UNIVERSITY OF XXX

DEPARTMENT OF XXX

Name of Applicant:

Student registration number:

Area code & telephone number(s):

E-mail address:

Promoter:

Submission date:

Proposed Title: The effect of blue, green, and urban spaces on stress levels in an adult population: a psychophysiological perspective

Alternative Title: Psychophysiological stress responses to urban, green, and blue spaces in a healthy adult population.

Research Problem

"Stress affects everyone, young and old, rich and poor. Life is full of stress. Stress is an every[day] fact of life that we must all deal with" (Salleh, 2008, p. 9). Research has shown that chronic stress has been found to weaken the immune system, contribute to diabetes, depression, cardiovascular disease, upper respiratory infections, and the development of numerous diseases through the weakening of the body to control its inflammatory response (Cohen et al., 2012; Dimsdale, 2008). Cardiovascular disease remains the leading cause of death in modern society, and psychosocial stress has been identified as a key culprit in its development (Henning, 2014).

Hans Selye first discovered this biological response to 'diverse nocuous agents', terming it the general alarm syndrome (Selye, 1936). This concept was further refined, and stress was then defined, in 1950, as the nonspecific bodily response to a demand for change (Selye, 1950). Since then, the concept of stress has undergone numerous reconceptualisations and definitions, with the currently most accepted perspective maintaining that "not all conditions that trigger physiological response are stressful/threatening, and that stress is a cognitive perception of uncontrollability and/or unpredictability that is expressed in a physiological and behavioural response" (Geva, Pruessner & Defrin, 2014, p. 2418).

From a psychological perspective, stressors can be classified as external or internal, where the former refers to psychosocial situations such as job stress or familial strife. The latter refers to self-imposed stress from, for example, the fear of failure (Ahmed & Julius, 2015).

Physiologically, stress is defined as a state of threatened or perceived threat to homoeostasis (Charmandari, Tsigos, & Chrousos, 2005). Stressors serve as input signals that are received and acted upon by the stress system, triggering many physiological responses (Henning, 2014). These responses are vast, including the strengthening of skeletal muscles, an increase of concentration, pupil dilation, heart rate increase, and the release of numerous stress hormones (Palmer & Cooper, 2010). As mentioned above, the consequences of these responses over an extended period have adverse physiological effects (Cohen et al., 2012).

Since stress is becoming an ever-increasing feature of adult daily life, it would be beneficial to determine a way with which to counter these effects in a time and cost-effective manner (Salleh, 2008). Existing interventions such as medication, therapeutic interventions, or physical activity are valuable but are not always viable options. A problem therefore exists where the rapidly increasing levels of stress in society are not being met with adequate, viable treatment solutions.

The stress relieving effects of natural areas have been studied as alternatives, but the content of these areas have rarely been defined. The vast majority of studies examining the benefits of natural areas do not distinguish between green spaces and waterscapes (blue spaces) (Nieuwenhuijsen et al., 2014). Researchers have started to allude to the potentially restorative effects of water (over and above the green spaces they usually occur in) and as such, an opportunity exists to determine the extent to which blue areas can provide effective restoration from stress.

Since the landscape being investigated is relatively new in its delineation, it is necessary to define these key concepts. Urban areas are nearly always included in green space studies and usually serve as the compactor group. Definitions of urban space are generally positioned from a sociological or town planning approach and subsequently highlight the diversity of social roles or physical localities (Sutton & Kemp, 2011). For the purpose of the present study, urban space will, therefore, refer to city areas, where the prominent visual features are man-made, such as walkways, buildings, or streets, and there are minimal to no natural features such as trees, shrubs, or grass.

Green space, in contrast, is defined by the Oxford English Dictionary as “an area of grass, trees, or other vegetation set apart for recreational or aesthetic purposes in an otherwise urban environment” (Stevenson, 2010). While this definition highlights the separation of natural areas from the urban environment, it does not specify whether water forms part of these areas. There does not yet exist one comprehensive, standard definition of blue space, but Foley and Kistemann (2015) provide a useful starting point, albeit from a public health policy perspective. According to these authors, blue space is defined as “health-enabling places and spaces, where water is at the centre of a range of environments with identifiable potential for the promotion of human wellbeing” (Foley & Kistemann, 2015, p.2). For the purpose of the present study, the notion of water as the central feature is of fundamental importance. A natural area containing a water element will most likely also contain green spaces (trees alongside a waterfall, for example), but it is necessary for the water feature to be the main attraction.

Literature Review

There exist numerous studies that have examined the benefits of green space, regarding its effect on well-being, stress, and attention restoration. Operationally, however, very few studies differentiate between green and blue spaces, and blue areas often (unintentionally) form part of green spaces. Consequently, there is a paucity of studies examining blue space as a unique concept in relation to restoration and stress relief (Nieuwenhuijsen et al., 2014).

An extensive review of literature yielded only two studies addressing the stress relieving effects of blue space. Roger Ulrich was the first researcher to comprehensively address the stress relieving effects of natural areas (Ulrich, 1981). His study titled *Natural versus urban scenes: Some psychophysiological effects* examined the effects of viewing slides of predominately green, blue, and urban scenes respectively on mood, affect, alpha amplitude, and heart rate. Both natural areas had more positive effects on mood state and affect scales than urban scenes, specifically where water scenes were responsible for sharp decreases in the Fear Arousal factor of the Zuckerman Inventory of Personal Reactions. Alpha amplitude was significantly higher when viewing water and these scenes also held attention and interest more effectively than urban scenes. There were no significant differences in heart rate between scenes (Ulrich, 1981).

More recently, Gidlow et al. (2016) examined the psychophysiological responses to walking in green, blue and urban areas in their study titled *Where to put your best foot forward: Psycho-physiological responses to walking in natural and urban environments.* Thirty-eight adults participated in 30-minute self-paced walks in residential (urban), natural (green) and natural with water (blue) environments. Psychophysiological responses were measured regarding mood, cognitive function, restoration, salivary cortisol, and HRV, and were measured at three points: T1 at baseline, T2 at the end of the walk, and T3 at 30 minutes after leaving the environments. Results indicated that mood and cortisol improved at T2 and T3 in all environments, green and blue environments provided greater restoration experiences, and cognitive benefits continued at T3. Of interest, however, is that HRV data was inconclusive, displaying no consistent patterns between any of the environments or time markers (Gidlow et al., 2016). Since HRV is so sensitive to physiological changes, it is possible the inclusion of physical activity in the research confounded these results.

The remainder of the studies on the benefits of blue space address concepts such as personal preference, spirituality, and overall health benefits, and as such have not been included in the present review of relevant literature (Bulut, & Yilmaz, 2009; Burmil, Daniel, & Hetherington, 1999; Foley & Kistemann, 2015; Herzog, 1985; Hipp, & Ogunseitan, 2011; Nasar & Li, 2004; Völker & Kistemann, 2013).

Concerning green spaces, there exist a slightly larger number of studies examining the psychophysiological effects of green natural areas on stress levels. The most recent study, published by Ewert, Klaunig, Wang, and Chang (2016), examined the effects of visitation to natural environments on stress levels as measured by salivary cortisol levels. Forty-seven adult participants' salivary cortisol levels were measured before and after visiting a local park, which incidentally included a prominent view of a lake. Findings indicated that cortisol levels were significantly lower after visiting the park than upon arrival, in addition to finding a significant positive correlation between levels of cortisol reduction and length of visit (Ewert et al., 2016). A number of green space studies have employed salivary cortisol as a measure of stress reduction, with varying success (Jiang, Chang & Sullivan, 2012; Thompson et al., 2012; Tyrväinen et al., 2014; van den Berg & Custers, 2011).

As mentioned above, some of the physiological responses to stress include those produced by the cardiovascular system. Of relevance to the present study is Heart Rate Variability (HRV), which refers to the variation in time between successive heartbeats, as a result of the constant influence of internal and external stimuli on the heart (Karim, Hasan & Ali, 2011; Rudak, 2005). This continual change, caused by the influence various stimuli causes the heart to require dynamic innervation of the sympathetic and parasympathetic systems. This autonomic control system, constantly adjusting for stimuli, results in a high variability between heart beats. High HRV is, therefore, indicative of a healthy functioning autonomic and cardiac system (Rudak, 2005).

For this reason, researchers have used measures of heart rate, HRV, and blood pressure to assess stress reduction in response to green spaces. In 2013, Brown, Barton and Gladwell examined how viewing green and urban spaces prior to a stressor affected autonomic function during stress recovery. Heart rate variability and blood pressure were used to assess autonomic function and findings indicated that 1) parasympathetic activity was significantly higher in stress recovery following viewing a natural scene, and 2) standard deviation of R-R intervals (HRV) was greater when viewing nature scenes than urban scenes. These findings together imply that natural scenes have positive effects on the stress recovery process (Brown et al., 2013).

Similarly, in 2013, Tsunetsugu et al. examined the stress relieving effects of viewing forest landscapes in Japan. Forty-eight males were assessed at baseline on numerous psychophysiological measures in control and experimental groups respectively. Findings corresponded with Brown et al. (2013) whereby parasympathetic activity was enhanced while viewing natural scenes. Diastolic blood pressure was lower in forested areas, and heart rate was also significantly lower in each minute of viewing the green areas than the urban areas (Tsunetsugu et al., 2013).

Older studies utilising cardiovascular measures include Hartig, Evans, Jamner, Davis and Gärling's (2003) *Tracking restoration in natural and urban field settings* and Laumann, Gärling and Stormark's (2003) *Selective attention and heart rate responses to natural and urban* *environments.* Hartig et al. (2003) found that both systolic and diastolic blood pressure were lower in the natural environment condition than the urban condition, following a Stroop and binary classification task. Laumann et al. (2003) used cardiac inter-beat interval (IBI) as their measure of autonomic arousal and found that those viewing natural scenes had a longer IBI than those viewing urban scenes. A longer IBI is indicative of a lower heart rate and consequently reduced autonomic arousal.

Justification, Aim, and Objectives

As discussed, stress has been linked to numerous health issues and diseases, even death (Cohen et al., 2012; Dimsdale, 2008; Henning, 2014). For this reason, it is imperative for individuals to find techniques to effectively manage and reduce stress in their daily lives. These means will furthermore likely be more widely employed if they are cheap or free, as opposed to time-consuming, costly measures. Literature has started addressing the use of green spaces to this end, and the potentially heightened restorative effects of blue spaces have been alluded to. There is nonetheless a paucity of research into the stress relieving effects of blue spaces specifically, and this study will, therefore, address this dearth of knowledge.

This research will undertake to fill a knowledge gap substantially, regarding both its focused attention on blue spaces and its use of breakthrough technology assessing HRV and consequent Cardio Stress Index. Furthermore, should the research reveal significant findings in this regard, substantiation will be provided for the maintenance of green and blue spaces in society. This research could, therefore, be beneficial to public policies and town planning strategies.

The aim of this study is to investigate the extent to which urban, green and blue spaces contribute to stress relief, measured psychophysiologically. The consequent objectives are to determine:

- How a stressor impacts heart rate variability;
- how effectively urban spaces reduce stress, as measured by physiological and psychological measures;
- how effectively green spaces reduce stress, as measured by physiological and psychological measures; and
- how effectively blue spaces reduce stress, as measured by physiological and psychological measures.

Theoretical Paradigm

This study is underpinned by one prominent theory from which a related theoretical hypothesis stems. The main theory is evolutionary psychology, which essentially postulates that human behaviour and psychological functioning is a result of adaptive processes, which have occurred over many years (Barrett, Dunbar, & Lycett, 2002). Stemming from this is Roger Ulrich's 1991 stress reduction theory (SRT) which posits that exposure to natural areas provides psychophysiological relief from stress in human beings.

Evolutionary Psychology

Evolutionary psychology is a theoretical perspective that dates back to Charles Darwin's 1859 theory of natural selection and posits that evolution is responsible not only for individuals' physiological adaptations but also for their psychological characteristics and processes (Buss, 1995; Confer et al., 2010). Arising from this notion is the idea that the human mind is a complex system of integrated psychological adaptations that have evolved as a response to adaptive problems. An individual's behaviour then is a direct product of this system, and functions to protect the adaptive instincts of humans (Confer et al., 2010). Although evolutionary arguments differ somewhat from author to author, the common theme is that humans have an innate predisposition to respond positively to natural settings, and to configurations of natural settings that provide favourable conditions to the survival of the species (Ulrich et al., 1991). It has been postulated that natural environments are processed more easily and efficiently by humans because the brain and sensory systems evolved in natural settings (Wholwill, 1983).

Stress Reduction Theory

After numerous years of investigation into the positive effects of nature on human beings, Ulrich et al. produced a study in 1991, which ultimately served as the basis of the stress reduction theory (SRT). Ulrich et al. postulated that from a psycho-evolutionary perspective, encounters with unthreatening natural environments would have a stress reduction and restorative effect, whereas urban environments would impede recuperation.

Working from these assumptions, Ulrich et al. (1991) developed a study to test the effectiveness of natural scenes in stress relief. One hundred and twenty undergraduates were exposed to a stressor and were then placed in the recovery condition where they viewed images of natural and urban settings. Various physiological measures were used as well a self-rating psychological scale of stress experiences. Results clearly indicated that recovery was quicker and more complete when subjects viewed natural environments, rather than urban environments. Physiological measures found that stress recovery is widespread in body systems and occurs effectively in natural environments. Results of the psychological assessment were congruent with physiological findings in that natural scenes elicited more positive ratings and provided greater restoration on affective dimensions (Ulrich et.al., 1991).

These findings led Ulrich to develop his theory of stress reduction, which is based on the following elements: 1) individuals respond unconsciously to natural settings as a result of their evolutionary adaptive responses to nature; 2) exposure to nature produces rapid stress restoration effects, and 3) these responses are based on the need for the survival of the human species (Menatti & Casado da Rocha, 2016; Ulrich et.al., 1991). Ulrich's findings prompted interest and investigation by researchers over the years and his findings of stress reduction from natural scenes has been validated numerous times since (Hartig, et al., 2003; Keniger, Gaston, Irvine, & Fuller, 2013; Maller, Townsend, Pryor, Brown, & St Leger, 2006; Thompson, et al., 2012; Van Den Berg & Custers, 2011).

Proposed Research Methodology

Research Question

The research question for the following study is: How do urban, green, and blue areas contribute to psychophysiological stress relief in a healthy adult population?

Research Design

Due to the fact that this study aims to investigate the causal effects of a treatment on an individual, an experimental research strategy will be used, employing the elements of manipulation, measurement, comparison, and control. These elements are essential in accomplishing the goal of proving the cause and effect relationship between variables (Gravetter & Forzano, 2009). More specifically, a pretest-post-test control group design will be employed. This implies that both the treatment and control groups will be tested before treatment, and both groups will be retested after the treatment groups have been exposed to the treatment conditions (Shadish, Cook & Campbell, 2002). A four-group design will be employed whereby one group will serve as the control, and the other three will be exposed to urban, blue, and green treatments respectively. This will enable the researcher to accurately compare the effects of each treatment with both each other and the control group. This design can be represented in the following manner:

TG1	*O*	*S*	T^1	*O*
TG2	*O*	*S*	T^2	*O*
TG3	*O*	*S*	T^3	*O*
CG	*O*	*S*		*O*

In the above schematic diagram, TG = Treatment Group, CG = Control Group, O = Observation, S = Stressor, T^1 = Treatment 1, T^2 = Treatment 2, and T^3 = Treatment 3.

Sampling

Probability sampling is often purported to be the gold standard in sampling techniques, as it ensures that all members of the population have an equal chance of being selected to participate, thereby ensuring generalisability of results (Hulley, Cummings, Browner, Grady & Newman, 2013). However, it can be extremely time-consuming, costly, and not viable, especially when the researcher is unable to locate the entire population (Brink, van der Walt & van Rensburg, 2006; Struwig & Stead, 2001). Since this study aims to include individuals of all races, genders, and occupations in early adulthood (between the ages of 18 and 39), locating a list of the entire population in this group is virtually impossible, and as such, probability sampling is not viable. Participants will be required to fall into the aforementioned age group, to ensure homogenity among participants in terms of physical, social, and psychological development (Louw & Louw, 2009)

Non-probability convenience sampling will, therefore, be employed, with the aim of obtaining a final minimum sample of 400 individuals where 300 are randomly assigned to each treatment group (100 per group), and 100 are similarly assigned to the control group (Gravetter & Forzano, 2009). It is not expected that gender or race will impact significantly on physiological measures; however, the use of random assignment will increase the statistical probability of the groups being demographically similar (Miller, 2013). Students in the physiology and psychology departments will be recruited through advertising posters placed in their respective departments. Social media (LinkedIn, Facebook, Twitter, etc.) and word of mouth will be utilised to recruit those outside of the university and individuals will be encouraged to invite colleagues and friends to participate.

A screening measure will be used to exclude potential participants who fall outside of the proposed age range, have pre-existing heart conditions, have other medical conditions, or are taking chronic medication that affects heart rate and blood pressure. Since is it expected that some participants will need to be excluded on this basis, efforts will be made to recruit an initial sample of at least 450 individuals.

Measurement Instruments

There are a number of measurement instruments that will be included in this study to adequately assess all psychophysiological components of the research. As indicated, a screening questionnaire will be utilised to ensure all participants taking part in the study meet the required criteria.

Physiological measures

The primary physiological indicator for the present study is the Cardio Stress Index (CSI), which provides an indication of the current stress loading of the heart (Henning, 2014). This index is obtained by the transformation of HRV data, collected by breakthrough technology: the Viport™. This small, non-invasive device is placed on the chest above the heart and provides quick and effective ECG measurements. This device collects HRV readings and automatically transforms this HRV data into the CSI (Rudak, 2005).

To collect raw HRV data, the Zephyr™ BioHarness will be used in conjunction with the Viport™. This device is strapped to the chest and provides measurements of HRV, skin conductivity and breathing rate.

Numerous studies have shown that blood pressure is positively linked to stress (Gasperin et al., 2009). To this end, an electric sphygmomanometer will be used, assessing systolic/diastolic pressure in millimetres of mercury (mmHg).

Psychological measures

Due to the fact that affective responses need to be measured in fairly rapid succession, the Zuckerman Inventory of Personal Reactions (ZIPERS) will be utilised (Zuckerman, 1977). The ZIPERS is a broad yet brief 12-item scale assessing affect on five factors: Fear, Positive Affects, Anger/Aggression, Attentiveness/Interest, and Sadness. Participants indicate on a 5-point Likert scale the extent to which each item describes the way they feel at that particular moment. This scale (and slight adaptions thereof) has been used extensively and effectively in previous research, with reliability scores ranging between α=0.74 and α=0.88 (Hartig, Mang & Evans, 1991; Valtchanov & Ellard, 2010; Valtchanov, Barton & Ellard, 2010; Ulrich et al., 1991; Zuckerman, 1977).

The Nature Relatedness Scale (NRS) will be used in conjunction with the ZIPERS to assess the extent to which participants feel connected to nature, with the aim of explaining differential responses to the natural environments presented. The scale consists of 21 Likert scale items, assessing NR-Self, NR-Perspective, and NR-Experience. Cronbach's alpha for the full scale was 0.87 and 0.84 for NR-Self, 0.66 for NR-Perspective, and 0.80 for NR-Experience, indicative of good internal consistency (Nisbet, Zelenski & Murphy, 2008).

Data Collection Procedures

All groups will have baseline physiological measures assessed, and will complete the ZIPERS and NRS. They will then be exposed to a five-minute clip from a frightening film, serving as the stressor. This clip will be designed to elicit a stress response, but will not contain any scenes of explicit violence (to humans or animals), sex, or have religious connotations. Treatment group one will then be exposed to a five-minute video of an urban scene, treatment group two will view a five-minute video of a green scene, and treatment group three will watch a five-minute video of blue spaces.

The control group will not watch anything (after the stressor) and will sit in the room, remaining as inactive and comfortable as possible. Participants will not have access to their tablets or mobile devices as personal or work communication could potentially cause stress responses, which would affect the physiological variables being assessed. The participants would already be accustomed to the room they are sitting in so the room can be considered a neutral stimulus. Participants in the control group will be required to sit quietly in the room for the same amount of time as the treatment groups to control for the possible confounding effects of time.

Numerous studies have examined the effects of 'surrogate nature' (photographs and videos) on restoration and stress relief and have found that exposure to virtual scenes of nature produces similar restorative effects to real nature, provided the virtual scenes are visually realistic (de Kort & Ijsselsteijn, 2006; de Kort, Meijnders, Sponselee, & Ijsselsteijn, 2006; Felsten, 2009; Valtchanov, & Ellard, 2010). To this end, the urban, green, and blue scenes will be recorded by the researcher with a head mounted Go-Pro while walking in these settings, providing a first-person view, allowing participants to have the sense of walking in these areas themselves. Additionally, the use of video (as opposed to photographs) will allow for the inclusion of auditory as well as visual stimuli.

The Viport™ and Zephyr™ BioHarness will be recording physiological data throughout the procedure, and participants will complete the ZIPERS and NRS again upon completion of the videos (or five minutes of sitting, for the control group) once the Viport™ and Zephyr™ BioHarness have been removed. Blood pressure will then be measured a second time. This will allow for the assessment of changes in perceived stress levels.

Data Analysis

Psychological assessments

Demographic data will be assessed by frequency analyses to obtain a better understanding of the final sample population. A multivariate analysis of variance (MANOVA) will be used to compare mean ZIPERS scores from baseline to after treatment between the four groups, and paired-samples t-tests will be conducted to compare the same mean scores within each group (Pallant, 2010). The same set of analyses will be conducted on NRS scores.

Physiological assessments

The Viport™ provides numerous readings of cardiac health, including heart rate, heart rhythm, the duration of vascular excitation (QRS duration) and the CSI (EuroMedix, 2009). The CSI is provided as a percentage and both MANOVAs and paired-samples t-tests will be conducted to compare CSI scores before and after treatment across the four groups, and within groups respectively. Furthermore, multiple regression will be carried out to determine the extent to which each of the treatments contribute to the CSI.

The MANOVA and paired-samples t-tests will also be conducted on the HRV and blood pressure results to assess the extent to which these data change before and after the various treatments.

Ethical Considerations

In order to comply with the ethical requirements of the American Psychological Association (2010), certain procedures will be implemented. Firstly, to ensure all participants have a full understanding of what they will be consenting to, an information sheet will be provided, detailing the purpose of the research, the expected duration, and the data collection procedure. It will be explained that they will be exposed to a stressor and the need for this will also be explained. Participants will be informed that they have the right not to participate or withdraw at any time, without consequence. This information will be provided in a participant information sheet, and participants will be required to sign a separate informed consent form before participation.

Confidentially of participants will be maintained by assigning each person a participant number, and participants will not be required to provide any personal information beyond their gender, age, and occupation. Information relating to their health-related activities will be captured, but it is not foreseen that this will compromise confidentiality in any manner.

Deception in research can be problematic as people sometimes alter answers once they know what the expected or desired results of the study are (Gravetter & Forzano, 2009). It is extremely difficult for people to alter their physiological states voluntarily as such, deception will not be required to obtain accurate measurements. Furthermore, the subject matter – responses to urban, green, and blue spaces – is innocuous and it is anticipated that participants will not feel the need to respond to the psychological assessments in a manner not reflective or their actual experiences.

Although a stressor is required to induce a physiological stress response in participants, it is not anticipated that it will cause any long-lasting negative psychological consequences. Nonetheless, debriefing will be made available for those who require it to ensure minimal harm to participants.

In accordance with the University of Pretoria's policies, the data obtained from the present project will be securely stored at the Department of Psychology in Room 11-24 for a minimum of 15 years. This data will be stored for research purposes and may be accessed by the researcher for further research. Participants' permission for this will be addressed in the informed consent form.

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