015). The parasympathetic, vagally mediated system allows the heart rate to be reduced by lowering the frequency of spontaneous depolarization of the SA node, and by reducing the rate at which depolarization impulses are transmitted from the SA node to the atrioventricular (AV) node. The regulation of heart rate is

the result of a dynamic interplay between the sympathetic and parasympathetic components and so at any instant there will be a certain "sympathovagal" balance (Gordan, Gwathmey, & Xie, 2015). The heart rate response to stressors such as postural changes, deep breathing and lower body negative pressure is used as an index of the ANS response (Tymko et al., 2016).

Heart Rate Variability (HRV)

Heart Rate Variability (HRV) refers to the beat to beat alterations in heart rate calculated by quantifying the amount of R-R intervals (duration between two consecutive R-waves of the ECG) changes as generated from an electrocardiogram (ECG) data (Shaffer et al., 2014). The R-R interval can be influenced by both physical and psychological variables, including certain drugs. Beta-blockers, a drug used for hypertension, have shown to trigger an increase in HRV in some individuals, while other common anti-hypertension medications, such as diuretics and angiotensin-converting enzyme (ACE) inhibitors may decrease the overall HRV (Schroeder et al., 2003). Moreover, certain anti-depression medications such as serotonin-norepinephrine reuptake inhibitor (SNRIs) and selective serotonin reuptake inhibitor (SSRIs) have been shown to decrease HRV in some individuals (Kemp et al., 2010).

According to McCraty and Shaffer (2015), the irregular alterations of the heartbeat are readily obvious when heart beat is observed on a beat to beat basis. The fluctuation in heart rate responses is due to multifaceted, nonlinear interactions among various physiological systems. Therefore, "HRV is… a measure of neurocardiac function that reflects heart-brain interactions and ANS dynamics" (McCraty & Shaffer, 2015, p. 47). To assess whether a person is healthy requires an optimal level of HRV, self-regulatory capacity, adaptability or resilience. On the other hand, if the heart beat exhibits an abnormal rhythm (arrhythmias or nervous system chaos), it is damaging to effective physiological function and energy consumption (McCraty & Shaffer,

2015). Nevertheless, McCraty and Shaffer assert that "too little variation indicates age-related system depletion, chronic stress, pathology, or inadequate functioning in various levels of self-regulatory control systems" (p. 47).

Components of Heart Rate

HRV was originally assessed by calculating the mean beat to beat heart rate commonly called the R-R interval, and its standard deviation is measured on a short term ECG. Up to now about 26 different types of arithmetic manipulations of R-R intervals have been used (Sambasivam & Gururajan, 2013). The RMSDD index has been the most commonly used variable. RMSDD is a time domain measure of HRV and it is scientifically defined as the root mean square of the differences of the successive R-R intervals (McCraty & Shaffer, 2015; Shaffer et al., 2014). MAX-MIN or peak-valley quantification of HRV is the difference between the shortest R-R interval during inspiration and the longest during expiration (Sambasivam & Gururajan, 2013). Furthermore, the spectral analysis of HRV has been developed which transforms the signal from time domain to frequency domain or power spectral density (PSD) (McCraty & Shaffer, 2015; Shaffer et al., 2014). According to Shaffer et al., the power spectrum of heart rate and blood pressure yields four major bands. A High Frequency (HF) peak ranging between 0.15 to 0.40 Hz which reflects a parasympathetic or vagal activity of the ANS as the HF is correlated with respiratory sinus arrhythmia (RSA). A Low Frequency (LF) peak ranging between 0.04 and 0.15 Hz is associated with blood pressure control, reflecting sympathetic activity of ANS. Sympathetic activations in the LF peaks can be due to physical activity or emotional stress reactions. A Very Low Frequency (VLF) peak ranging between 0.0033 and 0.04 Hz is associated with increased risk of adverse effects and the VLF has stronger correlations with "all-cause mortality" than HF and LF peaks. Normal VLF power indicates a

healthy function while an increased VLF power (due to stressors) reflects an increased sympathetic activity. VLF is believed to relate to thermoregulation and kidney functioning (Paso, Langewitz, Mulder, Roon, & Duschek, 2013). It is interesting to note that healthy individuals experience an increase in VLF power during their sleep and peaks before they wake up which correlates to their having the morning cortisol peak. The final peak is the Ultra Low Frequency (ULF) peak which falls below 0.0033 Hz. This can only be measured with 24-h or longer recordings and at this point of time, the clinical relevance for this peak is unknown (McCraty & Shaffer, 2015; Shaffer et al., 2014).

Factors influencing the power spectrum of HRV

Numerous factors such as age, body posture, gender, physical fitness, breathing cycles, circadian cycles and mental capacity influence the ANS and heart mechanisms (McCraty & Shaffer, 2015). Furthermore, respiration has a strong influence on heart rate and this phenomenon is known as the respiratory sinus arrhythmia (RSA). Recent research shows that a reduction in tonic or phasic HF is largely related to the evocation of emotions (behavior and emotion dysregulation) as well as related to symptoms that reflect both internalizing and externalizing psychopathology. These include anxiety, phobias, attention problems, autism, callousness, conduct disorder, depression, non-suicidal self-injury, panic disorder, trait hostility, thought disorders, psychopathy and schizophrenia (Beauchaine & Thayer, 2015). Furthermore, comorbid internalizing and externalizing symptoms show even greater reductions in HF during an emotion evocation as compared to either internalizing symptoms or externalizing symptoms alone (Beauchaine & Thayer, 2015). These altered HF marks have an adverse effect on health outcomes such as cardiovascular diseases.

A reduction in the standard deviation of the RR interval and RMSSD values indicates a reduction in HRV. For instance, RR interval variance decreases when age increases, while at rest and change of posture (McCraty & Shaffer, 2015). The reduction in variance will lead to a decreased HRV. The ratio between the two measures, LF/HF, is believed to signify a sympathovagal balance and is used as an index of parasympathetic and sympathetic balance, which is an estimate of workplace stress (Paso et al., 2013).

The activity of the ANS involves Baroreceptors and baroreflex as important components in HRV and autonomic activity. Baroreceptors are stretch receptors in the blood vessels that detect a rise in the blood pressure and signal the heart to slow down. Conversely, these baroreceptors send signals to the brain to increase the heart rate when the blood pressure decreases. The negative feedback loop of the baroreceptors, or baroreflex, works to maintain homeostasis and systemic health (Khazan, 2013).

The Importance of HRV in Assessing Workplace Stress

The demand control model of workplace stress suggests that when demands are high and the control is low with low social support will cause workplace employees to be stressful. In other words, there is an imbalance between the job demand and the person's ability to meet those demands (Muchinsky & Culbertson, 2016). Increased HRV decreases performance anxiety (Shaw, Wilson, & Nihon, 2012) and increases resilience (McCraty & Shaffer, 2015). On the other hand, decreased HRV is associated with mental stress in lab experiments which have indicated a lack of mental ability to respond by physiological variability and complexity. If the condition is prolonged, it may lead to cardiovascular diseases (McCraty & Shaffer, 2015). HRV is relatively lower during work periods. It is consistent with other studies that HRV is a sensitive

indicator of workplace stress. Resting has a positive effect on HRV and blood pressure. Intermittent rest periods between work have shown an improvement in HRV.

Hillebrand et al. (2013) conducted a meta-analysis of 8 studies on the relationship between HRV and cardiovascular diseases among 21988 participants. These studies used the standard deviation of the normalized N–N interval (SDNN), low-frequency (LF) or high-frequency (HF) spectral component as a measure of HRV. They found that a low HRV is associated with a 32–45% increased risk of a first cardiovascular event in populations without known CVD. An increase in SDNN of 1% resulted in an approximately 1% lower risk of fatal or non-fatal CVD.

A Summary of Heart Rate Measures

Important information on heart rate components can be summarized from the past literature as follows:

- All the components of HRV are markers of sympathetic and parasympathetic activity
- The low frequency band:
    - Is associated with blood pressure control and sympathetic activity
    - Is high when the person is in high strain conditions
- The high frequency band
    - Is an indicator of parasympathetic autonomic response
    - Is an indicator of respiratory sinus arrhythmia (RSA)
    - Is reduced when the person is in high strain conditions
- The ratio of low to high frequency
    - Is an estimate of workplace stress
    - Is used as an index of parasympathetic and sympathetic balance

    - Is correlated with high strain, when high
- The very low frequency is
    - Linked to temperature control
    - Correlated with a high ANS activity, when high, implying a high strain
- Reduced HRV predicts sudden death and is a marker of fatal ventricular arrhythmia
- Reduction in HRV can be observed from the time domain components like RMSDD
- All of the above components are accountable for the identification of increased cardiac reactivity in individuals under high stress

Practical Applications of Heart Rate Monitors

Biofeedback is a method of allowing a person to be aware of his or her body's physiological functions such as heart rate, body temperature, blood pressure, respiration, and brainwave activity (Lehrer & Gevirtz, 2014; McCraty & Zayas, 2014). Multiple biofeedback modalities are used in the healthcare such as electromyography (EMG), heart rate variability (HRV), electrocardiogram (ECG), electroencephalograph (EEG), and feedback thermometers (Rataasirpong, Sverduk, Prince, & Hayashino, 2012).

HRV is sensitive to both physiological and psychological disorders. Recently, HRV has been used as a tool to improve the diagnosticity of heart rate in both the working and non-working population. Assessing HRV and the effects of workplace stress on the heart can help to predict the occurrence of a cardiac disease such as allowing a person to be aware of his or her physiologic mechanisms such as heart rate and breathing patterns, and to decide to take or not to take further actions towards reducing autonomic reactivity and regulating homeostatic physiologic mechanisms (McCraty & Shaffer, 2015). The assessment of HRV is a mediation towards improving health, performance and decision-making abilities (Lehrer & Gevirtz, 2014; McCraty & Zayas, 2014). As a result, it has become essential to measure HRV.

Historically, HRV measurements require a high quality electrocardiogram (ECG), but the cost and complexity of ECG equipment has made it difficult to perform a HRV analysis particularly in the workplace. To address this need, several portable heart rate monitoring devices have been designed. For this study, the non-invasive Heartmath emWave Pro Plus technology will be used (Institute of HeartMath, 2016). The HeartMath HRV device uses an ear or a fingertip sensor to assess heart-rhythm patterns and HRV ranges (Institute of HeartMath, 2016).

CHAPTER THREE

METHODOLOGY

The literature review on stress has shown that stress can be perceived in terms of general physiological and psychological reactions that provoke adversarial mental or physical health conditions when a person's adaptive capabilities are overextended. Where workplace stress is concerned, an employee experiences workplace stress when he or she is unable to manage or cope with physiological demands within the workplace content or context as shown in Figure 11.

In terms of stress assessments, there has been an extensive use of psychometric measures on workplace stressors that are self-reported (Panari, Guglielmi, Ricci, Tabanelli, & Violante, 2012; Spector & Jex, 1998) without the use of physiological measurements. Hence, Lazarus (1990) argued that the best method to measure stress effectively is by using a mixed method of both empirical and interpretive surveys which give the researcher a well-rounded picture of participants' subjective experiences and state. Mauss, Jarczok, and Fischer (2016) report that HRV is an important biomarker (primary mediator of neurophysiologic pathway), one of the variables in the Allostatic Load Index that is easily assessable and accessible to measure workplace stress.

Moreover, there are researchers who have conducted workplace stress using HRV with industries such as Media Workers in Finland and Poland (Lindholm, 2013; Bortkiewicz, Gadzicka, Szymczak, & Zmyslony, 2012), Police Special Forces in the United States (McCraty & Atkinson, 2012; Andersen et al., 2015), Medical Centers in the United States and Germany (Pipe et al., 2012; Linden, Jackson, Rutledge, Nath, & Lof, 2010; Rieger, Stoll, Kreuzfeld, Behrens, & Weippert, 2014; Borchini et al., 2015), Church Staff in the United States (Bedell & Kaszkin-Bettag, 2010), Fire-fighters in South Korea (Shin, Lee, Yang, Lee, & Chung, 2016),

Machinery workers in Brazil and China (Monteze et al., 2015; Li et al., 2012), Airplane Manufacturing Employees in Germany (Loerbroks et al., 2010), Employees from five companies in Korea (Kang et al., 2015) and Teachers in Taiwan (Chang & Shen, 2011). However, there are no researchers using HRV to assess workplace stress in an actual workplace setting in Hong Kong.

The purpose of this study is to test the effects of Hong Kong Employees' workplace stress on Heart Rate Variability. This chapter describes the research method, participants, instrumentation, data collection and data analysis. Institutional Review Board (IRB) procedures are identified and data analysis plans are described.

Research Method

As the research study was to explore the effects of workplace stress on Heart Rate Variability (HRV), which utilized the power spectral components and key time domain measures of heart rate variability to analyze heart rate data after the employee had self-reported his or her level of stress over two scales: one was the Personal and Organizational Quality Assessment (POQA) (Institute of HeartMath, 1997) and the other was the Perceived Stress Scale (PSS) (Cohen, Kamarck, & Mermelstein, 1983). After these assessments were completed, a correlation between the Heart Rate Variability (HRV) and both POQA and PSS was conducted. Hence, this study adopted a Quantitative research design to quantify relationships between or among variables - the independent or predictor variable (s) and the dependent or outcome variable (s). In this case, PSS and POQA are the dependent variables while HRV measurements such as SDNN, RMSSD, MHRR and normalized coherence are the independent variables (Yoshikawa, Weisner, Kalil, & Way, 2008). Researchers in correlational studies have collected two or more variables for a specific group of people where the data are numbers that reflect specific

measurements of the variables in question (Leedy & Ormrod, 2014). In this study, HRV, quantified by the four variables (SDNN, RMSSD, MHRR and normalized coherence) was correlated with the perceived stress quantified by the POQA-R4 rating scale as well as the Perceived Stress Scale.

Participants

The chosen study population was made up of full-time employees in a large corporation of over 500 employees (hereinafter referred to as "Company X"). All employees of the company were welcomed to participate. The full-time participants were working at least 40 hours per week. Company X employs over 500 office work employees. Company X operates out of different locations in Hong Kong. The research was conducted in an air-conditioned room on the 19th floor within the temperature between 22-26°C in one of the locations in which Company X operates in Hong Kong. The building is unobstructed by the external traffic within a large urban area that has a population density of 639,900.

Study Sample

To reduce Type II errors, or false negatives, a power analysis was conducted to determine the sample size for this study (Murphy, Myors, & Wolach, 2014). Conducting a power analysis to determine the sample size is an important component in the research planning process. The value for effect size r for Pearson correlation is 0.10 for a small effect size, 0.30 for a medium effect size, and 0.50 for a large effect.

Upon review of the literature to determine the correlation between HRV and the perceived stress of Hong Kong Employees, no previous research studies were found on this topic; thus, an estimated medium effect size of .30 will be used in this study. The Sample Size Calculator was used to conduct a power analysis to determine the sample size (Clinical &

Translational Science Institute, 2017). To achieve a power of .80 and an estimated effect size of .30, with a significance level, or alpha (α), of .50, the total sample size needed for this study is 85 employees (Clinical & Translational Science Institute, 2017).

Inclusion/Exclusion criteria. Eligible employees were: full-time employees working at least 40 hours per week for Company X; male or female; at least 18 years of age; and able to read, write, and understand English. However, employees who had taken any kind of medication that might influence the results or caffeinated/alcohol beverages within 2 hours prior to the session were excluded from the study.

Sampling procedures. After the participating employees of Company X signed the informed consent forms, they accessed the online POQA questionnaire as well as filling up the PSS questionnaire. Once the questionnaires were filled up, the researcher performed biometric tests on the employee using the emWave Pro Plus.

Study Setting

The study was performed between 08:00 a.m. and 08:00 p.m. in an air-conditioned room within the temperature range of 22-26°C. In general, this temperature range was acceptable for the study (Pina et al, 1995).

Instrumentation

Validity and Reliability

The primary purpose of this research study as mentioned previously was to introduce a new practical assessment, Heart Rate Variability (HRV) to assess employee stress in the workplace in Hong Kong, with a secondary purpose to explore the correlational ties between HRV quantitative measurements and other captured quantitative data on workplace stress of employees in Hong Kong. Subjective workplace stress measurements can have limited reliability and validity due to the likelihood of overestimating the answers and the risk of bias

(Gupta et al., 2014; Van den Berg, Elders, Zwart & Burdorf, 2009). According to previous research, both subjective and objective aspects are required to measure workplace stress as they are interrelated (Ezoe & Morimoto, 1994; Jarvelin-Pasanen et al., 2013; Parkka et al., 2009).

It was of interest to investigate how well the POQA and PSS corresponded with an objective measure, which could reflect the balance between an employee's individual resources and demands of the workplace environment. A possible psychophysiological concept related to workplace stress is the Heart Rate Variability (HRV), which is an extensively accepted and validated objective measure reflecting of the healthy functioning, self-regulatory capacity, adaptability and resilience of one's body (McCraty, 1996). Moreover, a number of research studies have demonstrated HRV to be a strong independent predictor of future health (Dekker et al., 2000; McCraty & Shaffer, 2015; Shaffer, McCraty & Zerr, 2014). Reduced HRV has been found in different cardiac pathologies and in patients under stress who suffer from anxiety, panic or worry (Shaffer et al., 2014); in patients with autonomic dysfunction, including asthma and depression (Agelink, Boz, Ullrich & Andrich, 2002; Kazuma, Otsuka, Matsuoka & Murata, 1997); and in death from several causes (Berntson, Norman, Hawley & Cacioppo, 2008). Hence, HRV has been strongly recommended as the appropriate tool to assess the level of strain at work and recovery from work (Jarvelin-Pasanen, 2013).

Most historical workplace stress researches that correlated HRV with workplace stress have shown a negative correlation between the variables. A few available studies have tested both objective and subjective measures to get a better prediction of the way to cope with workplace stress and to explore the relationship between HRV (both one- and five-minute recordings) and PSS. However, no studies have explored the relationship between HRV and POQA. Fohr et al. (2015) investigated how subjective self-reported stress (PSS) is associated

with objective heart rate variability (HRV)-based stress and have found that subjective self-reported stress is associated with objective physiological stress. Hence, Fohr et al. suggest that objective stress assessment provides an additional aspect to the evaluation of stress.

Da Silva et al. (2015) have assessed the correlation between PSS and HRV parameters. They reported that decreased heart rate variability (HRV) is associated to increased mortality rates in certain heart diseases. Moreover, the correlation between psychological stress, measured by the perceived stress scale (PSS-14), and HRV parameters obtained during 5 minute at rest was evaluated. Data from 35 healthy young volunteers showed a significant correlation between PSS-14 scores and Low Frequency-LF (ms2) by frequency domain HRV analysis. Other variables such as High Frequency and Standard Deviation of R-R intervals had also negative coefficients but did not have any significant correlation with PSS-14. No correlation between PSS-14 and sympathovagal balance parameters was found. Data interpretation demonstrated that an increase in perceived stress was correlated to a decrease in heart rate variability, which may suggest an important mechanism in cardiovascular pathophysiology that is potentially valuable for further research.

Orsila et al. (2008) correlated perceived mental stress during occupational work with heart rate variability (HRV), using a traditional questionnaire and a novel wristop heart rate monitor with a related software. A single survey item was used to assess perceived mental stress, which was elicited on a visual analog scale (from 0—very little stress to 10—very high stress) during the workday. Subjects who scored 6 or more were considered stressed. The periods studied were formed on the basis of the information written in the subjects' study diaries. The same diary data was also used to verify significant variations in HRV. The aim was to find HRV parameters useful for mental stress detection. The researchers found the highest

correlation between perceived mental stress with the differences between the values of triangular interpolation of (RR) interval histogram (TINN) and the root mean square of differences of successive RR intervals (RMSSD) obtained in the morning and during the workday ($r = -.73$ and $r = -.60$, respectively). The analysis shows that as the RMSSD and TINN value differences increase from night to morning, the stress decreases.

HRV has been examined to provide an accurate and reproducible quantitative measure of mental health in social, emotional and cognitive research, as HRV is affected by blood pressure and respiration (Quintana & Heathers, 2014). A risk mentioned by Quintana and Heathers (2014, p. 1) is that "if the direction of causality between experimental task and the coordinated response within cardiac, circulatory and respiratory variables is poorly understood simple relationships between task and output changes may be obscured". Often uncontrolled measures like medicine, food and water consumption, a full bladder, and time of day may severely influence HRV and should be considered in future experiments (Quintana & Heathers, 2014).

To summarize, due to the increased need to utilize both subjective and objective aspects to measure workplace stress, it is of paramount interest to introduce a new practical assessment, Heart Rate Variability (HRV) to assess long-term effects of employee stress in the workplace in Hong Kong. Furthermore, this research has explored the correlational ties between HRV quantitative measurements and other captured quantitative data (PSS, POQA) on workplace stress of employees in Hong Kong. The aim of this research study was to examine whether heart rate variability (HRV) was related to workplace stress, using PSS as well as POQA, and could therefore be a valid biometric stress measure in future workplace stress measurements on a global basis. The hypothesis was that HRV would be negatively correlated with PSS and POQA scales indicating high stress.

Instruments

Two scales were used to collect data on the dependent variables perceived stress scale (PSS) as well as Personal and Organizational Quality Assessment (POQA). These scales represented operationalization of the dependent variables in the conceptual framework, and both of them had sound psychometric properties. See Appendices A and B for sample instruments and scoring descriptions.

Personal and Organizational Quality Assessment-Revised 4 Model. The POQA-R4 is an instrument developed by researchers at the Institute of HeartMath. It contains 49 questions on four major scales of workplace quality directly related to health and workplace performance. Barrios-Choplin and Atkinson (2000) describe that the instrument gathers self-reported information on socio-demographic and key psychological and workplace elements associated with the overall quality and effectiveness of the individual and the organization. The instrument uses eight items of socio-demographic information about the respondents' characteristics which include gender, age, marital status, employment status, level of education, the number of hours worked per week, the number of years in the company, and the number of years in the current role (Barrios-Choplin & Atkinson, 2000). The 49 items are divided into four factors which measure emotional vitality, emotional stress, organizational stress, and physical symptoms of stress. They have been empirically validated and found to be reliable based on a measurement study conducted on the existing POQA-R database of 2,540 employed adult respondents (Barrios-Choplin & Atkinson, 2000).

At the primary scale level (the four factors), the minimum number of items assigned to a factor was 8 and the maximum number of items assigned was 15; at the subscale level (the sub-factors or components within a factor), the range of items assigned to a given subscale was from

2 to 8. Overall, under this new framework, 6 of the 9 multi-item subscales were measured by 5 or more items.

Two statistical analyses were conducted to verify the measurement validity and reliability. In the first analysis, the seven scales and their associated subscales were subjected to an analysis of internal consistency of measurement using Cronbach's coefficient alpha (α). The results of the four primary scales showed that all constructs exceeded the criterion for technical adequacy ($\alpha > 0.75$): the alpha coefficients ranged from 0.76, for Organizational Stress, to 0.92 for Emotional Vitality and Emotional Stress. The results for the nine multi-item subscales showed that, with one exception (Relational Tension, $\alpha = 0.69$), these constructs also achieved or exceeded the criterion for technically adequate measurement reliability. Across the other eight multi-item subscales the alpha coefficient ranged from 0.76, for Health Symptoms, to 0.90, for Emotional Buoyancy, Intention to Quit, and Anxiety/Depression.

In the second analysis, all 49 items were factor analyzed (results not shown) to compare the item classifications resulting from the factor analysis with their nominal designation into the four primary scales and nine multi-item subscales of the POQA-R4's. With a few exceptions, the factor analysis item classifications corresponded to the nominal classification of the items into the categories for the primary scales. Overall, the results from both statistical analysis procedures confirm the validity of the items assignment to the scales and subscales and also confirm that the measurement reliability is more than technically adequate. In short, all of the available statistical evidence suggests that the measurement basis of the scales and subscales of the POQA-R4 framework appears to be psychometrically sound (Barrios-Choplin & Atkinson, 2000).

Perceived Stress Scale. The instrument used in this research to measure *perceived stress* was the Perceived Stress Scale (PSS) by Cohen and Williamson (1988); therefore the operation definition of *perceived stress* is the score on the PSS. The PSS is a 10-item questionnaire that measures situations in the employee's life that are deemed stressful. This Likert-type instrument has each item scored 0 (never), 1 (almost never), 2 (sometimes), 3 (fairly often), to 4 (very often). An example question on the PSS is: *In the past month, how often have you felt nervous and "stressed"?* The total score possibility of the PSS is 56, with the higher the number, the greater the perceived stress. Scores near 13 are considered average, with scores greater than 20 indicating high stress. The Cronbach's alpha internal reliability of the PSS ranges from 0.84-0.86 (Cohen & Williamson, 1988).

The original PSS was a 14-item survey, with the subsequent development of 4-item and 10-item versions. The Cronbach's alpha coefficient for the internal reliability of the original PSS-14 was .75. In an exploratory factor analysis (EFA) of the PSS-14, Cohen and Williamson (1988) eradicated four poorly performing items and the alpha coefficient increased to 0.84-0.86 on the newly developed PSS-10. Scores on the PSS-10 and PSS-4 demonstrated moderate convergent variability, but the PSS-4 scores performed with a relatively low reliability (.60), with the result that the PSS-10 is the recommended perceived stress tool for this research (Cohen & Williamson, 1988; Taylor, 2015). Nevertheless, the PSS-4 is recommended only for situations where perceived stress measurements must be taken quickly (Taylor, 2015).

emWave Pro Plus®. The emWave Pro Plus, designed by the Institute of HeartMath (2016), is a computer software program that collects pulse data through a pulse sensor that can be plugged to a computer (See Appendix C). The pulse sensor can be placed on the participant's earlobe or fingertip. The software then translates the information from the participant's heart

rhythms into user-friendly graphics displayed on the computer monitor, which allows the researcher to watch in real time how thoughts and emotions are affecting the participant's heart rhythms (see Appendix C for the example of the computer monitor HRV reading). We learn that the emWave Pro Plus uses Photoplethysmography (PPG) technology which is based on the ability of hemoglobin to absorb light. As the amount of hemoglobin passes through the blood vessels changes due to the pulsatile nature of blood transportation, the amount of absorbed light also changes (Russoniello, Zhirnov, Pougatchev, & Gribkov, 2013). PPG technology is a reliable and valid method of capturing and quantifying real time HRV data, both resting HRV and deep breathing tests (Russoniello et al., 2013). The pulse sensors used with the emWave Pro Plus during an individual's resting state (not ambulatory state) is identical to the recordings used with ECG (McCraty, Zinn, & Atkinson, 2002). For this research, HRV was measured by various parameters: SDNN, RMSSD, MHRR and normalized coherence. SDNN is the standard deviation of all mean normal-to-normal intervals measured in milliseconds. The measure reflects the ebb and the flow of all the factors that contribute to HRV and the heart's ability to respond to hormonal changes (McCraty & Watkins, 1996; Task force of the European Society of Cardiology and the North American Association of Pacing and Electrophysiology (ESC-AAPE), 1996). The RMSSD is the root mean square of successive differences between the normal heartbeats reflecting the short-term variance in heart rate. This value provides an estimate of the parasympathetic regulation of the heart (McCraty & Watkins, 1996; ESC-AAPE, 1996). MHRR is the mean heart rate range, which is the difference between the maximum and the minimum heart rate during each breathing cycle. The result is then expressed in beats per minute, as the mean of these heart rate differences for each measured cycle (McCraty & Watkins, 1996; ESC-AAPE, 1996). Finally, normalized coherence is a frequency domain measure of coherence

where power in the coherence peak of the power spectrum density is divided by total power. This measure represents the ratio of coherence relative to total power and ranges from 0 – 100 (McCraty & Watkins, 1996). Moreover, a coherent heart rhythm is visualized as a harmonic sine-wave-like signal with a narrow, high-amplitude peak in the low frequency (0.04-0.26 Hz) region of the HRV spectrum. Coherence is evaluated by detecting the maximum (coherence) peak in the 0.04-0.26 Hz range, calculating the integral in a window 0.030 Hz wide, centered on the highest peak in that region, and then calculating the total power of the entire spectrum (Shaffer, McCraty & Zerr, 2014). The emWave Pro Plus is based on decades of research, incorporating the patented HRV measurement and has been used by tens of thousands of people in over 85 countries (Institute of HeartMath, 2016).

Data Collection

The Data Collection schedule was from 7 July 2017 to 30 September 2017.

Recruitment Processes

Once institutionally approved, employees of Company X were invited to participate in this study. A recruitment email was sent to employees of Company X a week before the start of the research study (see example email in Appendix E). The recruitment email briefly described the study, the inclusion/exclusion criteria, as well as the compensation (incentive) for the participants if they chose to participate and complete the research study requirements. The exclusion criteria was listed to inform potential participants the reasons why they would not qualify for this research study so that they didn't need to attend the Principal Researcher's visit, thus further protecting their privacy.

Informed Consent

At the visit by the Principal Researcher (PR) at one of the meeting rooms in the official premises of Company X, the participants who chose to participate completed the informed consent process before the data collection began. To fully complete this process, each participant read the informed consent form and was allowed to ask any additional questions regarding the study before signing and dating the informed consent form (see Appendix G). Finally, the participant received a personal copy of his or her informed consent form. The PR determined if the participant was eligible for the research study by asking the participant whether he or she had consumed any caffeinated/alcohol beverages within 2 hours prior to the session.

During Data Collection

After the participant had signed the informed consent form, the research study data was collected in three sets: (1) Online survey – POQA, filled by the participants, (2) Pen-filling survey – PSS, filled by the participants and (3) objective measurements (HRV) collected by the PR.

For HRV measurements, each participant was recorded individually in a quiet room, in a seated position. The participants received instructions for the test and the emWave Pro Plus pulse sensor was placed on their earlobes. Participants were instructed to remain seated, to stay relaxed and to refrain from making any significant or rapid body movements. Each session started with the five-minute resting state HRV assessment where the participant was told to breathe normally. Once the five minutes were up, participants were instructed to breathe according to the six-breath protocol. This breathing method provided a physiological challenge to assess the maximum HRV range (amplitude) during a one-minute period through deep breathing at the specific rate of five seconds of inhalation and five seconds of exhalation. Once achieved, there were six complete breath cycles over the course of one minute. The emWave Pro

Plus software uses a breath-pacer to facilitate the regularity of the breathing. The entire minute has to be artefact-free so that the six cycles of the minimum and the maximum can be determined. Participants' compliance has to be closely monitored as insufficient deep breathing or poor synchronization with the breath pacer may result in lower test results. The average duration for each HRV testing session is seven minutes. The PR who administered the HRV test was a Heartmath Certified Practitioner (See Appendix D).

Data Analysis

With the assistance from Mike Atkinson, Research Manager from Heartmath Institute (See Appendix H), Descriptive characteristics and Pearson correlation analysis between HRV measures (IBI, SDNN, RMSSD, MHRR, normalized coherence, Total power, Very low frequency, Low frequency and High frequency power along with the Low frequency/High frequency ratio), POQA and PSS scales were performed using the SPSS Version 22.0 (IBM Corp, 2013). The significance level for correlations was set at alpha of .05. To correct for skewness, HRV frequency domain measures and RMSSD were natural log transformed prior to performing the correlation analysis.

Limitations and Delimitations

Researcher Bias is a process where the researcher performing the research influence the results, in order to portray a certain outcome. Shuttleworth (2009) has described how researcher bias can occur in four ways as follow:

(1) Surrogate Information Error. Although the research is on workplace stress, however the stress stemming from the employees might have been non-workplace related such as family bereavement and loss, relationship breakdown, financial problems, family illnesses, commuting pressures, etc.

(2) Design Bias. This error may have occurred after the research has been completed and the results have been analyzed. For example, the group tested may have been mostly females or mostly males or all over a certain age.

(3) Inclusive Bias. This error may have occurred as a result of giving way to practical or administration convenience where in this research, participants might be coming from a certain department or line of service which tends to fit a narrow demographic range of the corporation.

(4) Measurement Bias. This might arise at the data collection stage and in the process of measuring. In this research study, participants in the study might be reluctant to give socially unacceptable answers when completing the questionnaires, for fear of being judged or might not be self-aware enough to provide accurate responses. This might skew the results and cause errors in the correlational analysis.

Summary

This research used a quantitative correlational approach by introducing a new quantitative measurement tool such as emWave Pro Plus which can measure the HRV of workplace employees and which can correlate the results with two sets of quantitative self-reported perceived stress questionnaires: POQA and PSS. The results generated from this research were expected to add to the existing body of knowledge related to contemporary workplace stress, a new stress measurement tool as well as HRV.

CHAPTER FOUR

RESULTS

This research studied workplace stress as experienced by full-time employees in an actual large corporation. The purpose of the quantitative correlation research was to introduce a new quantitative measurement tool such as emWave Pro Plus in the workplace and to compare HRV results with two other sets of quantitative self-reported measurements of stress. The following four research questions were examined:

1. In what way can HRV be used to accurately measure long-term effects of workplace stress in Hong Kong?
2. What are the effects of workplace stress in Hong Kong on HRV?
3. In what way does HRV compare with self-reports of stress in Hong Kong?
4. What is the overall level of comfort a typical Hong Kong employee experiences?

These questions were investigated with Pearson correlation analysis of HRV measures (IBI, SDNN, RMSSD, MHRR, normalized coherence, Total power, Very low frequency, Low frequency and High frequency power along with the Low frequency/High frequency ratio), POQA and PSS scales using SPSS Version 22.0 (IBM Corp, 2013) to examine the relationships between the new HRV measurements and the two quantitative self-reported perceived stress data.

Demographic Characteristics

Full-time employees from Company X were welcomed to participate in the research study. A total of 87 people signed the consent forms to participate, of which 2 were excluded due to technical artefacts in the dataset related to the one-minute of six deep-breath cycles protocol. This resulted in 85 participants who completed the HRV measurements, POQA and

PSS questionnaires. Frequency tables for the demographic characteristics are presented in Figure 12 to Figure 18, while descriptive statistics related to the research are presented in Table 2. The majority of the subjects were female (61.1%) and 38.8% were male. Most of the subjects were within the age 31-40 (47%). 43.5 % were within the age 21-30, and 8.2% were within the age 41-50. Only 1 subject was more than 50 years old and no subjects were under age 21.

The majority of participants reported working between 41-50 hours per week (47%); 21% of participants reported working between 36-40 hours per week; 17.6% working 51-59 hours per week and 14% reported working more than 60 hours.

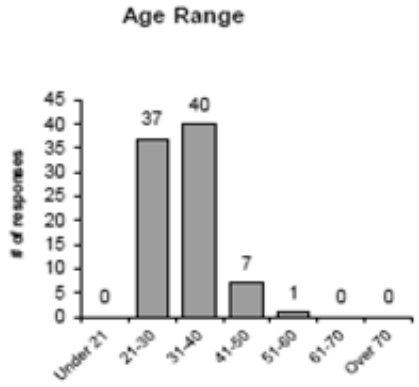

Figure 12: Age Range of participants as reported from POQA-R4.

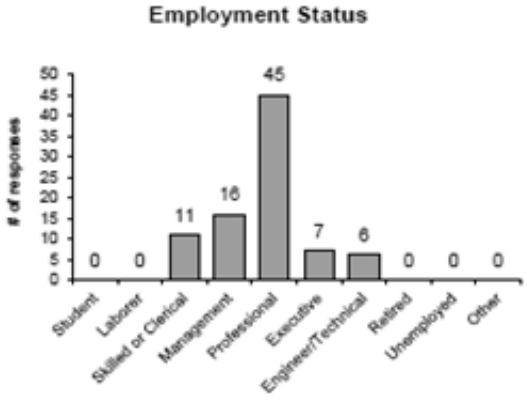

Figure 13: Employment Status of participants as reported from POQA-R4.

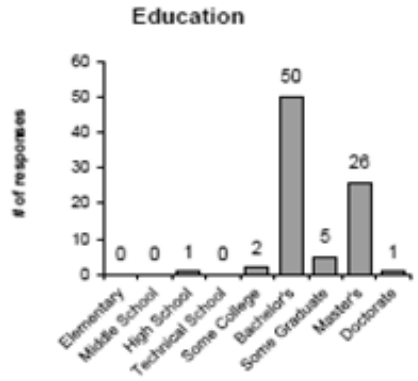

Figure 14: Education Levels of participants as reported from POQA-R4.

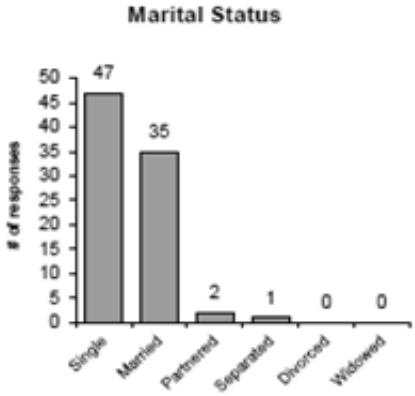

Figure 15: Marital Status of participants as reported from POQA-R4.

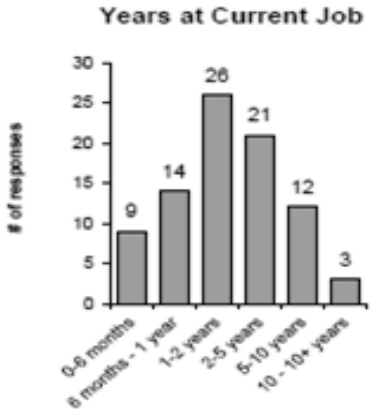

Figure 16: Years at Current Job of participants as reported from POQA-R4.

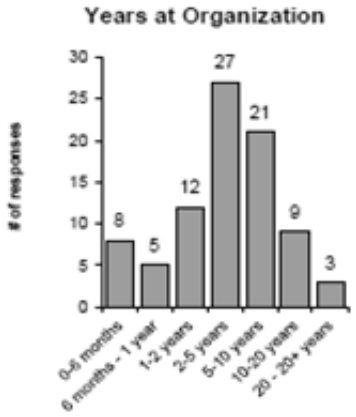

Figure 17: Years at Organization of participants as reported from POQA-R4.

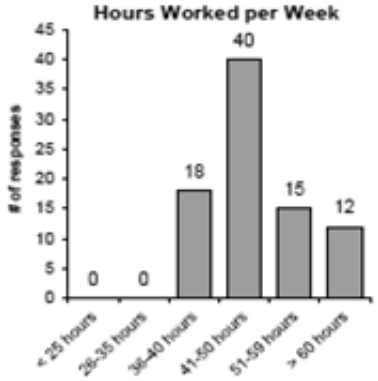

Figure 18: Hours Worked per Week of participants as reported from POQA-R4.

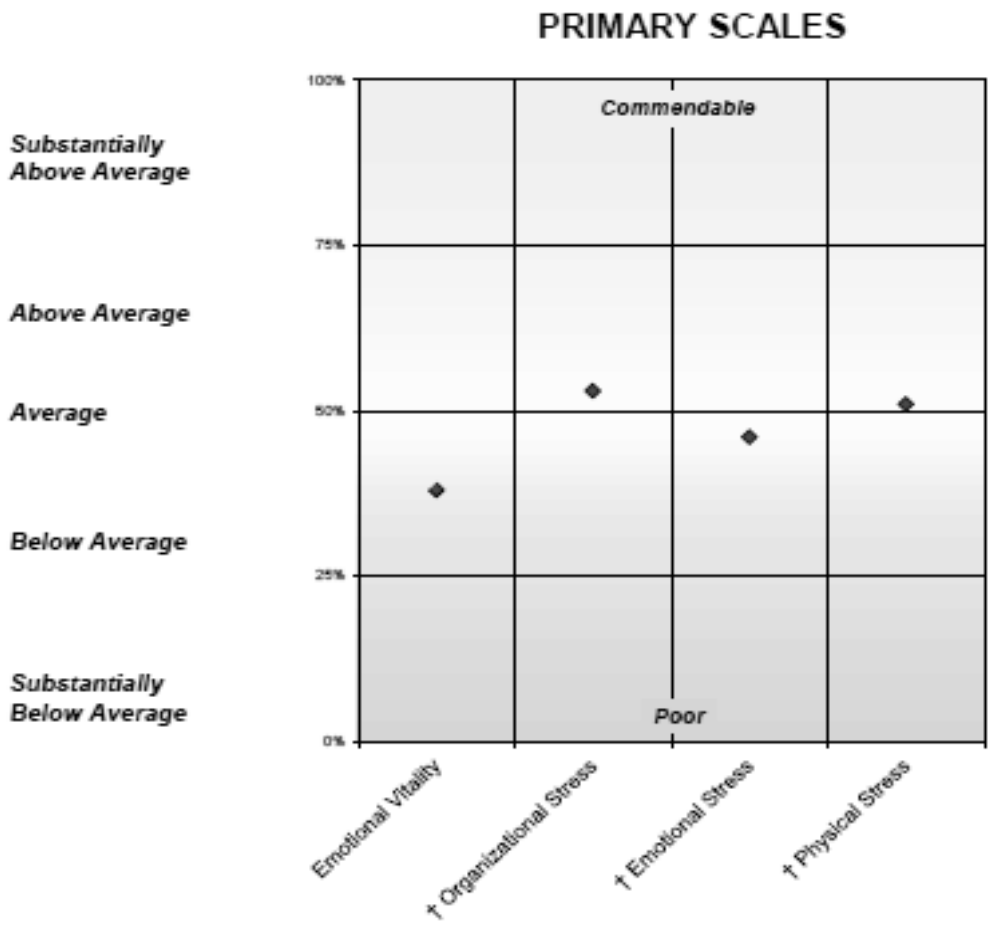

Figure 19: Organizational Scores as compared to norms from a large sample of 5971 employees as reported from the POQA-R4.

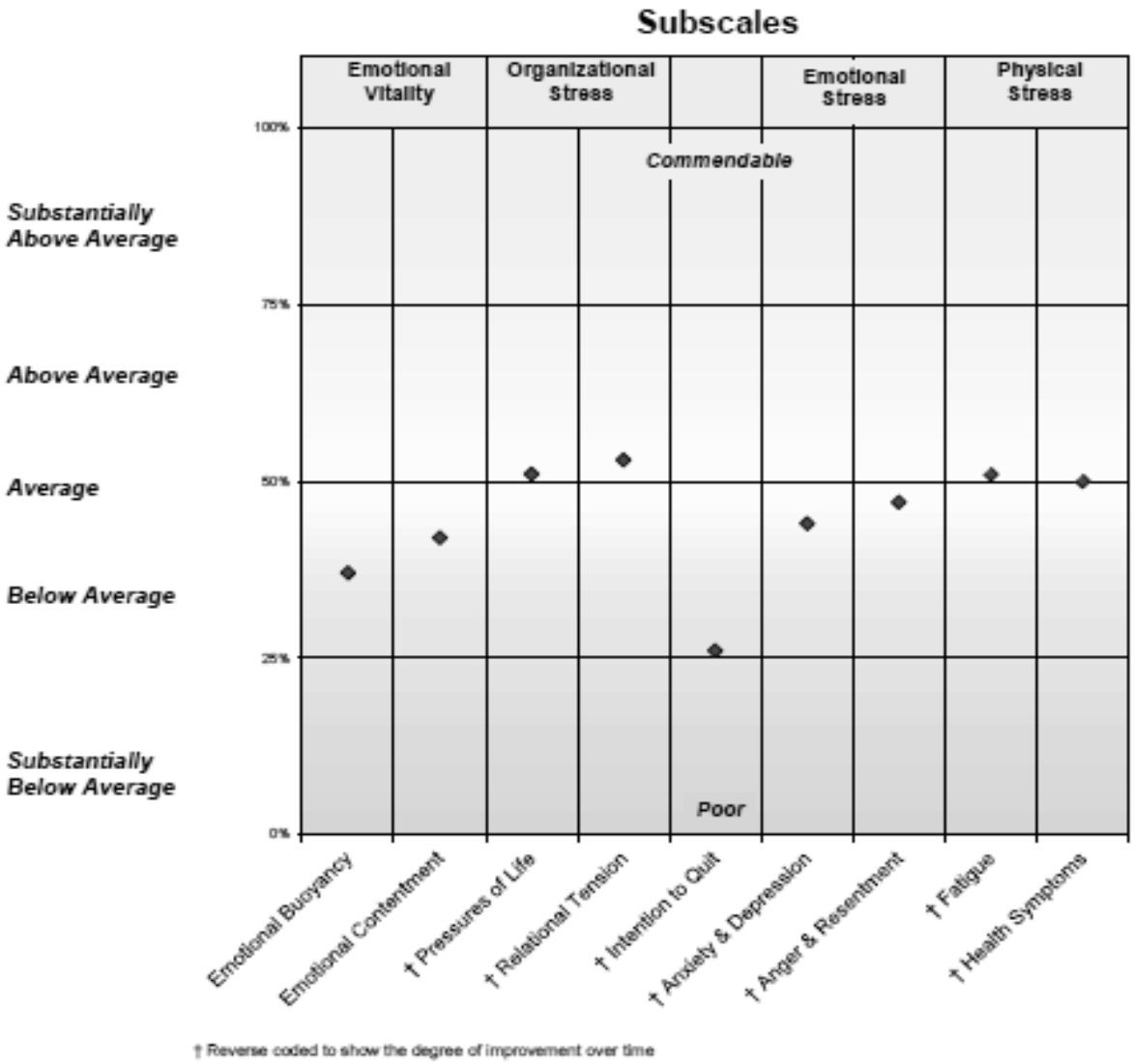

Figure 20: Associated Subscales as reported from the POQA-R4.

Table 2

Descriptive Statistics

	Male	Female			
Gender, n	33	52			
	N	Mean	SD	Min	Max
Age, y	85	32.65	6.10	23	54
1-Minute HRV Deep Breathing Assessment					
Mean Heart Rate, BPM	85	70.37	8.67	53	99.5
Mean Inter-beat interval, ms	85	874.92	104.47	623.7	1142.8
Mean Heart Rate Range, BPM	85	20.73	8.11	6.6	43.8
SDNN, ms	85	87.73	26.88	41.8	165.7
Ln RSSD, ms	85	4.08	0.36	3.4	5
Normalized Coherence, %	85	79.17	10.81	48	92.9
5-Minute Resting HRV					
Mean Heart Rate, BPM	85	69.03	9.86	37.3	100.1
Mean Inter-beat interval, ms	85	891.35	138.80	603.6	1616
SDNN, ms	85	53.70	15.65	25.3	97.3
Ln RMSSD, ms	85	3.77	0.33	3	4.7
Ln Total power, ms^2/Hz	85	6.54	0.73	4.8	7.8
Ln Very low frequency, ms^2/Hz	85	5.45	0.88	3.4	7.2
Ln Low frequency, ms^2/Hz	85	5.11	0.97	2.7	7.3
Ln High frequency, ms^2/Hz	85	5.14	0.80	3	6.8
Ln Low frequency / High frequency ratio	85	-0.04	0.95	-2.3	2.3

Normalized Coherence, %	85	38.93	9.72	18.5	71
Perceived stress scale	85	17.69	5.70	4	36
Personal and Organizational Quality Assessment – Revised					
Emotional Vitality	85	4.13	0.89	2.2	6
Organizational Stress	85	4.30	1.00	1.8	6.2
Emotional Stress	85	2.76	0.81	1.2	5.5
Physical Stress	85	3.16	0.89	1.3	5.1
Emotional Buoyancy	85	4.17	1.01	2.1	6.3
Emotional Contentment	85	4.07	1.01	2.3	6
Pressures of Life	85	4.45	1.24	1.2	6.6
Relational Tension	85	4.21	1.24	1.3	7
Stress	75	8.40	3.33	1	14
Anxiety & Depression	85	2.92	0.98	1.3	6.3
Anger & Resentment	85	2.62	0.80	1.1	4.9
Fatigue	85	3.75	1.21	1.3	6.5
Health Symptoms	85	2.78	0.86	1.2	5
Intention to Quit	85	3.89	1.66	1	7

Table 3

Pearson Correlations

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1. Age	-																															
1-Minute HRV Deep Breathing Assessment																																
2. Mean Heart Rate, BPM	-0.02	-																														
3. Mean Inter-beat interval, ms	0.01	-.983**	-																													
4. Mean Heart Rate Range, BPM	-0.18	.583**	-.533**	-																												
5. SDNN, ms	-.235*	-0.03	0.09	.723**	-																											
6. Ln RMSSD, ms	-0.20	-0.18	.240*	.623**	.885**	-																										
7. Normalized Coherence, %	0.05	0.07	-0.07	0.12	0.20	0.01	-																									
5-Minute Resting HRV																																
8. Mean Heart Rate, BPM	-0.01	.825**	-.814**	.433**	-0.15	-.250*	-0.06	-																								
9. Mean Inter-beat interval, ms	-0.03	-.751**	.777**	-.370**	0.19	.276*	0.07	-.956**	-																							
10. SDNN, ms	-.290**	-.326**	.358**	0.07	.423**	.439**	0.13	-.423**	.468**	-																						
11. Ln RMSSD, ms	-.395**	-.329**	.364**	0.14	.501**	.565**	0.09	-.453**	.496**	.781**	-																					
12. Ln Total power, ms^2/Hz	-.272*	-.273*	.294**	0.11	.405**	.429**	0.10	-.332**	.347**	.895**	.671**	-																				
13. Ln Very low frequency, ms^2/Hz	-.215*	-.357**	.377**	-0.13	0.16	.244*	-0.01	-.407**	.420**	.698**	.472**	.827**	-																			
14. Ln Low frequency, ms^2/Hz	-0.12	-0.09	0.12	0.19	.348**	.318**	0.08	-0.15	0.16	.744**	.526**	.831**	.536**	-																		
15. Ln High frequency, ms^2/Hz	-.402**	-.243*	.257*	0.20	.532**	.531**	0.16	-.323**	.330**	.736**	.835**	.664**	.394**	.465**	-																	
16. Ln Low frequency / high frequency ratio	0.21	0.10	-0.09	0.02	-0.10	-0.12	-0.07	0.12	-0.12	0.16	-0.16	.309**	.235*	.658**	-.357**	-																
17. Normalized Coherence, %	0.11	0.01	-0.03	0.02	0.11	0.04	0.07	-0.01	0.01	0.20	0.08	.284**	-0.02	.326**	.265*	0.10	-															
18. **Preceived stress scale**	0.03	0.18	-0.19	0.17	0.02	0.01	0.09	0.18	-.217*	-.255*	-.282**	-0.18	-0.13	-0.08	-0.19	0.07	-0.03	-														
Personal and Organizational Quality Assessment - Revised																																
19. Emotional Vitality	0.12	0.06	-0.03	-0.06	-0.14	-0.10	-0.07	0.07	-0.03	0.00	-0.03	-0.06	-0.07	-0.07	-0.05	-0.04	0.11	-.479**	-													
20. Organizational Stress	0.07	-0.15	0.16	-0.02	0.10	0.11	-0.01	-0.16	0.14	0.05	0.03	0.06	0.15	0.01	0.05	-0.04	-0.04	.411**	-.358**	-												
21. Emotional Stress	-0.08	0.12	-0.12	.216*	0.06	0.13	0.03	0.04	-0.07	0.03	0.05	0.08	0.10	0.11	0.03	0.08	-0.09	.723**	-.484**	.422**	-											
22. Physical Stress	-0.04	0.16	-0.17	0.17	0.03	0.06	0.20	0.05	-0.06	0.03	0.00	0.06	0.10	-0.01	0.08	-0.08	-0.03	.394**	-0.17	.382**	.561**	-										
23. Emotional Buoyancy	0.20	0.02	-0.01	-0.02	-0.08	-0.03	-0.06	0.08	-0.05	0.00	-0.05	-0.06	-0.09	-0.04	-0.05	-0.02	0.16	-.427**	.919**	-.314**	-.428**	-0.15	-									
24. Emotional Contentment	-0.02	0.08	-0.05	-0.10	-0.18	-0.16	-0.06	0.03	0.02	0.01	0.01	-0.03	-0.01	-0.07	-0.03	-0.06	0.03	-.428**	.836**	-.315**	-.435**	-0.17	.553**	-								
25. Pressures of Life	-0.02	-0.16	0.18	-0.07	0.05	0.06	0.11	-0.18	0.17	0.07	0.07	0.05	0.16	-0.02	0.10	-0.11	-0.13	.381**	-.344**	.899**	.430**	.400**	-.339**	-.252*	-							
26. Relational Tension	0.14	-0.07	0.08	0.04	0.12	0.10	-.222*	-0.05	0.04	-0.02	-0.05	0.04	0.04	0.03	-0.02	0.05	0.13	0.21	-0.18	.725**	0.15	0.12	-0.12	-0.20	.393**	-						
27. Stress	0.17	-0.04	0.03	0.04	0.07	0.12	0.02	-0.10	0.05	0.03	-0.02	0.02	0.08	0.02	-0.04	0.07	-0.03	.378**	-.266*	.430**	.395**	.320**	-0.18	-.318**	.240*	0.19	-					
28. Anxiety & Depression	-0.15	0.13	-0.13	0.19	0.05	0.12	-0.01	0.06	-0.09	0.06	0.09	0.09	0.10	0.07	0.06	0.03	-0.11	.669**	-.517**	.406**	.918**	.514**	-.489**	-.417**	.406**	0.14	.429**	-				
29. Anger & Resentment	0.01	0.08	-0.08	0.20	0.05	0.12	0.06	0.02	-0.04	-0.01	-0.01	0.06	0.07	0.13	-0.01	0.13	-0.05	.649**	-.360**	.362**	.905**	.509**	-.285**	-.374**	.377**	0.14	.278*	.661**	-			
30. Fatigue	-0.07	0.18	-0.18	0.20	0.05	0.08	0.14	0.04	-0.05	0.00	0.03	0.02	0.07	-0.03	0.08	-0.10	-0.03	.428**	-0.17	.458**	.606**	.883**	-0.13	-0.18	.464**	0.18	.367**	.580**	.524**	-		
31. Health Symptoms	0.00	0.11	-0.13	0.11	-0.01	0.02	0.21	0.05	-0.06	0.05	-0.03	0.08	0.10	-0.01	0.06	-0.06	-0.02	.287**	-0.15	.229*	.406**	.902**	-0.15	-0.12	.254*	0.04	0.21	.354**	.387**	.594**	-	
32. Intention to Quit	-0.06	-0.13	0.12	-0.09	0.04	0.08	0.07	-0.15	0.12	0.12	0.15	0.19	.234*	0.10	0.13	0.00	0.04	.400**	-.389**	.557**	.444**	.288**	-.436**	-0.21	.536**	.325**	.284*	.455**	.350**	.335**	0.19	-

Correlation, significance (2-tailed). * $p < 0.05$, ** $p < 0.01$

Quantitative Data Results

HRV and Subjective Stress

Three significant negative correlations were found between Subjective Stress and HRV measures: (1) Perceived Stress and 5-minute Mean Inter-Beat-Interval (IBI), r = -0.217*; (2) Perceived stress and 5min SDNN, r = -0.255* and (3) Perceived stress and Ln 5min RMSSD, r = -0.282** (see Table 3).

HRV and Age

Significant negative correlations were found between age and the HRV measures; 1-minute SDNN ($r = -.235$, $p < 0.01$), 5-minute SDNN ($r = -.290$, $p < 0.01$), 5-minute RMSSD ($r = -.395$, $p < 0.01$), Total Power ($r = -.272$, $p < 0.05$), Very Low Frequency ($r = -.215$, $p < 0.05$) and High Frequency ($r = -.402$, $p < 0.01$). There are more significant relationships between the HRV measurements during the 5-minute resting period than with the 1-minute Deep Breathing Assessment.

HRV and Emotional Stress

First of all, a significant positive correlation was found between Emotional Stress and the Mean Heart Rate Range (MHRR), r = 0.216* (see Table 3).

HRV and Relational Tension

A significant negative correlation was found between Normalized Coherence and Relational Tension ($r = -.222$, $p < 0.05$).

Very Low Frequency (VLF) and Intention to Quit

A significant positive correlation was found between Intention to Quit and 5-minute Ln Very Low Frequency (VLF), r = 0.234* (see Table 3).

PSS and POQA-R4

The PSS and POQA-R4 were strongly correlated, except for Relational Tension.

A Summary of Results

This chapter presented descriptive statistics and quantitative correlational results between HRV (Objective Stress), PSS and POQA-R4 (Subjective Self-Reported Stress) that attempted to answer the following research questions.

Research Question 1: In what way can HRV be used to accurately measure the effects of workplace stress in Hong Kong?

HO: There is no (statistically significant) relationship between HRV and Workplace Subjective Stress (H0: r=0).

H1: There is a (statistically significant) relationship between HRV and Workplace Subjective Stress (H1: r<>0).

Since there were three significant negative relationships between perceived stress scale (short term stress) and HRV; Perceived stress and 5min IBI, r= -0.217*, Perceived stress and 5min SDNN, r= -0.255* and Perceived stress Ln 5min RMSSD, r= -0.282**, H0 would be rejected. This indicates that overall HRV is significantly correlated with short-term perceived workplace stress.

Research Question 2: What are the effects of workplace stress in Hong Kong on HRV?

A negative relationship between short-term perceived stress and HRV means that the lower the short term perceived stress, the higher the overall HRV the person is capable of producing. Moreover, a significant positive correlation was found between Emotional Stress and the Mean Heart Rate Range (MHRR), r = 0.216*, which indicates that the higher the emotional stress an employee faces, the higher his or her HRV.

Research Question 3: In what way does HRV compare with self-reports of stress in Hong Kong?

The participants self-report results on the POQA revealed the stressors and after effects of employee stress. Comparing the four primary scales of the organizational scores to norms from a large convenience sample of 5971 working adults, Figure 19 shows that out of the four primary scales: emotional vitality, organizational stress, emotional stress and physical stress, with emotional vitality and emotional stress within the Below Average range. From the correlational analysis, it was reported that a significant positive correlation was found between Emotional Stress and the Mean Heart Rate Range (MHRR), $r = 0.216^*$, which indicates that the higher the emotional stress an employee faces, the higher his or her HRV. Moreover, from the associated subscales in Figure 20, out of the nine subscales, Emotional Buoyancy, Emotional Contentment, Intention to Quit, Anxiety & Depression, and Anger & Resentment were within the Below Average range. A significant positive correlation was found between Intention to Quit and 5 minute Ln Very Low Frequency (VLF), $r = 0.234^*$ which indicates that healthier employees may have higher intentions of quitting their jobs.

Research Question 4: What is the overall level of comfort a typical Hong Kong employee experiences?

A significant negative correlation was found between age and the HRV measures; 1 minute SDNN ($r = -.235$, $p < 0.01$), 5 minute SDNN ($r = -.290$, $p < 0.01$), 5 minute RMSSD ($r = -.395$, $p < 0.01$), Total Power ($r = -.272$, $p < 0.05$), Very Low Frequency ($r = -.215$, $p < 0.05$) and High Frequency ($r = -.402$, $p < 0.01$). This indicates that the older the employee, the lesser his or her overall HRV.

A significant negative correlation was also found between Relational Tension and Normalized Coherence ($r = -.222$, $p < 0.05$), which may indicate that the healthier an employee, the lesser the relational tension.

The mean PSS score is 17.69 where 13 is considered average while 20 or above is considered High Stress. On the other hand, the mean overall stress score in the POQA is 8.4 where 0 is the lowest (Most Calm) and 14 is the highest (Most Stressed). Moreover, from the descriptions in Research Question 3, out of the four primary scales: emotional vitality, organizational stress, emotional stress and physical stress, both emotional vitality and emotional stress are within the Below Average range while the rest of the scales are in the average range.

The next chapter presents an interpretation and discussion of the results followed by the conclusions and summaries regarding the findings linked to the relevant research, limitations and implications of the study and recommendations for future research.

CHAPTER FIVE

A DISCUSSION ON THE FINDINGS

In this chapter, the major results and findings of the research are discussed. In addition, the limitations faced while conducting the study are presented. The final section of the chapter provides recommendations for future research.

Research on workplace stress measurements varied without much accuracy and effectiveness (Penny George Institute for Health & Healing, 2012; Feldman, Greenson, & Senville, 2010; Newman & Beehr, 1979). Moreover, one of the gaps is the usage of outdated assessments to measure workplace stress (Centre for Studies on Human Stress, 2012).

This resulted in two purposes of this research: One purpose of this study was to introduce a new practical assessment such as emWave Pro Plus which assesses employee stress with HRV as a biomarker using a specific protocol. The second purpose of this research study was to explore the correlational ties between quantitative HRV measurements and two other sets of quantitative data to assess workplace stress of employees in Hong Kong: the Personal and Organizational Quality Assessment (POQA) from Heartmath (Barrios-Choplin & Atkinson, 2000) and the Perceived Stress Scale (PSS) (Cohen, Kamarck, & Mermelstein, 1983).

To recall, the following four research questions were examined:

1. In what way can HRV be used to accurately measure the effects of workplace stress in Hong Kong?
2. What are the effects of workplace stress in Hong Kong on HRV?
3. In what way does HRV compare with self-reports of stress in Hong Kong?
4. What is the overall level of comfort a typical Hong Kong employee experiences?

These questions were investigated with Pearson correlation analysis between HRV measures (IBI, SDNN, RMSSD, MHRR, normalized coherence, Total power, Very low frequency, Low frequency and High frequency power along with the Low frequency/High frequency ratio), and the POQA and PSS scales using SPSS Version 22.0 (IBM Corp, 2013) to examine the relationships between the new HRV-assessment and the two quantitative self-reported perceived stress data.

A Discussion on the Findings

The results of the correlation analysis are important as an attempt to answer basic questions for the unit analyzed and significant associations (Creswell, 2015).

Research Question 1. In order for the researcher to test the hypothesis as to whether HRV can be used to accurately measure workplace stress in Hong Kong, the researcher has cited how both subjective and objective aspects are required to measure workplace stress as they are interrelated (Ezoe & Morimoto, 1994; Jarvelin-Pasanen et al., 2013; Parkka et al., 2009). It was of the researcher's interest to investigate how well the POQA and PSS correspond with HRV, an objective measure, which can reflect the balance between an employee's individual resources and demands of the workplace environment. Both HRV and PSS were described to be a strong independent predictor of future health as well as indicators of workplace stress (Ezzati et al., 2014; McCraty & Shaffer, 2015). In this study, it was hypothesized that POQA and PSS would have a negative correlation with HRV.

In line with the findings of previous studies, there were more significant relationships between the HRV measures and PSS than with the POQA. Most historical workplace stress research that correlates HRV with workplace stress shows a negative correlation between the variables. For instance, the results are consistent with those of Da Silva et al. (2015) when they

assessed the correlation between PSS and HRV parameters and reported that the increase in perceived stress is correlated to a lower heart rate variability in healthy young subjects. Moreover, Da Silva et al analyzed data from 35 healthy young volunteers and found a significant correlation between Perceived stress and Low Frequency-LF (ms2) by frequency domain HRV analysis. Probably due to the smaller number of subjects, other global variables such as Total Power and SSDN had also negative coefficients, but did not have any significant correlation with PSS-14, yet this study contributed to the literature three additional significant negative correlations between PSS and HRV, with (1) Perceived Stress and 5 minute Mean Inter-Beat-Interval (IBI); (2) Perceived stress and 5min SDNN, and (3) Perceived stress and Ln 5min RMSSD.

Similarly, Fohr et al. (2015) found that subjective self-reported stress has been associated with the objective physiological stress which is consistent with the result of this research. Hence, Fohr et al suggested that the objective stress assessment such as HRV provides an additional aspect to the evaluation of stress.

Research Question 2. It was surprising to see a significant positive correlation between Emotional Stress and the Mean Heart Rate Range (MHRR), which indicates that the higher the emotional stress an employee faces, the higher his or her HRV. At first glance, it seems counter-intuitive, however, the researcher offers four perspectives to explain this surprising finding.

***Personality*.** According to Turiano et al. (2013), it appears that an employee can be a "healthy neurotic." Turiano and his team concluded that the health anxiety that employees who are high in neuroticism or emotional stress may feel adaptive when it is accompanied by high conscientiousness. In other words, neuroticism or emotional stress may lead the person to worry but conscientiousness leads the person to be self-disciplined and to take action when one's

behavior veers into the unhealthy range. The unhealthy neurotics are the ones whose low conscientiousness means that they have fewer healthy coping mechanisms. Turiano et al further pointed out that when employees were stressed and unhappy, they might turn to overeating, drinking, and smoking. Nevertheless, they said that it was possible that other known health culprits could play a role such as lack of sleep, or even a relationship conflict.

Asian Culture. Numerous research studies have established that using emotion suppression, whether routinely or experimentally-induced, is associated with the unhealthy well-being (Tsai, 2016). Moreover, emotion suppression eliminates the experience of positive emotions while enhancing the experience of negative emotions. Contrary to western cultures, the Asian culture tends to mask negative emotions which are deemed as signs of maturity and awareness. In addition, their reluctance to express negative emotions have potential negative relational concerns which threaten group harmony. This may provide insights to the current research which holds the view that unhealthy Asian employees tend to suppress their emotions and that the suppressed emotions are not regulated successfully.

Emotion Regulation. Emotion regulation involves the process by which people manage both negative and positive emotions. Furthermore, successful emotion regulation, by either reappraisal or suppression, has been shown to lead to increased vagally mediated HRV (Fujimura & Okanoya, 2012). Fujimura and Okanoya therefore suggest that healthier employees (in this research study) are able to better regulate their emotional stress as compared to the unhealthier ones because participants with a high baseline of vagally mediated HRV may be spontaneously using emotion regulation strategies more often during an emotional conversation than participants with a low baseline of vagally mediated HRV.

Age Factor. As the majority of the participants in this research were between the age of 21 and 40 (considered as a young population group), according to R. McCraty, these participants are possibly still physiologically resilient and as the amount of HRV reflects long-term processes, emotional stress traits would not show up until later in life, reflecting a depletion of the wear and tear on the ANS (personal communication, October 10, 2017).

Research Question 3. From the POQA, the low score of emotional vitality indicates low scores on both Emotional Buoyancy and Emotional Contentment Subscales. A low score on the Emotional Buoyancy subscale indicates that it is likely that the employees feel that they have low levels of emotional energy available for investment in their work and personal lives. A low score on the Emotional Contentment subscale suggests that the employees may be feeling only low levels of contentment and inner peace with their lives, both at work and off the job.

On the same side of the coin, the low score of emotional stress as shown in Figure 19 indicates low scores on both the Anxiety/Depression and the Anger/Resentment subscale (Figure 20). When looking at the normative summary scales which are reverse coded, low scores on the Anxiety/Depression subscale indicate that a notable proportion of employees may be experiencing high levels of anxiety, unhappiness, sadness, and/or depression. Low scores on the Anger/Resentment subscale indicate that a notable proportion of employees may be experiencing high levels of anger and resentment and may experience difficulty in controlling their feelings and emotions.

Hence, from the correlational analysis, it was reported that a significant positive correlation was found between Emotional Stress and Mean Heart Rate Range (MHRR), which indicates that the higher the emotional stress an employee faces, the higher his or her HRV. Discussions on this were noted in Research Question 2.

Intention to Quit. The poor score on this subscale in the POQA indicates that there is an increased likelihood of a notable proportion of employees who are feeling sufficiently dissatisfied with their work environment and that they are thinking about leaving the organization (i.e., quitting their jobs). Yet another surprising finding from the research is that a significant positive correlation between Intention to Quit and 5 minute Ln Very Low Frequency (VLF) which indicates that healthier employees may have higher intentions of quitting their jobs. From the literature review, a Very Low Frequency (VLF) peak, ranging between 0.0033 and 0.04 Hz, is associated with an increased risk of adverse effects, and the VLF has stronger correlations with "all-cause mortality" than HF and LF power. According to McCraty & Shaffer (2015), a lower VLF is the most predictive of future health problems, since a low VLF power is associated with arrhythmic death and posttraumatic stress disorder. Furthermore, the low power in VLF is associated with high inflammation and has been correlated with low levels of testosterone (McCraty & Shaffer, 2015).

Trying to make sense that healthier employees have an intention to quit, according to Porges (2016), from a polyvagal perspective, when an employee is in a situation that resembles a life-threatening situation, he or she may be unable to utilize mobilization strategies (quitting their jobs) or use social engagement strategies (relating to other colleagues) to get out of the situation. Additionally, the "neuroception" features of that challenge may cause that employee to experience a shutdown condition, which is characterized by the old unmyelinated vagus and coupled with reduced blood flow, especially blood flow to the brain and exhibiting dissociative features. Porges further stated that the greater issue is not the traumatic experience at the workplace, but the making sense of the physiological response that the traumatic event has triggered. In other words, it is not just about the bad event but the consequences of that event on

the employees' physiology and on their nervous systems that is profoundly changing their ability to adapt in the workplace. This may well explain why employees who are not having intentions to quit are what Porges has coined as "immobilized with (or without) fear".

Research Question 4. In line with previous research findings, significant findings between age and the HRV measures indicate that the older the employee, the lesser his or her overall HRV (Russoniello et al., 2013). It is surprising however that the MHRR in the 1 min deep breathing assessment was not as significantly related to age, especially as age was highly correlated with the SDNN and RMSSD in the 5 minute resting HRV assessment. A possible explanation for this is that the 1 min deep breathing assessment is a challenge test that is getting at how much overall HRV the participants' system is capable of producing at that time. Having that in mind, the majority of the participants in this research were between the age of 21 and 40 (considered as a young population group), which possibly explains why the age correlations in the 1 min assessments were not stronger if the age range was not wide enough (R. McCraty, personal communication, September 22, 2017).

Relational Tension. A significant negative correlation was also found between Relational Tension and Normalized Coherence, which may indicate that the healthier an employee, the lesser the relational tension. According to R. McCraty, relational tension is clearly a source of stress, and he suggests that it is one of the most harmful types of stress. When there is a lower coherence in the 1-min test, especially if the amount of HRV is within the normal range (MHHR, and SDNN), he suspects that it indicates an issue with the coupling of the respiratory and the cardiovascular systems within the brainstem. He postulates that this will eventually be shown to be an early warning indicator and is associated with future health challenges (personal communication, September 26, 2017).

Furthermore, McCraty (2017) states that relational tension due to lack of coupling and alignment with others may be reflected in lower coupling of the respiratory and cardiovascular systems. He describes how HRV synchronization between mothers and young children nourishes a biological synchronized rhythm which provides the foundation for a social rhythm for the child. Hence, the development of one's internal biological oscillators is critical to future social connection and self-regulation.

Where relational tension is concerned, Porges (2017) suggests that "toxic load" should be understood from the psychological and physiological standpoint such as bodily cues. A healthy employee needs to feel "safe" not just physically but "as an emotion, mood or affective state" as well. Porges postulates that physiologically, it is of paramount importance to feel safety such as how the employee's nervous system desires to feel safe. A decrease in relational tension can be seen as having "effective social interactions" among colleagues, superiors and subordinates which "may actively dampen defense systems and, when defense is down-regulated…[employee's] physiological sate provides neural opportunities for [one] to learn and to form strong social bonds while simultaneously supporting health, growth and restoration", thus healthier employees (Porges, 2017, p. 115). Porges instigates the significance of social interactions in enabling employees to feel safe because an absence of compassionate face-to-face interactions among colleagues which include bodily cues and vocal cues with warm controlled voices triggers bodily state shifts which fuels the internal defenses and foster miscommunication and misunderstandings amongst colleagues such as "task instructions". Moreover, the researcher has observed how the increased use of technology in the workplace such as online chats dampens face-to-face interactions. Porges further describes how the Social Engagement system activates the Vagus nerve where for instance, having calm conversations will not only enhance connection

with other colleagues but it triggers neural circuits in our bodies that calm the heart, relax the gut and turns off the fear response. The Vagus nerve is further described as having the ability to transmit messages quickly from the brain stem to the heart, lungs, and intestines. Moreover, the Vagus nerve regulates some facial muscles, including the ear, and can enhance our ability to give others appropriate facial cues and even hear others better. Hence, the Vagus nerve influences the employee's heart rate and breathing, and is involved in how an employee perceives, reacts and recovers from stress. When an employee feels confident in a social context, his or her heart rate and breathing slows down, the blood pressure drops with stress responses switching off. The body enters a state of physical calmness. Hence, an employee feels safe to move closer to another colleague, making intimacy possible. Therefore, social engagement can enhance our sense of safety, creating a positive feedback loop which leads to further calming. On the other hand, if the body detects that he or she (an employee) is in "danger", it switches to the fight/flight response, driven by the body's HPA (Hypothalamic-Pituitary-Adrenal) Axis, which changes into symptoms of anxiety in the workplace context.

Mean Score. The mean PSS score is 17.69 where 13 is considered average while 20 or above is considered High Stress. On the other hand, the mean overall stress score in the POQA is 8.4 where 0 is the lowest (Most Calm) and 14 is the highest (Most Stressed). In this study, the correlational analysis between PSS and POQA are significantly correlated, therefore, this suggests that the overall level of comfort an employee experiences is a level close to High Stress. Moreover, from the discussions in Research Question 3, out of the four primary scales: emotional vitality, organizational stress, emotional stress and physical stress, both emotional vitality and emotional stress are within the Below Average range, while the rest of the scales are in the average range. The poor score on the Intention to Quit subscale of POQA is the most

surprising finding and is considered a red flag to management as it indicates that a notable proportion of employees are feeling sufficiently dissatisfied with their work environment that they are thinking about quitting their jobs.

Limitations and Delimitations

A limitation of measurement bias might have occurred since the survey data was self-reported, results depended on the effort and honesty of each participant. Participants in the study might have been reluctant to give socially unacceptable answers in the questionnaires, for fear of being judged or are not self-aware enough to provide accurate responses. This might skew the results and caused errors in the correlational analysis. Since the research was on workplace stress, another limitation of surrogate information error might have occurred because the stress the employees experienced might have been non-workplace related such as family bereavement and loss, relationship breakdown, financial problems, family illnesses, commuting pressures, etc. It was also observed that the age range of the participants seemed to have skewed towards the younger population group of 21-40 and this might have led to a design bias limitation. Furthermore, participants that came from four lines of services within the corporation were not equally distributed – Department A (57.6%), Department B (11.7%), Department C (22.3%) and Department D (8.2%), which might have delineated a narrow demographic range of the corporation known as a measurement bias (Shuttleworth, 2009).

According to an article search, this was the first research conducted on the relationship between HRV, POQA and PSS in Hong Kong and using HRV as a potential physiological objective measurement for workplace stress. The sample size (n=85) of HRV measures was relatively large compared to other research studies and according to Clinical & Translational

Science Institute (2017), the total sample size was of a significant level to achieve a power of .80 and an estimated effect size of .30.

Implications for Office Work

The overall research stresses that an average employee experiences a close to high level of workplace stress on a regular basis and therefore presenting a universal threat to organizational costs and workplace performance. The research data has concluded that emotional stress and relational tension are inherent in the workplace. Emotional stress may deplete one's internal resources regardless of whether one is healthy or non-healthy. Consequently, employee turnover may occur when employees are dissatisfied with the workplace environment. Besides, existing employees who do not have any intention of quitting may be exhibiting immobilization with (or without) fear, leading to a drop in workplace performance. It is therefore very critical to find new and effective tools such as HRV assessments to measure and monitor stress as well as having effective interventions to reduce and prevent workplace stress.

Implications for individuals. During the research study, all participants received a 5 to 10 minutes of Quick Coherence therapy where they learned skills of heart-focused breathing to respond to their perceived stress. This technique is simple, discrete, portable, fast and effective which makes it applicable at the workplace and elsewhere.

Implications for organizations. It is recommended that organizations ought to implement organizational resilient strategies such as Mindfulness Psychology as an integral part of a strategic framework of change management initiatives. The act of being mindful for employees and leaders within an organization means to be aware in the present moment, intention in thought and purposeful in action. Additionally, beneficial outcomes for the overall

organization include competitive advantages, employee engagement, decreased attrition, increased productivity, better wellbeing, leadership development, better collaboration leading to healthier organizational culture, climate, longevity and social coherence.

Implications for OD. The outcome of this research provides OD a possibility to inculcate a culture of open-mindedness and to explore new concepts rooted in quantum physics and stress. Secondly, this research provides OD with an opportunity to develop new theories, skills and tools to pioneer the next generation of OD scholar-practitioners, adding to the body of knowledge as well as ensuring the longevity of OD. For instance, employees are more than a brain and a body but are constantly surrounded by a measurable human energy biofield that impacts individuals on emotional, physical, psychological levels as well as the people around them.

Recommendations for Further Research

A purpose of having future research is to align the various researches with the social and global Coherence notion propelled by the Heartmath Institute. Future research will continue to address topics ranging from stress to reducing violence, reducing health costs, emotional regulation, biofeedback interventions, stress management and even other non-workplace topics such as the academic performance of children of different ages, PTSD, intuition, and much more. Hence, further research on the effects of employee stress and HRV needs to be conducted. The researcher has several suggestions for future research.

Repeat research. Similar research can be conducted in other Asian countries such as Singapore, Taiwan with a more diversified age group. A second way is to repeat the research with other subjective perceived stress surveys.

Heart-brain and face-heart connections. Integrating the works of McCraty (2017) and Porges (2017), comparable studies on heart-brain and face-heart connections can be further explored to add to the current body of knowledge regarding relational tension and resilience.

HRV research. Future research studies could use HRV stress measurements to evaluate the effectiveness of stress management interventions. Based on the findings, organizations can objectively identify the most effective intervention types and customize an employee assistance program to reduce workplace stress. Another study could include repeating the original research with additional primary biomarkers which can serve as confirmatory approaches.

Conclusion

This research has explored the correlation between a new quantitative stress measurement known as the emWave Pro Plus and compared it with two other sets of quantitative self-reported perceived stress data: the Personal and Organizational Quality Assessment (POQA) from Heartmath (Barrios-Choplin & Atkinson, 2000) and the Perceived Stress Scale (PSS) (Cohen, Kamarck, & Mermelstein, 1983). This research has looked at the effects of Hong Kong Employees' Workplace Stress on Heart Rate Variability (HRV).

Results from the study show that three significant negative correlations were found between Subjective Stress and HRV measures: (1) Perceived Stress and 5 minute Mean Inter-Beat-Interval (IBI); (2) Perceived stress and 5min SDNN; and (3) Perceived stress and Ln 5min RMSSD (see Table 2). It has been shown that HRV is an accurate objective measure for the short-term perceived workplace stress.

Three surprising findings have been found in the research in terms of Emotional Stress, Intention to Quit and Relational Tension. Firstly, a significant positive correlation has been found between the Emotional Stress and the Mean Heart Rate Range (MHRR), which indicates

that the higher the emotional stress an employee faces, the higher his or her HRV. Secondly, a significant positive correlation has been found between Intention to Quit and 5 minute Ln Very Low Frequency (VLF), which indicates that healthier employees may have higher intentions of quitting their jobs. Thirdly, a significant negative correlation has been found between Relational Tension and Normalized Coherence, which may indicate that the healthier an employee, the lesser the relational tension. Discussions have been held to explain these surprising findings in order to make sense of the data. The research shows promising results and future studies should continue to tap into HRV as an objective measure of mental health and workplace stress.

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Appendix A: Perceived Stress Scale (PSS-10) with Scoring

The following questions ask about your feelings and thoughts during THE PAST MONTH. In each question, you will be asked HOW OFTEN you have felt or thought in a certain way. Although some of the questions are similar, there are small differences between them and you should treat each one as a separate question. The best approach is to answer fairly quickly. That is, don t try to count up the exact number of times you felt in a particular way, but tell me the answer that in general seems the best.

For each statement, please tell me if you have had these thoughts or feelings: never, almost never, sometimes, fairly often, or very often. (Read all the answer choices each time)

Never Almost Never Sometimes Fairly Often Very Often

B.1 In the past month, how often have you been upset because of something that had happened unexpectedly? 0 1 2 3 4

B.2 In the past month, how often have you felt unable to control the important things in your life? 0 1 2 3 4

B.3 In the past month, how often have you felt nervous or stressed?

0 1 2 3 4

B.4 In the past month, how often have you felt confident about your ability to handle personal problems? 0 1 2 3 4

B.5 In the past month, how often have you felt that things were going your way?

0 1 2 3 4

B.6 In the past month, how often have you found that you could not cope with all the things you had to do? 0 1 2 3 4

B.7 In the past month, how often have you been able to control irritations in your life?

0 1 2 3 4

B.8 In the past month, how often have you felt that you were on top of things?

0 1 2 3 4

B.9 In the past month, how often have you been angry because of things that happened that were outside of your control? 0 1 2 3 4

B.10 In the past month, how often have you felt that difficulties were piling up so high that you could not overcome them? 0 1 2 3 4

Perceived Stress Scale Scoring

Each item is rated on a 5-point scale ranging from never (0) to almost always (4). Positively worded items are reverse scored, and the ratings are summed, with higher scores indicating more perceived stress.

PSS-10 scores are obtained by reversing the scores on the four positive items: For example, 0=4, 1=3, 2=2, etc. and then summing across all 10 items.

Items 4, 5, 7, and 8 are the positively stated items.

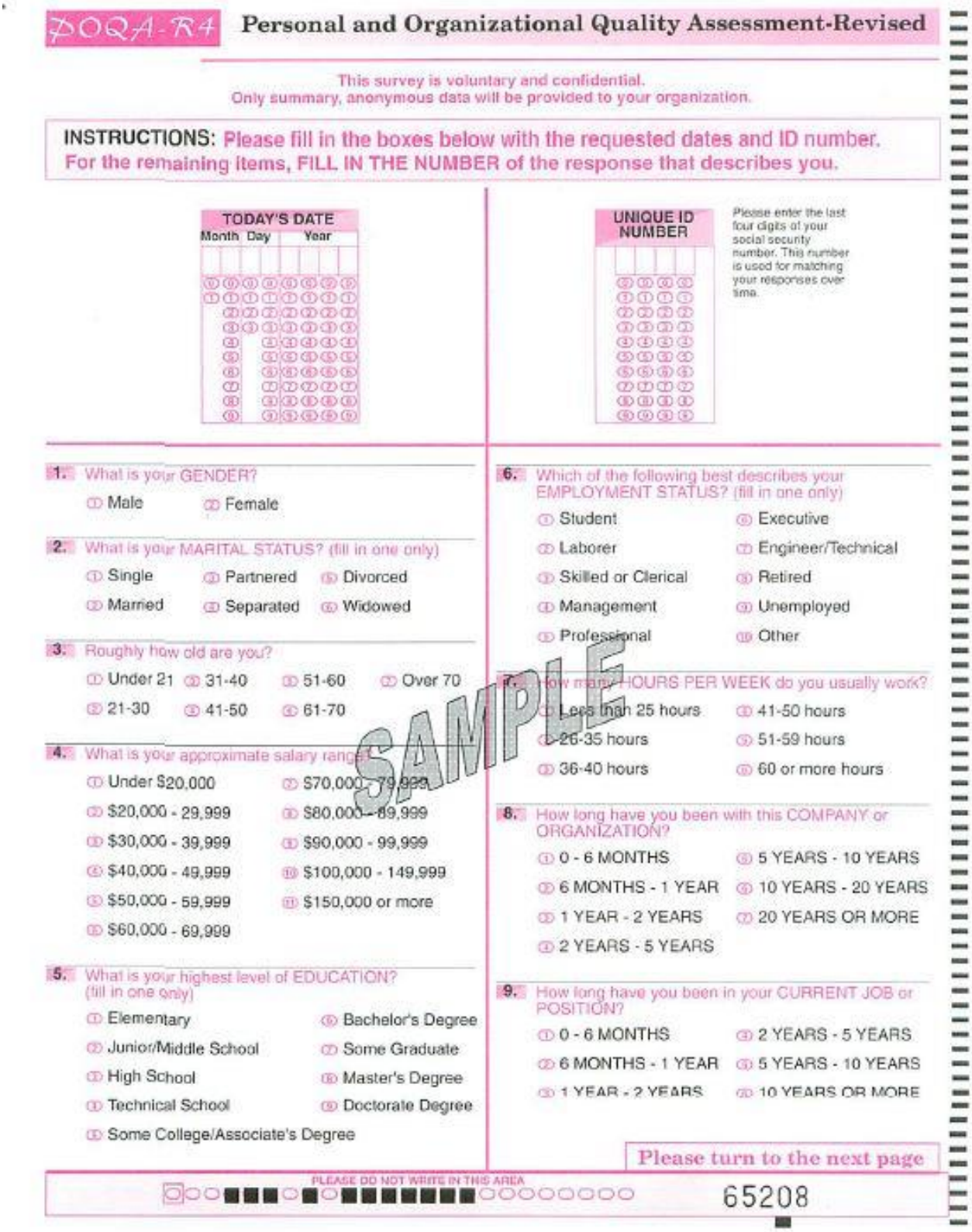
Your Perceived Stress Level was _____

Scores around 13 are considered average. In our own research, we have found that high stress groups usually have a stress score of around 20 points. Scores of 20 or higher are considered high stress, and if you are in this range, you might consider learning new stress reduction techniques as well as increasing your exercise to at least three times a week. High psychological stress is associated with high blood pressure, higher BMI, larger waist to hip ratio, shorter

telomere length, higher cortisol levels, suppressed immune function, decreased sleep, and increased alcohol consumption. These are all important risk factors for cardiovascular disease.

Dr. Cohen's Scales: We welcome copies (e-mail is OK) of any in press or published papers using any of Dr. Cohen's scales that you are willing to share with us, and thank you in advance for your generosity. They will not be redistributed or linked without your permission.
Permission for use of scales is not necessary when use is for nonprofit academic research or nonprofit educational purposes. (Retrieved on May 18, 2017 from http://www.psy.cmu.edu/~scohen/scales.html)

Appendix B: Personal and Organizational Quality Assessment-Revised 4 Model (POQA-R4)



POQA-R4 **Personal and Organizational Quality Assessment-Revised**

This survey is voluntary and confidential.
Only summary, anonymous data will be provided to your organization.

INSTRUCTIONS: Please fill in the boxes below with the requested dates and ID number.
For the remaining items, FILL IN THE NUMBER of the response that describes you.

TODAY'S DATE — Month, Day, Year

UNIQUE ID NUMBER — Please enter the last four digits of your social security number. This number is used for matching your responses over time.

1. What is your GENDER?
   ① Male ② Female

2. What is your MARITAL STATUS? (fill in one only)
   ① Single ② Partnered ③ Divorced
   ④ Married ⑤ Separated ⑥ Widowed

3. Roughly how old are you?
   ① Under 21 ② 21-30 ③ 31-40 ④ 41-50 ⑤ 51-60 ⑥ 61-70 ⑦ Over 70

4. What is your approximate salary range?
   ① Under $20,000 ② $20,000 - 29,999 ③ $30,000 - 39,999 ④ $40,000 - 49,999 ⑤ $50,000 - 59,999 ⑥ $60,000 - 69,999 ⑦ $70,000 - 79,999 ⑧ $80,000 - 89,999 ⑨ $90,000 - 99,999 ⑩ $100,000 - 149,999 ⑪ $150,000 or more

5. What is your highest level of EDUCATION? (fill in one only)
   ① Elementary ② Junior/Middle School ③ High School ④ Technical School ⑤ Some College/Associate's Degree ⑥ Bachelor's Degree ⑦ Some Graduate ⑧ Master's Degree ⑨ Doctorate Degree

6. Which of the following best describes your EMPLOYMENT STATUS? (fill in one only)
   ① Student ② Laborer ③ Skilled or Clerical ④ Management ⑤ Professional ⑥ Executive ⑦ Engineer/Technical ⑧ Retired ⑨ Unemployed ⑩ Other

7. How many HOURS PER WEEK do you usually work?
   ① Less than 25 hours ② 26-35 hours ③ 36-40 hours ④ 41-50 hours ⑤ 51-59 hours ⑥ 60 or more hours

8. How long have you been with this COMPANY or ORGANIZATION?
   ① 0 - 6 MONTHS ② 6 MONTHS - 1 YEAR ③ 1 YEAR - 2 YEARS ④ 2 YEARS - 5 YEARS ⑤ 5 YEARS - 10 YEARS ⑥ 10 YEARS - 20 YEARS ⑦ 20 YEARS OR MORE

9. How long have you been in your CURRENT JOB or POSITION?
   ① 0 - 6 MONTHS ② 6 MONTHS - 1 YEAR ③ 1 YEAR - 2 YEARS ④ 2 YEARS - 5 YEARS ⑤ 5 YEARS - 10 YEARS ⑥ 10 YEARS OR MORE

SAMPLE

Please turn to the next page

PLEASE DO NOT WRITE IN THIS AREA

65208

POQA-R4 **Personal and Organizational Quality Assessment-Revised**

INSTRUCTIONS:
Following is a list of words that describe feelings people sometimes have. Please FILL IN THE NUMBER which reflects how frequently you have felt the following during the LAST MONTH.

	NOT AT ALL	ONCE IN A WHILE	SOMETIMES	FAIRLY OFTEN	OFTEN	VERY OFTEN	ALWAYS
1. Resentful	①	②	③	④	⑤	⑥	⑦
2. Fatigued	①	②	③	④	⑤	⑥	⑦
3. Annoyed	①	②	③	④	⑤	⑥	⑦
4. Sad	①	②	③	④	⑤	⑥	⑦
5. Body aches (Joint Pain, Backaches, etc.)	①	②	③	④	⑤	⑥	⑦
6. Headaches	①	②	③	④	⑤	⑥	⑦
7. Rapid Heartbeats	①	②	③	④	⑤	⑥	⑦
8. Depressed	①	②	③	④	⑤	⑥	⑦
9. Exhausted	①	②	③	④	⑤	⑥	⑦
10. Blue	①	②	③	④	⑤	⑥	⑦
11. Appreciative	①	②	③	④	⑤	⑥	⑦
12. Relaxed	①	②	③	④	⑤	⑥	⑦
13. Anxious	①	②	③	④	⑤	⑥	⑦
14. Tired	①	②	③	④	⑤	⑥	⑦
15. My sleep is inadequate	①	②	③	④	⑤	⑥	⑦
16. Thankful	①	②	③	④	⑤	⑥	⑦
17. Indigestion, heartburn or stomach upset	①	②	③	④	⑤	⑥	⑦
18. Calm	①	②	③	④	⑤	⑥	⑦
19. Cynical	①	②	③	④	⑤	⑥	⑦
20. Muscle Tension	①	②	③	④	⑤	⑥	⑦
21. Grateful	①	②	③	④	⑤	⑥	⑦
22. Worried	①	②	③	④	⑤	⑥	⑦
23. Unhappy	①	②	③	④	⑤	⑥	⑦
24. Uneasy	①	②	③	④	⑤	⑥	⑦
25. Angry	①	②	③	④	⑤	⑥	⑦
26. Peaceful	①	②	③	④	⑤	⑥	⑦

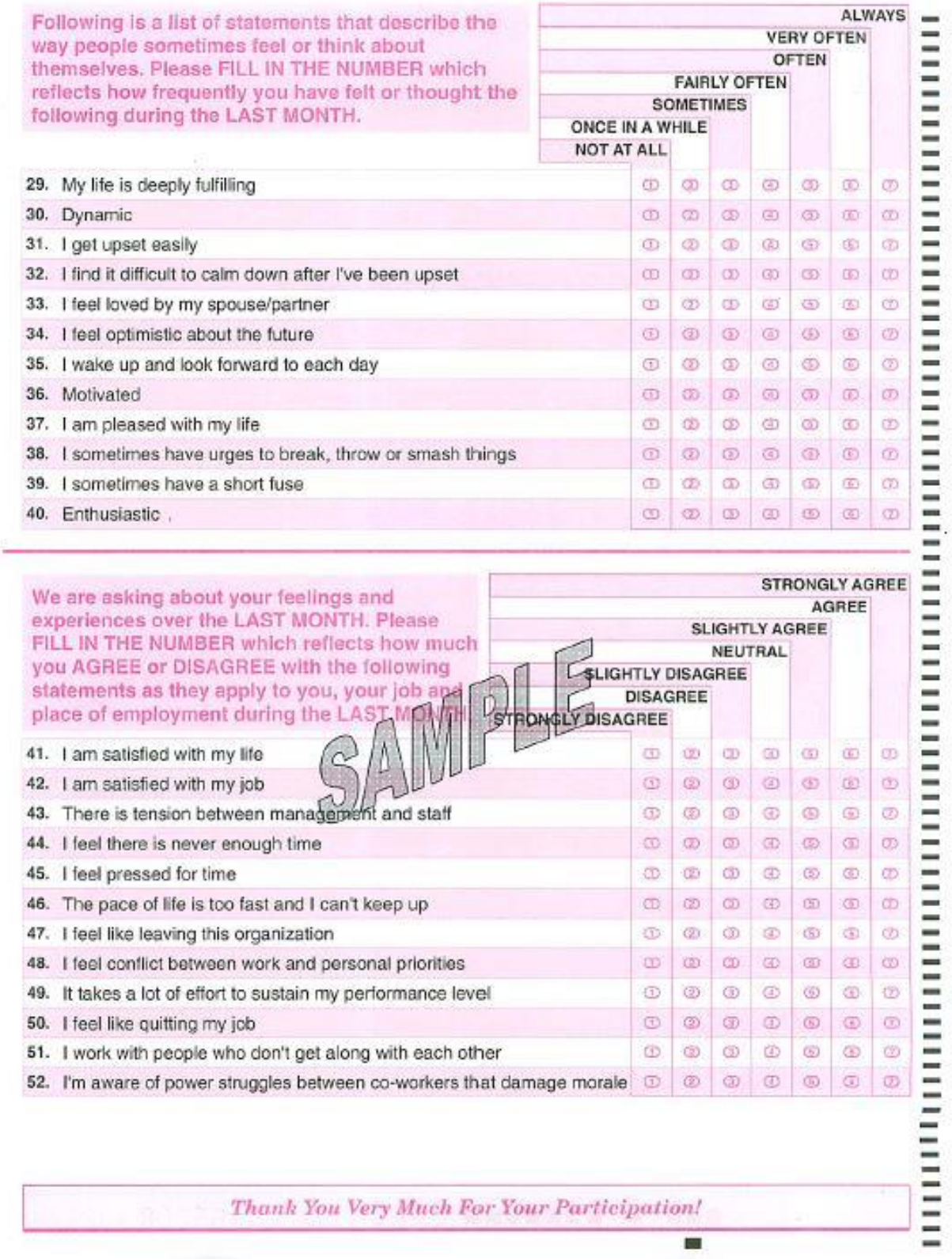
27. Over the last month my health has been:

Excellent	Good	Average	Fair	Poor
①	②	③	④	⑤

28. Fill in the bubble on the line below that indicates how stressed you have been in the past month:

Most Calm I've Ever Been ○—○—○—○—○—○—○—○—○—○—○—○—○—○—○—○—○ Most Stressed I've Ever Been

Please turn to the next page



Following is a list of statements that describe the way people sometimes feel or think about themselves. Please FILL IN THE NUMBER which reflects how frequently you have felt or thought the following during the LAST MONTH.

	NOT AT ALL	ONCE IN A WHILE	SOMETIMES	FAIRLY OFTEN	OFTEN	VERY OFTEN	ALWAYS
29. My life is deeply fulfilling	1	2	3	4	5	6	7
30. Dynamic	1	2	3	4	5	6	7
31. I get upset easily	1	2	3	4	5	6	7
32. I find it difficult to calm down after I've been upset	1	2	3	4	5	6	7
33. I feel loved by my spouse/partner	1	2	3	4	5	6	7
34. I feel optimistic about the future	1	2	3	4	5	6	7
35. I wake up and look forward to each day	1	2	3	4	5	6	7
36. Motivated	1	2	3	4	5	6	7
37. I am pleased with my life	1	2	3	4	5	6	7
38. I sometimes have urges to break, throw or smash things	1	2	3	4	5	6	7
39. I sometimes have a short fuse	1	2	3	4	5	6	7
40. Enthusiastic	1	2	3	4	5	6	7

We are asking about your feelings and experiences over the LAST MONTH. Please FILL IN THE NUMBER which reflects how much you AGREE or DISAGREE with the following statements as they apply to you, your job and place of employment during the LAST MONTH.

SAMPLE

	STRONGLY DISAGREE	DISAGREE	SLIGHTLY DISAGREE	NEUTRAL	SLIGHTLY AGREE	AGREE	STRONGLY AGREE
41. I am satisfied with my life	1	2	3	4	5	6	7
42. I am satisfied with my job	1	2	3	4	5	6	7
43. There is tension between management and staff	1	2	3	4	5	6	7
44. I feel there is never enough time	1	2	3	4	5	6	7
45. I feel pressed for time	1	2	3	4	5	6	7
46. The pace of life is too fast and I can't keep up	1	2	3	4	5	6	7
47. I feel like leaving this organization	1	2	3	4	5	6	7
48. I feel conflict between work and personal priorities	1	2	3	4	5	6	7
49. It takes a lot of effort to sustain my performance level	1	2	3	4	5	6	7
50. I feel like quitting my job	1	2	3	4	5	6	7
51. I work with people who don't get along with each other	1	2	3	4	5	6	7
52. I'm aware of power struggles between co-workers that damage morale	1	2	3	4	5	6	7

Thank You Very Much For Your Participation!

Scoring of POQA-R4:

Calculating Raw Scores

Raw scores are derived by first summing the values for the items in each of the dimensions. The sum for each dimension is then divided by the number of endorsed items in that dimension. For example, the Vitality dimension is comprised of six items. If the client responds to only five items, the sum is divided by five, not six. The five physical stress symptom items do not form a unified dimension, but are calculated as individual items.

Converting Raw Scores to Standardized T Scores

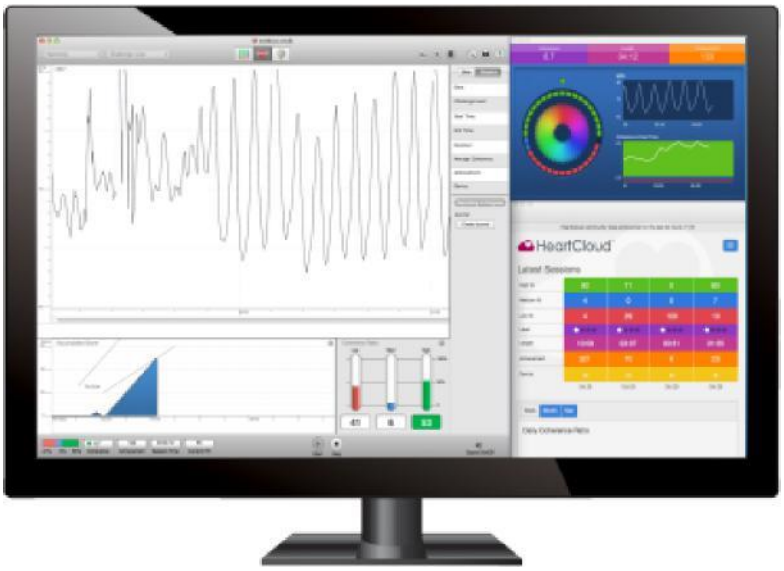
The raw scores for all dimensions and the individual physical stress symptom items are converted to standardized T scores with a mean of 50 and a standard deviation of 10. Standardized scales enable comparisons of performance or status of the group of interest with that of a relevant reference group and can be used to assist managers in comparing their employees' scores with similar others. The reference group serving as the normative population for the POQA survey consists of 567working adult men and women from a variety of occupations. Standardized T scores are plotted in a bar graph format showing their relationship to the reference group. The T score has a mean of 50 and a standard deviation of 10. This means, for instance, that an area T score of 60 accurately places a group in the 84th percentile of the normative population and an area T score of 70 places the same group in the 98th percentile.

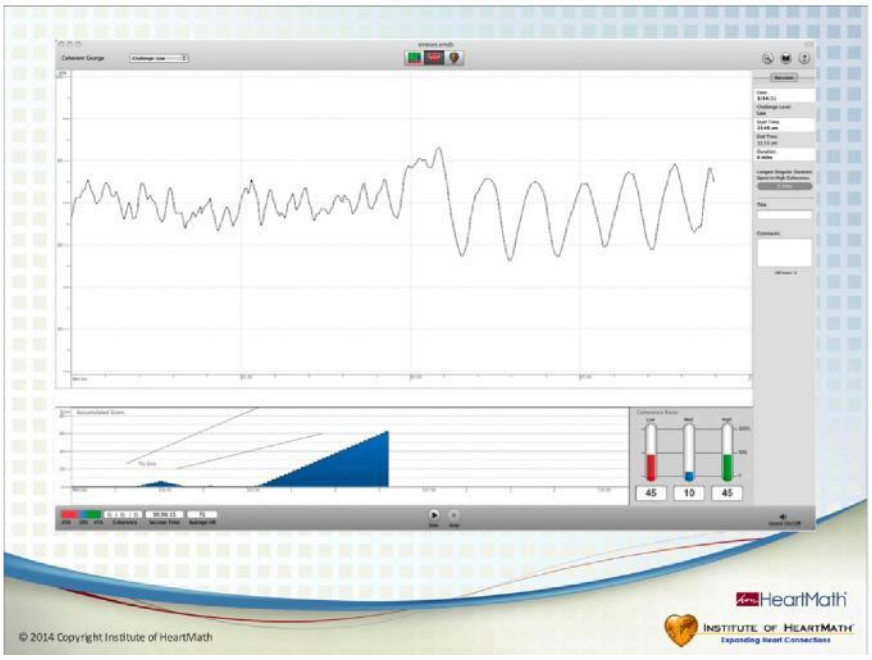
Report Format

The POQA report presents survey results in a clear and easily-interpretable format. Survey responses are reported as group scores (representing the average score of all respondents for each dimension). Standardized T scores are plotted on a bar graph with a

second axis indicating percentile in relation to the reference group. Raw scores are displayed in a table at the bottom of each page of the report. The report also includes a table showing the frequency distribution of the responses to each individual item (Institute of HeartMath & Caring Management Consulting, 1997).

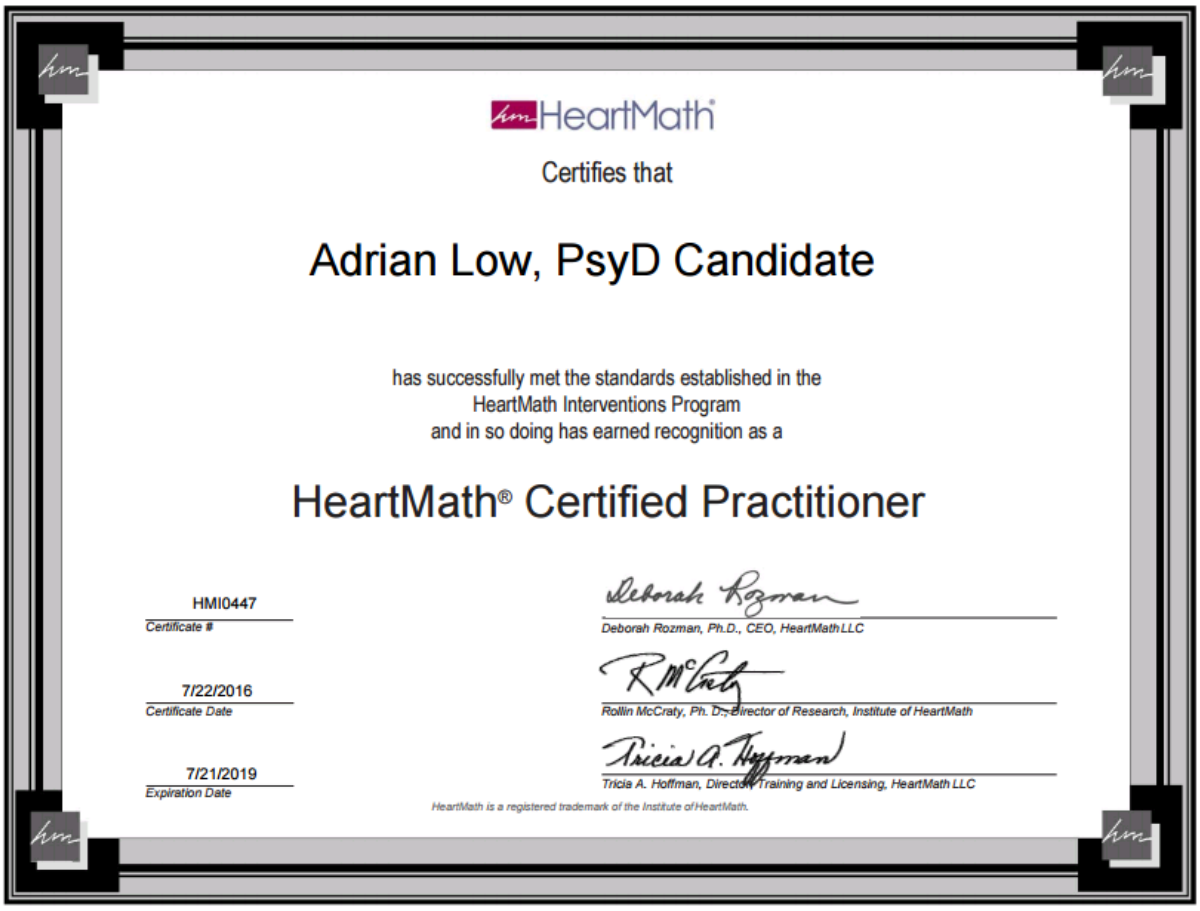
Appendix C: emWave Pro Plus Computer Hardware and HRV Monitor Reading





(Institute of HeartMath, 2016)

Appendix D: HeartMath Certified Practitioner Certificate



HeartMath

Certifies that

Adrian Low, PsyD Candidate

has successfully met the standards established in the
HeartMath Interventions Program
and in so doing has earned recognition as a

HeartMath® Certified Practitioner

HMI0447
Certificate #

7/22/2016
Certificate Date

7/21/2019
Expiration Date

Deborah Rozman, Ph.D., CEO, HeartMath LLC

Rollin McCraty, Ph. D., Director of Research, Institute of HeartMath

Tricia A. Hoffman, Director Training and Licensing, HeartMath LLC

HeartMath is a registered trademark of the Institute of HeartMath.

Appendix E: Sample Recruitment Email

To: Company X

From: Adrian Low, Doctoral Candidate

Dear colleagues,

I'm pleased to invite you to participate in my Clinical Psychology Doctoral Project at the California Southern University. This particular research study is to see how easy it would be to collect both physiological and psychological data in a large corporation.

In this research study, as I was trained in the use of Heart Rate Variability biofeedback (HRVB), I'll be collecting data using HRVB devices, which require a non-invasive procedure that incorporates breathing and heart rhythms. Studies have shown that HRVB can increase decision-making skills as well as decrease stress and increase resilience. I am hoping that each of you will consider volunteering for this research study.

If you are willing to participate in this research study, please click the button below and I will arrange the session with you at a mutually agreed date and time during the data collection phase. The exclusion criteria for this research study includes any employee who has taken any kind of medication that might influence the results or caffeinated/alcohol beverages within 2 hours prior to the session. For those of you who are eligible, the session will take approximately 25 minutes which includes collecting demographic information, two stress-related surveys as well as the HRVB measurements. Please read the attached information sheet, which also describes the compensation for those who are willing and eligible to participate.

I look forward to working with you!

Sincerely,

Adrian Low, PsyD Candidate

Appendix F: Company X Employee Information Sheet

Information Sheet
Participation in a Research Study
California Southern University
3330 Harbor Blvd, Costa Mesa, CA 92626

School of Behavioral Sciences

Principal Researcher Adrian Low Phone No. XXX-XXXXXXXX

E-mail: Adrian.low@my.calsouthern.edu Date: 30/6/2017

Please read the following information:

1. This is an invitation for you as a Company X Employee to participate in a research study under the direction of Adrian Low, PsyD Candidate.
2. The purpose of the project is to see how easy it would be to collect both physiological and psychological data in a large corporation.
3. If you consent to participate, you will be involved in the following process, which will occur in a 25-minute session:
    - ***i.*** The Principal Researcher (PR) will set up a session with you at a mutually agreed date and time at one of the meeting rooms in XXX and you will fill out an online demographic form that contains: age, gender, marital/relationship/family status, race, original baccalaureate degree, and workplace information.
    - ***ii.*** Participants who meet the inclusion/exclusion criteria will be asked to participate in the study.
    - ***iii.*** All eligible participants will sign the consent form, fill out the Perceived Stress Survey (PSS-10), the Personal and Organizational Quality Assessment-Revised 4 Model (POQA-R4) and the PR will also collect data from your

five-minute resting and breathing exercise as well as the one-minute forced deep breathing exercise.

4. Participation in this research study is voluntary and will not affect or influence any form of job evaluation. You have the right to withdraw at any time without any penalty. If you have any questions, you may contact the PR at the number listed above.
5. The risks to your participation in the research study include possibly recalling stressful life experiences when filling out the questionnaires. If you have ongoing stress or anxiety during or after the research process, you may contact the Employee Assistance Program (EAP) at 852-XXXXXXXX.
6. There is a compensation for your participation in this research study All participants will receive a 5 to 10 minutes of Quick Coherence Therapy after the session leading to a potentially decreased perceived stress, as well as being entitled to take part in a lucky draw for one of the following: Ten $100 Supermarket vouchers (the same participant could not win more than one voucher). In order to receive the compensation, you must complete all required processes of the above-described research study.
7. Your responses are strictly confidential. When the data and analysis are presented, you will not be linked to the data by your name, title or any other identification item.
8. The data will be stored in a secure and locked location for five years after which the data will be destroyed.

If you have questions about the study or about your rights as a research subject, you may contact the Chairperson of the California Southern University Institutional Review Board, c/o Dr. Linda Fischer at California Southern University, 3330 Harbor Blvd, Costa Mesa, CA 92626, irb@calsouthern.edu.

This project has been approved by the California Southern University Institutional Review Board.

Appendix G: Participant Consent Form

Participant Consent Form
Participation in a Research Study
California Southern University
3330 Harbor Blvd, Costa Mesa, CA 92626

School of Behavioral Sciences

Principal Researcher Adrian Low Phone No. XXX-XXXXXXXX

E-mail: Adrian.low@my.calsouthern.edu Date: 30/6/2017

Please read (listen to) the following information:

1. This is an invitation for you as a Company X Employee to participate in a research study under the direction of Adrian Low, PsyD Candidate.
2. The purpose of the project is to see how easy it would be to collect both physiological and psychological data in a large corporation.
3. If you consent to participate, you will be involved in the following process, which will take about 25-minute of your time.
    - ***i.*** The Principal Researcher (PR) will set up a session with you at a mutually agreed date and time at one of the meeting rooms in XXX and you will fill out an online demographic form that contains: age, gender, marital/relationship/family status, race, original baccalaureate degree, and workplace information.
    - ***ii.*** Participants who meet the inclusion/exclusion criteria will be asked to participate in the study.
    - ***iii.*** All eligible participants will sign the consent form, fill out the Perceived Stress Survey (PSS-10), the Personal and Organizational Quality Assessment-Revised 4 Model (POQA-R4) and the PR will also collect data from your five-minute resting and breathing exercise as well as the one-minute forced deep breathing exercise.

4. Participation in this research study is voluntary and will not affect or influence any form of job evaluation. You have the right to withdraw at any time without any penalty. If you have any questions, you may contact the PR at the number listed above.
5. The risks to your participation in the research study include possibly recalling stressful life experiences when filling out the questionnaires. If you have ongoing stress or anxiety during or after the research process, you may contact the Employee Assistance Program (EAP) at 852-XXXXXXXX.
6. There is a compensation for your participation in this research study All participants will receive a 5 to 10 minutes of Quick Coherence Therapy after the session leading to a potentially decreased perceived stress, as well as being entitled to take part in a lucky draw for one of the following: Ten $100 Supermarket vouchers (the same participant could not win more than one voucher). In order to receive the compensation, you must complete all required processes of the above-described research study.
7. Your responses are strictly confidential. When the data and analysis are presented, you will not be linked to the data by your name, title or any other identification item.
8. The data will be stored in a secure and locked location for five years after which the data will be destroyed.

As a research participant, I have read the above, have had any questions answered, and agree to participate in the research study. I will retain a copy of this form for my reference.

Participant's Signature _____ Date _____

Principal Researcher's Signature _____ Date _____

If you have questions about the study or about your rights as a research subject, you may contact the Chairperson of the California Southern University Institutional Review Board, c/o Dr. Linda Fischer at California Southern University, 3330 Harbor Blvd, Costa Mesa, CA 92626, irb@calsouthern.edu.

This project has been approved by the California Southern University Institutional Review Board.

Appendix H: Biography of Mike Atkinson

Mike Atkinson of Boulder Creek, California, the HeartMath Institute's Research Center Laboratory Manager, is responsible for the key development and implementation aspects of the Global Coherence Monitoring System. He has extensive experience gathering, processing and performing statistical analysis of a wide range of psychophysiological data. Atkinson is co-holder of three patents related to physiological coherence monitoring used in organizational, educational and health care settings. The Short-term and 24-hour HRV assessments that he has designed are used internationally by physicians, researchers and in health-care organizations. Atkinson, co-author of several psychological surveys that are used to assess stress, emotions and organizational effectiveness, has played a key role in many laboratory and field research studies examining the effects of stress and emotions on bodily systems, including heart-brain interactions and cognitive performance. He has co-written many scientific papers published in numerous professional journals.

Appendix I: Company X's Permission to Conduct Research Email

Dear Adrian and Doctoral Committee,

You may conduct the research so long as it is conducted on a voluntarily basis. Additionally, here is our comments and recommendations from the leadership:

- Recruitment email can be sent to [redacted] and other participants is allowed to be voluntarily recruited via word of mouth or referral
- At the end of the research project, [redacted], has the final decision to whether or not include its entity name in any published manuscripts, articles, newspapers or journals etc.

Best Regards

Appendix J: Completion of CITI Training

CITI PROGRAM

Completion Date 22-Jun-2017
Expiration Date 21-Jun-2020
Record ID 23642665

This is to certify that:

Adrian Low

Has completed the following CITI Program course:

Human Subjects Research (HSR) (Curriculum Group)
Doctoral Students (Course Learner Group)
1 - Basic Stage (Stage)

Under requirements set by:

California Southern University

CITI

Verify at www.citiprogram.org/verify/?w15d8bb90-5773-481f-81f8-d9283fb1c5ab-23642665