The Impact of Blue, Green, and Urban Spaces on Acute Stress Levels in an Adult Population: A Psychophysiological Perspective

by

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DECLARATION

I, Ruth Coetzer, declare that this thesis is my original work except where I used or quoted another source, which has been acknowledged. I further declare that the work I am submitting has never been submitted before for another degree to any other university or tertiary institution for examination.

Signature:

Ruth Coetzer

Date: 4 November 2022

ETHICS STATEMENT

The author, whose name appears on the title page of this dissertation, has obtained, for the research described in this work, the applicable research ethics approval.

The author declares that she has observed the ethical standards required in terms of the University of Pretoria's Code of ethics for researchers and the Policy guidelines for responsible research.

Signature Date: 4 November 2022

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DEDICATION

This thesis is dedicated to Jaime

- You would’ve done the same thing and I hope I’ve made you proud -

ABSTRACT

Stress is an ever-increasing feature of daily life. Particularly, repeated exposures to acute stress can result in multiple poor psychophysiological outcomes. These multiple poor outcomes can be operationalised as chronic stress. If the impact of acute stress can be managed, the longer-term impacts of chronic stress can be mitigated. Research has shown that exposure to green and blue spaces are beneficial. However, the existing literature on specifically the psychophysiological stress relieving effects of blue, green, and urban spaces is scarce. This study therefore aimed to assess the extent to which urban, green, and blue spaces impact acute stress, measured psychophysiologically. Furthermore, an integrated psychophysiological model was integrated with evolutionary psychology, the biophilia hypothesis, and stress reduction theory, to form a theoretical point of departure. A four-group, pre-test – post-test control group experimental design was employed, in which 118 participants were exposed to either a blue, green, or urban space video, following exposure to an acute stressor. The control group sat for the same length of time as the treatment groups' videos. Psychological measurement instruments included the Perceived Stress Scale, Nature Relatedness Scale, Restoration Scale, and four self-developed follow up items. Physiological data that were captured included blood pressure, heart rate, cardio stress index, and electrodermal activity. Overall, the results of two-way mixed ANOVAs, multiple regression, and a single-sample t-test demonstrated that urban areas have the poorest impact on acute stress when compared to green and blue areas. Green and blue spaces did not differ significantly from each other in their ability to impact acute stress, but blue spaces were found to be perceived the most restorative. The implication of these results is that exposure to green and blue spaces promote acute stress recovery and should be considered a viable treatment option for acute stress relief.

Key terms: acute stress, chronic stress, green space, blue space, urban space, stress reduction theory, evolutionary psychology, biophilia hypothesis, psychophysiology

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CHAPTER 1: INTRODUCTION

"There is a pleasure in the pathless woods,

There is a rapture on the lonely shore,

There is society where none intrudes,

By the deep Sea, and music in its roar:

I love not Man the less, but Nature more."

1.1 Introduction

The poem excerpt by Lord Byron (Baldwin, 2020) above reflects the love of nature that forms the basis of the present study. The ability of nature to draw one in and provide restoration has been a point of study for many years, yet there remains a paucity of research on the ways in which nature, especially water can provide relief from stress (Nieuwenhuijsen et al., 2014)

Although stress is such a commonly recognised concept, there exists disagreement regarding how best to define stress, what the various types of stress entail, and which stress reducing measures are most effective (Cooper & Quick, 2017; Engert et al., 2018; Nater, 2018; Weiser, 2014). The construct of stress is studied across multiple disciplines, however within the context of the present study, stress is conceptualised as a psychophysiological construct. Critically, the present study focuses on acute stress, which is operationalised as a sudden, short-term event that, if appraised as a stressor, evokes a sympathetic nervous system (SNS) and hypothalamic-pituitary adrenal-axis (HPA) response (Owton 2022).

This is differentiated from chronic stress, since chronic stress can be defined in more than one way; it can be defined as repeated exposure to acute stressors or as an on-going threatening unpleasant circumstance beyond one's control (Crosswell & Lockwood, 2020).

The present study is focused on the impact of urban and natural scenes on acute stress relief with the focus on how to combat acute stress effectively. This may reduce the negative impacts thereof, consequently reducing the impacts of chronic stress.

While the acute stress response is adaptive, in that it mobilises the body to respond to a threat, acute stress has been demonstrated to have a negative impact on working memory, decision making, attention, and motor control (Anderson et al., 2019; LeBlanc, 2009). These negative impacts impede functioning and could hold major implications for those whose careers involve having to make important decisions under acute stress conditions, such as the police force (Anderson et al., 2019). One context in which acute stressors are likely to occur is living in urban areas, especially areas that are becoming increasingly overpopulated.

Studies have shown that urbanisation has increased at a rapid rate globally over the past decade, where over half of the world's population has moved from rural to urban and large city environments (Bratman et al., 2015). This rapid increase in urbanisation has been demonstrated to be associated with poor mental health outcomes, an increase in overall stress levels and serves as a risk factor for the development of psychopathology (Santi et al., 2019; Tyrväinen et al., 2014, Ventriglio et al., 2021; von Szombathely et al., 2017). It is therefore theorised that a continuous rise in urbanisation would eventually result in more poor mental health outcomes and an increase in the development of psychopathology in coming years.

1.2 Problem statement and justification for the study

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 to everyone. Therefore, the problem exists where the rapidly increasing levels of stress in society are not being met with adequate, viable treatment solutions. Should it be possible for acute stress to be addressed and mitigated as it happens via exposure to natural (and particularly blue) spaces, there exists the potential for an effective, and cost effective (free) solution to combat acute stress.

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. As mentioned previously, an understudied area of research is how nature can mitigate the impacts of acute stress responses. Consequently, this can serve as the free measures discussed.

The general restorative benefits of nature have been well-documented, and the little available literature on how nature can relieve stress, both psychologically and physiologically appears to show a positive trend (Bratman et al., 2019; Kuo, 2015; Meredith et al., 2020; Miyazaki et al. 2014). That is, despite the lack of clarity in literature surrounding the type of stress being measured, natural outdoor areas tend to promote psychophysiological stress reduction (Marselle et al., 2021).

Literature on the benefits of nature tend to delineate nature types as either green or blue spaces. Green spaces typically refer to an outdoor natural area where the predominant visual focus is vegetation, including trees, shrubs, flowers, and grass. For example, forests, parks, nature reserves, and botanical gardens would be considered green spaces. Blue spaces, conversely, are outdoor natural areas where the predominant visual focus is water, such as a lake, the ocean, a waterfall, or a river. It is critical to note from the outset that although these areas are defined as green and blue spaces, the colours refer to the archetypal version of the area and the focus is not on the colour itself. This is clarified to avoid any confusion surrounding the presence of differently coloured elements (such as pink flowers, or a green sea) within their respective space.

While literature has started addressing the use of green spaces to reduce acute stress, there remains a paucity of research into the acute stress relieving effects of blue spaces, measured psychophysiologically. Following an extensive search via numerous search engines, including Scopus, EbscoHost, Google scholar, and Jstor, there appears to be no literature in the South African context that focuses on the acute stress relieving effects of blue and green spaces. The present study therefore aims to address this dearth of knowledge by employing a range of psychophysiological measurement types. These are utilised to measuring the induced acute stress responses of participants while being exposed to either an urban space, green space, blue space, or no space (in the case of the control group). These measurements include the Perceived Stress Scale (PSS), Nature Relatedness Scale (NRS), Restoration Scale (RS), and four self-developed follow up questions. Physiologically, acute stress responses are assessed by measuring blood pressure, heart rate, the cardio stress index (CSI), and electrodermal activity (EDA). To the author's knowledge, to date, no research has examined the impacts of blue spaces by measuring heart rate or EDA. To this end, the research will fill a knowledge gap by bringing new findings to the field of acute stress relief.

1.3 Aims and objectives

In light of the issues raised in the above discussion, the aim of the present study is to determine the extent to which urban, green, and blue spaces impact acute stress. In order to attain this aim, the following objectives and accompanying hypotheses were set:

- To investigate how effectively urban spaces impact acute stress, as measured by physiological and psychological measures;
  - H_1: Exposure to urban spaces significantly impacts acute stress, measured physiologically and psychologically
  - $H_{0(1)}$: Exposure to urban spaces does not significantly impact acute stress, measured physiologically and psychologically

- To investigate how effectively green spaces impact acute stress, as measured by physiological and psychological measures;
  - H_2: Exposure to green spaces significantly impacts acute stress, measured physiologically and psychologically
  - $H_{0(2)}$: Exposure to green spaces does not significantly impact acute stress, measured physiologically and psychologically

- To investigate how effectively blue spaces impact acute stress, as measured by physiological and psychological measures and;
  - H_3: Exposure to blue spaces significantly impacts acute stress, measured physiologically and psychologically
  - $H_{0(3)}$: Exposure to blue spaces does not significantly impact acute stress, measured physiologically and psychologically

- To determine the extent to which the spaces under investigation impact acute stress levels the most, as measured by EDA.

The second aim of the present study is to develop a psychophysiological model of acute stress relief, integrating the findings of this study with evolutionary psychology, the biophilia hypothesis, and stress reduction theory.

The methodology employed to address the above aims and objectives was a quantitative, experimental research design (Babbie, 2016). Specifically, a four-group pre-test-post-test control group design with one control group and three treatment groups was utilised.

A final sample of 118 young adult participants was obtained. The participants were assigned to one of three treatment groups, which involved exposure to either a blue, green, or urban scene. The control group did not receive any form of treatment. Data collection took place in a laboratory setting where participants were exposed to a stressor in the form of a jump scare movie clip and a balloon unexpectedly being burst behind them simultaneously. Those in the treatment groups then watched a short first-person video of an individual walking through either a forest, a city, or on the beach. Psychophysiological data were collected before, during, and after this stressor-treatment exposure. A detailed explanation of the chosen methodology is presented in Chapter 4.

Following the outlined aims and objectives set for the present study, the next section will provide an outline of the remaining chapters of this thesis.

1.4 Outline of the study

The current chapter (Chapter 1) provides the relevant background to the present study. It has provided the context, problem statement, and justification for the present study. It has furthermore provided the aims and objectives to execute the study.

Chapter 2 involves a comprehensive review of literature, firstly on stress and the challenges of clear delineation of stress types. This includes the author's proposed stress typology. The impact of urbanisation on stress and health is considered next, followed by a discussion of psychophysiological stress responses. An integration of existing psychophysiological stress response processes is presented. Available literature on natural areas, green spaces, and blue spaces is then discussed.

Chapter 3 focuses on three theoretical approaches to stress relief, including evolutionary psychology (EP), the biophilia hypothesis, and stress reduction theory (SRT). These are integrated with the psychophysiological stress response model that is presented in Chapter 2, to create a holistic theoretical framework.

Chapter 4 discusses the methodology employed in the present study. It restates the aim and objectives of the present study and outlines the research design, sampling techniques and procedures, and a description of the sample. The measurement instruments are described, the data collection and analysis procedures are explained, and the chapter concludes by describing the relevant ethical considerations of the study.

Chapter 5 presents the results obtained by means of the techniques described in Chapter 4. The psychological results are presented first, followed by the physiological results.

Chapter 6 discusses the results presented in Chapter 5 and integrates them with existing literature and theory. The limitations of the study are listed, and recommendations for future research are provided.

1.5 Conclusion

The present chapter has introduced the study and provided the background context for the research. The consequences of acute stress were provided, as well as the deleterious impacts of chronic stress, since chronic stress can be defined as repeated exposure to acute stress. The problem statement and justification were presented, indicating the gaps in existing literature that could be filled by the present study. The aim and objectives of the study were then presented. The following chapter will focus on a comprehensive discussion of available literature on the constructs being investigated.

CHAPTER 2: Literature Review

2.1 Introduction

This chapter will start by addressing the most recent findings regarding stress. This includes a brief introduction to the multifaceted concept of stress and a discussion regarding stress typologies and current debates on how best to classify stress types. This is followed by the researcher's own proposed stress typology, for the purposes of the present study. A discussion of the prevalence of stress and the impact of stress on health will follow, to provide justification for the need to address acute stress as rapidly as possible. Given the contrasting views in literature on how best to define the stress response from a psychophysiological viewpoint, an integrated model of stress response theories is consequently proposed.

The literature review is divided into two sections. The first portion provides an elucidation of current research on stress, in terms of existing typologies and theories of stress responses. The second half of this literature review involves a comprehensive review of recent literature on the stress-relieving effects of green and blue spaces. Since urban spaces typically promote stress, not stress relief (Bonnes et al., 2019), mention is made throughout the chapter of the impact of urban areas, firstly considering the deleterious effects of urbanisation and urban dwelling, and then when used as a comparator group in green and blue literature. Databases searched included EBSCOhost, JSTOR, Scopus, ScienceDirect, APA PsycNet, and Google Scholar. Search terms included combinations of "nature", "green space", "greenspace", "blue space", "bluespace", "garden", "outdoors", "water", "waterscape", "restoration", "relief" "urban", "stress", "acute stress", "fight or flight", "HPA-axis", "sympathetic nervous system", and "allostasis".

2.2 Stress

When asked to define stress, most individuals describe feelings of being overwhelmed or unable to cope, as a result of a potentially threatening circumstance or object (Lees, 2018; Thiel & Dretsch, 2011). However, despite centuries of research on the topic, researchers across disciplines still struggle to achieve consensus on a suitable, comprehensive definition of stress (Cooper & Quick, 2017; Engert et al., 2018; Nater, 2018; Weiser, 2014). One of the reasons for this is that the type of definition given will depend on the discipline of the person providing the definition (Hunter et al., 2019). For example, those in biological fields will focus their definition more on the physiological experiences and responses to stress while those in psychological fields will focus more on the individual life experiences and emotions of stress (Epel et al., 2018).

However, according to Crosswell and Lockwood (2020), this lack of consensus is less an issue of delineating how to measure or define various types of stress, and more an issue of the lack of specificity of terms used in stress research. Their definition of stress is that it is an "umbrella term representing experiences in which the environmental demands of a situation outweigh the individual's perceived psychological and physiological ability to cope with it effectively" (Crosswell & Lockwood, 2020, p. 2). This definition captures both the highly subjective nature of stress and the fact that it is both a psychological and physiological experience. The subjective element of stress refers to the notion that an encounter or event that is considered stressful by one individual, may not be perceived in a similar manner by a different individual (Zakreski & Pruessner, 2020).

It is necessary at this point to clarify that there is a difference between exposure to a stressful event, and the response to such an event (Crosswell & Lockwood, 2020), as these are dealt with separately in the present study. The event, or stimulus that evokes a stress response, is referred to as a stressor. There exist numerous types of stressors such as being fired or losing a loved one, however the present study employed a unique stressor that is always stressful. This stressor is a sudden, loud, and unexpected sound and produces what is referred to as an acoustic startle response (Martin et al., 2015). The details of how this stressor was administered are discussed in 4.6.

On the other hand, the stress response refers to the physiological, cognitive, and emotional reactions of the individual to the stressor (Crosswell & Lockwood, 2020). These involve the physiological changes and responses to the stressor and the activation of necessary emotional and cognitive resources to effectively respond to the stressor.

The purpose of the sudden loud sound to produce an acoustic startle response was to guarantee the elicitation of a stress response. The startle response is an involuntary defensive response that initiates the fight-or-flight response (Ćosić et al., 2016). The startle response will be discussed in greater depth in 2.2.3.

Next, the types of stress as defined by current research are delineated. The relationship between these types of stress, and the clarification of those used in the present study, are also perused.

2.2.1 Types of stress

There is general agreement among authors that acute and chronic stress are different from each other (Engert et al., 2018; Nater, 2018; Vrshek-Schallhorn et al., 2019). It is important at this stage to note that while the focus of the present study is on acute stress, the lack of agreement among authors regarding how best to classify acute stress (and other stress types) means that it is necessary to first examine existing typologies. Investigating the issues and inconsistencies of existing definitions will provide context and justification for the definition of acute stress as used in this study.

A prominent stress typology is from Crosswell and Lockwood (2020) (built on by work of Epel et al., 2018), and they define stress types as ranging from acute to chronic stress in the following manner:

Table 1 Stress typology

Type of stress	Definition
Chronic stress	Chronic stressors are prolonged threatening or challenging circumstances that disrupt daily life and continue for an extended period of time (minimum of one month).
Life events	Life events are time-limited and episodic events that involve significant adjustment to one's current life pattern, such as getting fired, being in a car crash, or the death of a loved one. Some life events can be positive (e.g. getting married, moving to a new place), and some become chronic (e.g. disability caused by car crash).
Traumatic life events	Traumatic life events are a subclass of life events in which one's physical and/or psychological safety is threatened.
Daily hassles (i.e. daily stressors)	Interruptions or difficulties that happen frequently in daily life such as minor arguments, traffic, or work overload, and that can build up overtime to persistent frustration or being overwhelmed.
Acute stress	Short-term, event-based exposures to threatening or challenging stimuli that evoke a psychological and/or physiological stress response, such as giving a public speech.

Note: Adapted from “Best practices for stress measurement: How to measure psychological stress in health research” in *Health Psychology Open*, *7*(2). by A. D. Crosswell and K. G. Lockwood, 2020

In this typology, there are types of stress that fall between acute and chronic stress, such as daily hassles or traumatic life events. From this typology, acute stressors are defined as intense, short-term exposures. What these may involve, other than the example provided in Table 1 above, are not given by the authors, nor is a definitive time period suggested outside of “short-term”. Daily hassles, as the name implies, are minor issues that occur during the course of a day. Similarly to acute stress, how long each event takes is recognisably difficult to define, as these are such subjective and circumstantially unique events. According to Epel et al. (2018), when the same daily hassles are faced regularly, they can be considered as a type of chronic stress. This sentiment is similar to the proposed notion by other authors that chronic stress is the repeated or constant exposure to acute stressors (Gray et al., 2017; Salomon et al., 2020).

In Table 1’s typology, life events and traumatic events can primarily be distinguished by the fact that life events can be either positive or negative events, while traumatic events are always negative (e.g. losing a loved one). As an example of a life event, being promoted may be a positive experience, but the additional pressure or responsibilities associated with the promotion may be considered stressful. Life events are time-limited in definition (i.e., the duration of the event constitutes the time of exposure to the stressor) but, depending on the type of event, may have long-lasting effects (in the case of negative life events) or positive effects (in the case of getting married, or getting a promotion). Similarly, traumatic events are time-bound to the event, but since they are inherently negative, may have long-lasting negative consequences.

Chronic stressors are more difficult to define (beyond the one approach provided above). While these are often characterised as prolonged circumstances that are present for more than one month, what constitutes a chronic stressor is debateable and the relationship between chronic stressors and life events can be bidirectional (Epel et al., 2018). That is, a life event such as losing a job can result in the chronic stress of financial strain, while conversely a chronic stressor such as living in an unsafe area may result in a traumatic life event such as being hijacked. This adds a layer of complexity to the relationships between the types of stress defined in the above typology.

This potentially bi-directional relationship, and the kind of events categorised into each category, may result in ambiguity in the academic endeavour of accurately defining and delineating stress types. For example, Epel et al. (2018) categorise experiencing abuse as a traumatic life event, but categorise "being in a conflictual relationship" as a chronic stressor (p. 152). This appears contradictory since, unless specified as a once-off occurrence, abuse of a person typically happens more than once, creating a prolonged circumstance which should therefore be classified as a chronic stressor (Bhandari & Sabri, 2020). Furthermore, as mentioned, this typology acknowledges the fact that chronic stress can be conceptualised as arising from being repeatedly exposed to the same daily stressor. As such, the question arises as to whether the stressor in question is a daily hassle, or chronic stress? A similar concern arises when considering traumatic events such as a natural disaster or the loss of a loved one. Hearing the news of the unexpected loss of a loved one is a traumatic event, but the initial shock upon hearing the news can be experienced as an acute stressor. These issues mentioned are not arbitrary semantic matters; the matter is of importance as it is directly related to the type of treatment or stress management technique sought out. The proposed new typology that takes these issues into account is discussed at the end of this section.

Some authors prefer to differentiate acute stress as only those events that cause the initiation of the SNS and HPA axis (discussed in 2.2.4.1.1 below), and all other stressors as chronic, ranging from mild to severe. For example, Zakresi and Pruessner (2020) categorise daily hassles as mild chronic stress, and traumatic life events as severe chronic stress. On the other hand, others assessing psychophysiological stress levels refer to both acute and chronic stress, but do not clearly delineate the terms or which stress type is being assessed and discuss stress responses (Engert et al., 2018; Nater, 2018).

The variation regarding the formation and definition of typologies of stress aims to highlight the lack of agreement on what constitutes the various types of stress, or the manner in which stress types should be categorised. Consequently, the following typology of stress is proposed, as applied in the present study:

Table 2 Author's proposed stress typology

Type of stress	Definition	Time frame
Acute stress	A sudden, short-term event that evokes a sympathetic nervous system and HPA-axis response. This can be anything that, if appraised as a stressor, triggers this physiological response. For example: a startle response, the moment of getting bad news, the	The moment of the event occurring

	moment of being injured, or any daily hassles, life events, or traumatic events that upon initial occurrence trigger a physiological response.	
Chronic stress	Can be defined in a few ways: - Repeated exposure to acute stressors (of the same or different type) - The longer-lasting impact of any acute stressor, such as the impact of losing a loved one or being injured - Living in conditions which are chronically stressful, such as living in poverty - On-going, threatening, unpleasant circumstances beyond one's control, for example childhood abuse, loss of income, or political instability	The time following the event

The fundamental difference between the proposed typology, and previously proposed typologies, is the distinction based on time, as opposed to event type. The reason for this, in the context of the present study, is because it is crucial to recognise that the moment of the occurrence of nearly any type of stressful event can be viewed as acute and eliciting a fight-or-flight stress response. If this is recognised, then it can be treated as such, with early intervention in the form of exposure to natural areas, holding the potential for minimizing longer-lasting impacts of any type of stressor.

A further reason for the proposed delineation is the importance of recognising that the same incident can result in both acute stress and chronic stress. By delineating by time, as opposed to event type, the issue of trying to categorise every possible stressful event into a handful of narrow categories is effectively eliminated.

Finally, the broader categorisation proposed above holds greater benefits in terms of proposed treatment of acute stress by natural areas, if such a treatment effect is found. Thus, if the results demonstrate that exposure to natural areas is effective in reducing acute stress responses, the implications for use as a treatment fall across a greater scope of stressful events, than the narrower definitions of acute stress previously proposed.

While recognising that stress, stressors, and stress responses are not regularly clearly defined, it is nonetheless necessary to investigate the extent and prevalence of stress, in the broad sense of the word. Understanding the extent to which stress is an issue, worldwide, provides context for the need for the present study. That is, if natural environments play a positive role in the reduction of acute stress, the negative consequences of stress can be mitigated before becoming problematic. Therefore, the following section addresses nation-wide reports on the prevalence of stress, both locally and internationally. Furthermore, as mentioned in 2.1, urban areas regularly promote stress and so the problems associated with the rise of urbanisation are discussed.

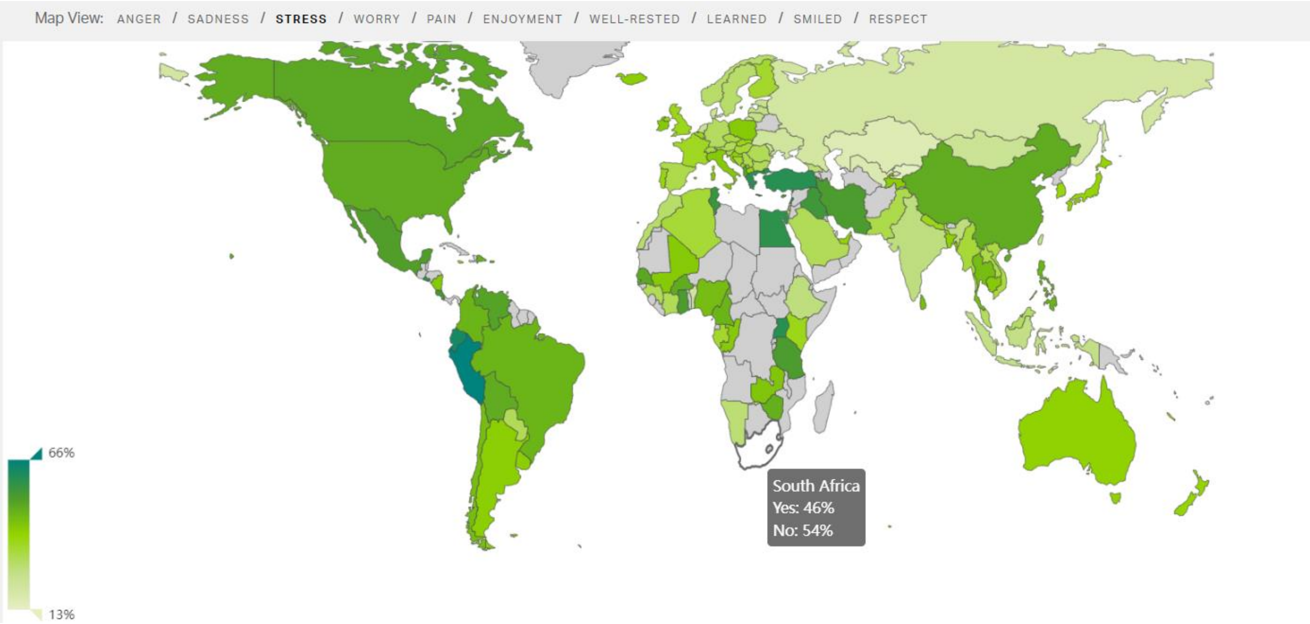
2.2.2 Prevalence of stress

Although reports of the prevalence of stress typically do not differentiate between acute and chronic stress, or between psychological and physiological stress, there are a handful of organisations that publish annual reports on stress as a general concept. One such study was undertaken by the United Kingdom's (UK) Mental Health Foundation in 2018. Their report, aptly titled "Stress: Are we coping?", revealed that 74% of surveyed people in the UK did not feel as if they were coping. Moreover, they reported that over the past year they had felt so stressed, that they were overwhelmed or unable to cope (Mental Health Foundation, 2018).

Gallup produces an annual report that provides insight into the global prevalence of stress. This report takes the form of a "Global Emotions" report, which includes Positive and Negative Experience Indexes, providing a breakdown of positive experiences and negative experiences (Gallup, 2021). One of the questions posed is "Did you experience the following feelings during a lot of the day yesterday? How about stress?" According to the most recent report, 2020 was the most stressful year, with 40% of adults stating they had experienced a lot of stress the previous day. This record high figure was a 5% increase from 2019 and, according to the report, represents an increase of almost 190 million more people experiencing stress than in 2019 (Gallup, 2021).

The range of reported stress varies from 13% (Kyrgyzstan) up to 66% (Peru). Locally, just under half of South Africa's population reported experiences of stress (46%). The following image is taken from an interactive map on Gallup's website that allows one to see the reported scores for each of the index questions per country. The selected index question was stress.

Figure 1 Reported South African stress levels in 2020



Note. Reported South African stress levels in 2020 *from "Gallup*" 2021"

These high levels of reported stress, locally and internationally, demonstrate the need for effective interventions and treatments for stress. While the type of stress being reported is unclear, it nonetheless remains critical that effective treatments for stress at its earliest onset are found.

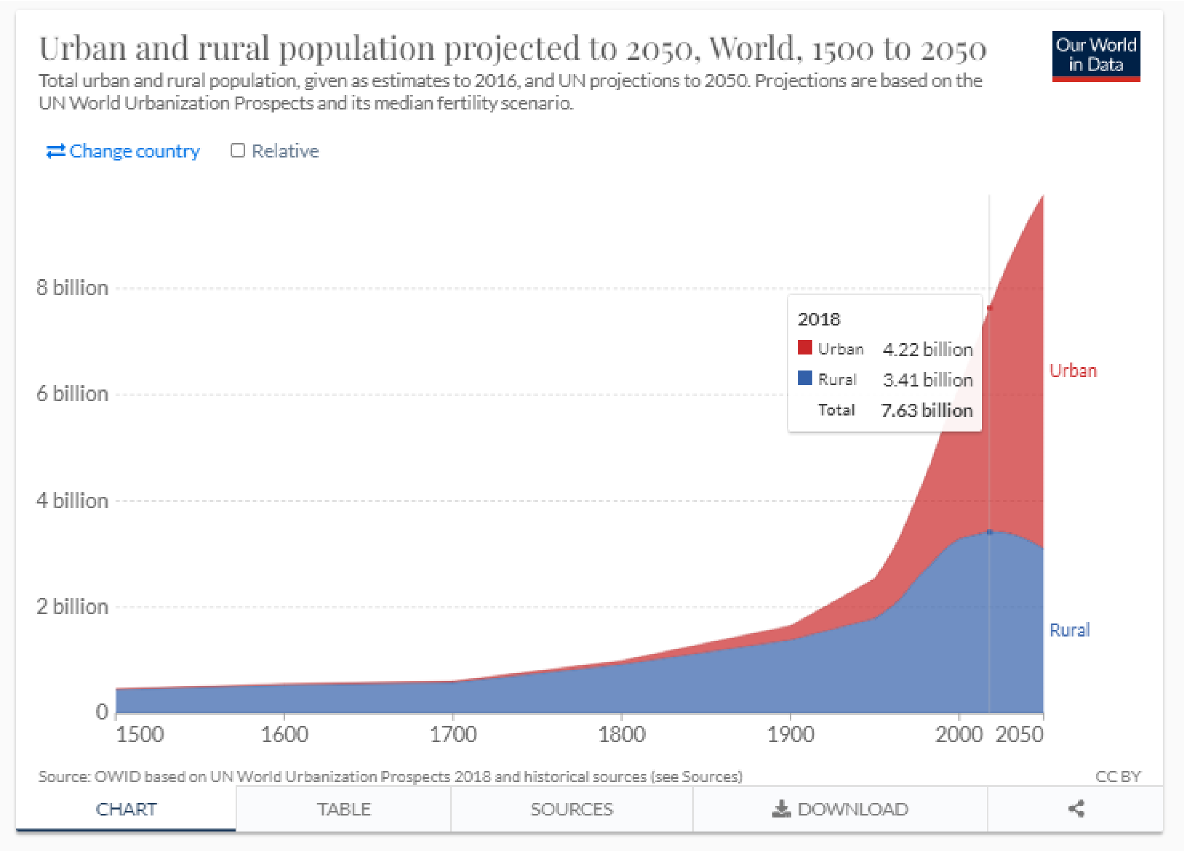
A possible reason why stress is not more clearly delineated when being reported, is because it is often conceptualised and reported as part of general mental health (Salari et al., 2020). The World Health Organisation (WHO) defines mental health as "a state of well-being in which the individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community" (WHO, 2018, para. 2). This conceptual incorporation of stress into general mental health provides a segue to examining the negative impacts of urban areas. That is, by understanding the negative impacts of urban areas on mental health, one can deduce that there are correspondingly negative impacts on stress.

Although there are many social, psychological, and biological (genetic) factors that influence mental health, multiple studies have demonstrated that living in urban areas are linked to poorer mental health outcomes (Krefis et al., 2018; Lecic-Tosevski, 2019; Reece et al., 2021; Santi et al., 2019; Ventriglio et al., 2021; von Szombathely et al., 2017; White et al., 2013). In fact, recent research has confirmed that living in an urban area is a risk factor for the development of mental disorders (Abbott, 2012; Ventriglio et al., 2021). Some of the proposed mechanisms for this negative impact of living in urban areas include air pollution (Choi & Yang, 2021; Zhang et al., 2018), noise pollution (Park & Evans, 2016; Steg & de Groot, 2019), overcrowding (Hosseini et al., 2021), violence and crime (Okkels et al., 2018), and travel congestion and accidents in commuting (Okkels et al., 2018; Park & Evans, 2016; Steg & de Groot, 2019).

Despite the research cited above all being centred on urban, city areas, there is still some debate regarding how best to define an urban area (Breckenkamp et al., 2017). For the present study, urban space will be defined as 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.

In terms of the exposure that people have, and will have, to these areas, while global populations have increased, the rate of urbanisation has increased at an even more rapid rate (United Nations World Urbanization Prospects, 2018). In 2018, the global population was approximately 7.6 billion, where 4.2 billion of these people (55.29%) lived in urban areas, while the remaining 3.4 billion (44.71%) lived in rural areas. It is projected by the United Nations (UN) that by 2050 the global population will have increased to 9.8 billion, but that the ratio of urban versus rural living will have changed to 6.7 billion (68.36%) in urban areas versus 3.1 billion (31.64%) in rural areas (Ritchie & Roser, 2019; UN, 2018). Figure 2 demonstrates the rapid rate of urbanisation to date, as well as the even more rapid projected rate of urbanisation to 2050.

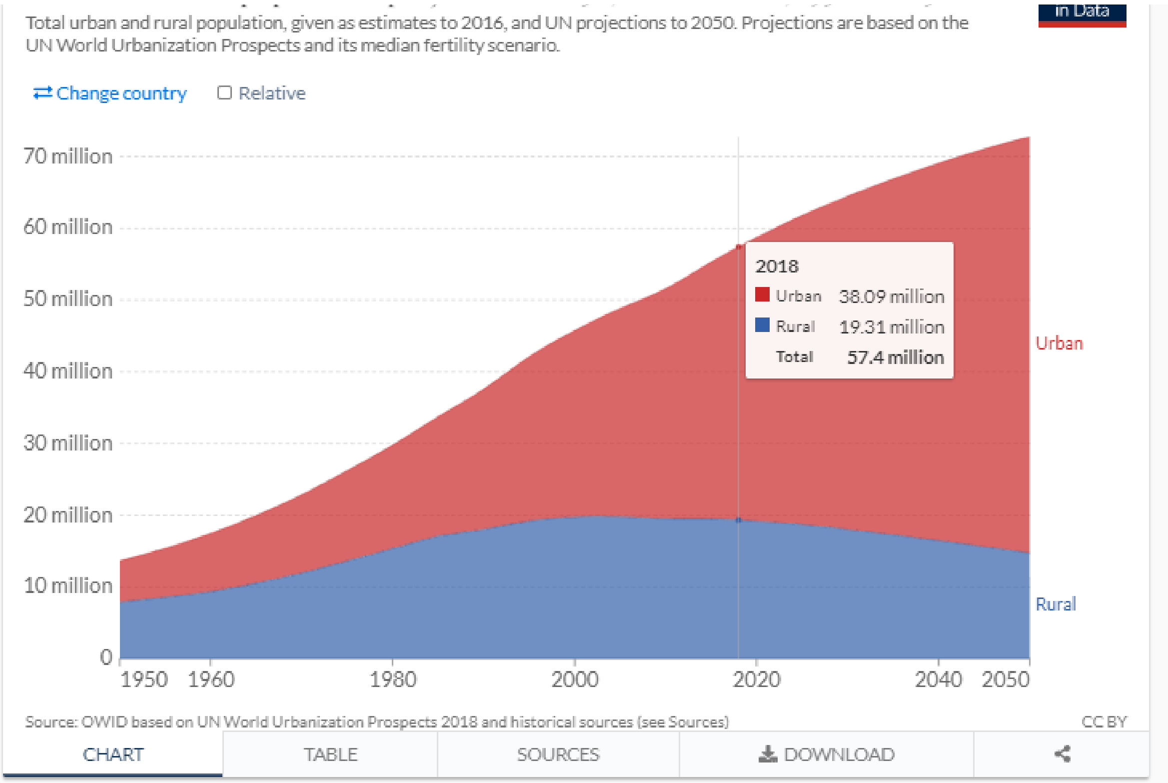
Figure 2 Urban and rural population projected to 2050



Note: Urban and rural South African populations projected to 2050. From "Our World in Data" by H. Ritchie and M. Roser, 2019.

In the South African context, this change is even more drastic. Although Figure 3 only shows data from 1950 (as this was the oldest available data point provided by the UN), the percentage of the total population in 2018 (57.4 million) living in urban areas was 66.35% (38.09 million people), compared to 33.65% (19.31 million people) living in rural areas. By 2050, this proportion is expected to change to a total population of 72.25 million, of which 58.06 million (79.8%) are expected to be living in urban areas compared to 14.7 million (20.2%) people living in rural areas (Ritchie & Roser, 2019; UN, 2018). Of particular importance is the rapid increase of urbanisation after the end of Apartheid in 1994. When laws segregating white people from non-white people were scrapped, the equality of access to jobs resulted in an increase of people moving to urban areas to look for work. While a detailed discussion of the nature and extent of urbanisation after the fall of Apartheid is beyond the scope of the present study, it is worth noting.

Figure 3 Urban and rural populations in South Africa, 1950 to 2050



Note: Urban and rural South African populations projected to 2050. From "*Our World in Data*" by H. Ritchie and M. Roser, 2019.

The implication of this increase in urbanisation rates is that the issues cited above, regarding the poor mental health outcomes related to living in urban areas, are likely to increase, not decrease in coming years, either locally or globally. This again highlights how important it is to mitigate the negative effects of urbanisation and stress as soon as possible.

2.2.3 Psychophysiological stress responses

Even though stress is a psychophysiological process, approaches to stress responses have typically separated physiological from psychological responses. In order to propose an integrated model, three physiological approaches will be discussed (the General Adaption Syndrome, which is focused on attaining homeostasis; the autonomic and endocrine responses to an acute stressor; and allostasis), followed by Lazarus and Folkman's (1984) psychological Transactional Theory of Stress and Coping. These will then be integrated into a proposed model of psychophysiological acute stress responses (Figure 9) including the areas in which natural spaces could make positive contributions.

2.2.3.1 General Adaption Syndrome (GAS)

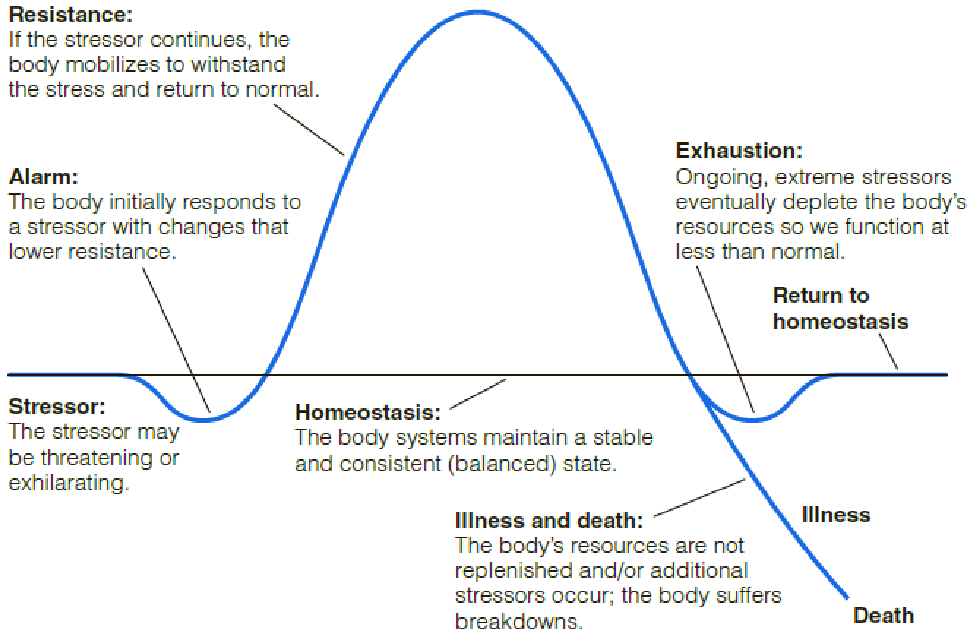
One of the most prominent theorists of the physiological response was Hans Selye, who is often considered the grandfather of stress research (Zakreski & Pruessner, 2020). His explanation of a stress response included a triphasic response pattern to a threat, without necessary specification of such stressor (these were termed 'noxious stimuli') (Selye, 1936). The main reason these threats were not specified as stressors, was because at the time there was not yet agreement regarding what "stress" or "stressors" were.

Before discussing each phase of the GAS, it is important to clarify how the non-specificity of response patterns were both a function of the time the theory was developed and a necessary step forward in the applicability of the theory. As mentioned, the GAS was developed in the 1950s and so scientific research in the realm of physiology and neuroscience was vastly different from today's body of knowledge (Zakreski & Pruessner, 2020). To this end, Selye was initially only able to posit that there were external, evocative, or noxious stimuli that triggered a requirement for adaptation by the organism. Nonetheless, the value of this is that it set the scene for further research into these (now known as) stressors while maintaining the understanding that the body responds in a way that is adaptive, to protect itself. Selye (1976a, b) maintained that regardless of the type of demand, or noxious stimuli, the requirement for adaptation was non-specific and occurred across all demands. Despite the age of the theory and the inevitable criticisms Selye faced due to his inability to be more specific, his theory forms a foundational understanding of how an organism responds to stress and will be built on in the following sections. Since the term 'stress' has since been further defined in 2.2.1, the word 'stressor' will be used going forward, when referring to the threat that elicits a stress response.

The triphasic response process of the GAS includes an alarm phase, where the body registers the threat and prepares itself to respond; the resistance phase, in which the body adjusts and adapts to withstand the long-term impacts of the stressor; and finally, the exhaustion phase. The exhaustion phase occurs when the body can no longer mobilise enough resources to withstand the stressor, returns to a homeostatic level and consequently breaks down (Selye, 1953).

The three stages of the general adaptation syndrome (GAS) are depicted in Figure 4.

Figure 4 The General Adaptation Syndrome



Note. Adapted from *"Defining, measuring, and managing stress"* (p.94), by L. Brannon et al., 2018.

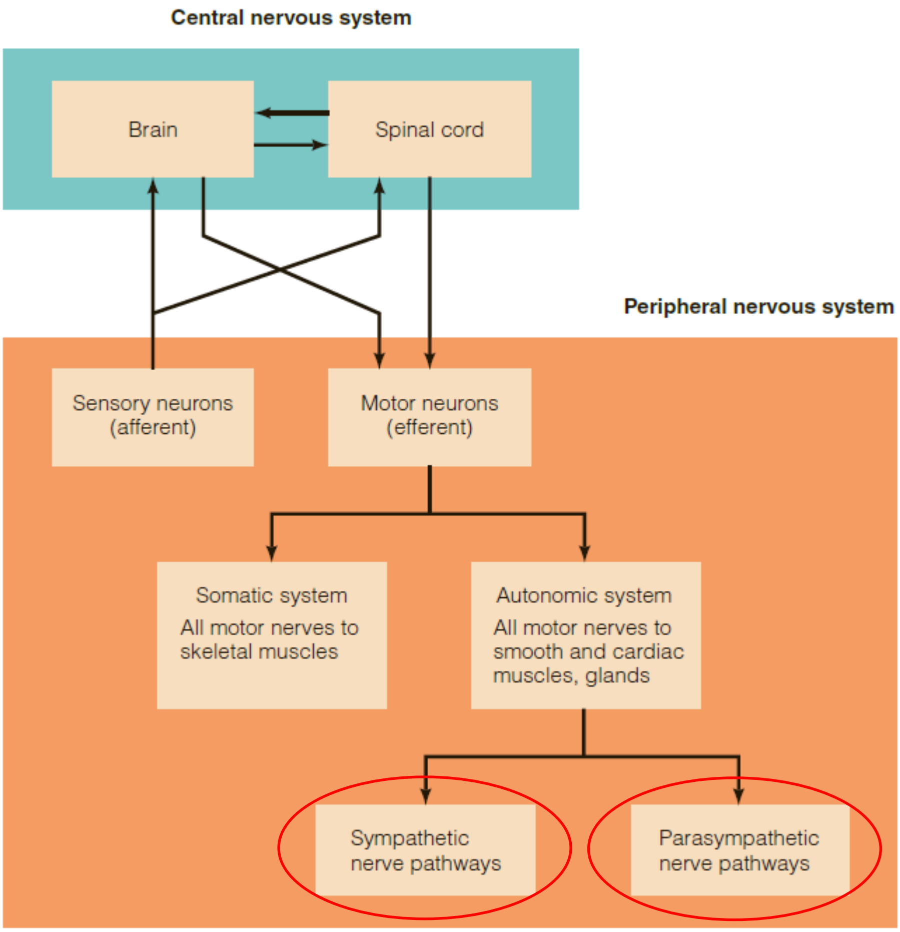
Before discussing each phase of the GAS, it should be noted that one of the elements of the theory that is missing are the time frames of each stage. That is, for example, the amount of time spent in the alarm phase and the resistance phase is unclear. While this may be viewed as a flaw of the original model, in the context of the present study it presents as an opportunity, for the integration with more modern theories. At this stage, it is deemed important to merge current knowledge of acute physiological stress responses with the GAS, as one of the aims of this study is to assess physiological responses to stressors.

2.2.3.1.1 Alarm phase

Within the first phase of GAS, the body registers a threat. Within this conceptual framework, the body is physiologically unable to distinguish life-threatening stressors (e.g. encountering a snake) from non-life-threatening stressors (e.g. riding a rollercoaster) and so it reacts in the same manner to both (Thiel & Dretsch, 2011). As will be discussed in Chapter 4, the period of time deemed to be the alarm phase in the present study was one minute. It is not possible to know whether this aligns with Selye's original time frame of the alarm phase (as this was not delineated), however the discussions that follow will present justification for the synthesis as presented.

During this alarm phase, Selye (1953) described the bodily response to the stimulus as a "call to arms". This initial response reflects the fight-or-flight response that, first proposed by Cannon (1932), mobilises the body for reaction. The fight-or-flight response is still accepted in current scientific literature and occurs as a result of the activation of the autonomic nervous system, more specifically the SNS (Freberg, 2019). The divisions of the nervous system, including the autonomic nervous system, are presented in in Figure 5. The sympathetic and parasympathetic pathways, the functions of which are assessed in the present study are circled in red.

Figure 5 Divisions of the nervous system



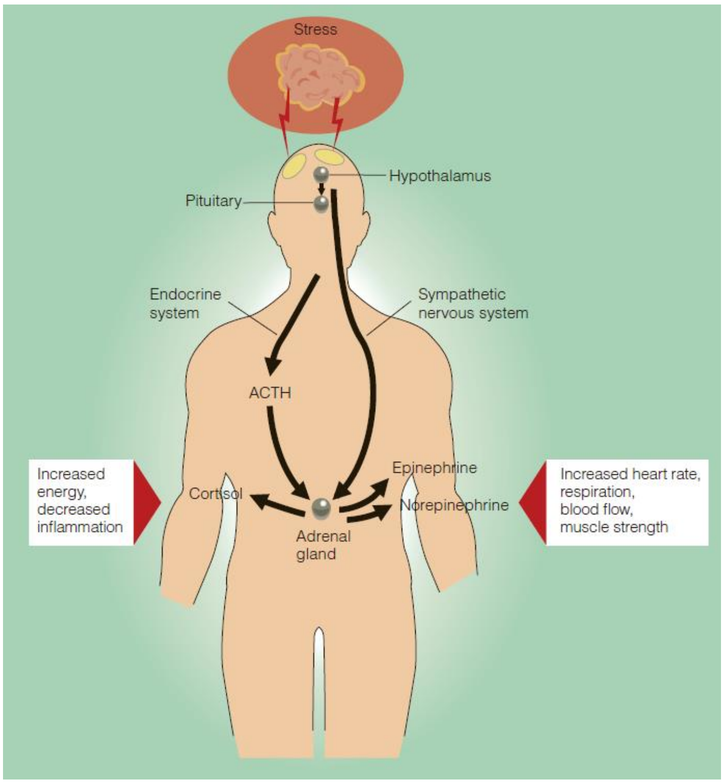
Note. Adapted from *"Defining, measuring, and managing stress"* (p.88), by L. Brannon et al., 2018.

The SNS is responsible for initiating the fight-or-flight response, by stimulating the release of adrenaline (epinephrine) and norepinephrine from the adrenal medulla into the bloodstream (Freberg, 2019). This, in turn, stimulates various responses, such as increased respiration, heart rate and blood pressure, constricted blood flow to the skin, decreased digestion, stimulation of sweat glands, dilation of pupils, and a decrease in reproductive function (Brannon, et al., 2018). These changes are functional when preparing to fight or flee in that it is more important, for example, to have a temporarily increased amount of oxygen if needing to run, than it is to be able to reproduce.

In tandem with the SNS response, the second physiological response that occurs is activation of the HPA axis, which responds and maintains its function more slowly than the immediate activation of the SNS. When a stressor is encountered, the hypothalamus releases corticotrophin releasing hormone (CRH), which stimulates the pituitary gland. The anterior lobe of the pituitary gland, in turn, releases adrenocorticotropic hormone (ACTH) into the bloodstream, stimulating the adrenal glands. The adrenal medulla, within the adrenal glands, release cortisol, which produces effects that assist in dealing with stress. These include a raise in blood sugar levels (gluconeogenesis), which provides energy for cells, an anti-inflammatory effect, and which acts as a defence against possible swelling incurred from injuries while fighting or fleeing, and an inhibition of non-essential functions, such as reproductive processes (Brannon et al., 2018; Heaney, 2013). The HPA-axis contains a feedback loop to regulate the amount of cortisol being produced (Wentzel et al., 2020), but this this response is secondary to the initial response discussed here. Therefore, the role of the feedback loop is discussed as part of the resistance phase, which follows next.

Figure 6 provides a simple depiction of the SNS and HPA-axis responses to a stressor.

Figure 6 Physiological response to stress



Note. Adapted from *"Defining, measuring, and managing stress"* (p.91), by L. Brannon et al., 2018.

In the present study this alarm phase was initiated by a sudden, loud, unexpected sound that elicited an acoustic startle response. The startle response is surprisingly uncommon in studies of stress, given its ability to bypass cognitive appraisal (or “highjack the amygdala”) and produce a fight-or-flight response (Field et al., 2015). This response is elucidated as a consequence of the ‘quick and dirty’ pathway whereby the thalamus transmits signals directly to the amygdala, the region of the brain responsible for processing emotions related to fear and survival (Owton, 2022). The amygdala responds immediately by initiating the fight-or-flight response; there is no cognitive processing of the stimulus (Field et al., 2015). The pathway is called ‘quick and dirty’ because while it is reliably effective in producing an immediate startle response, the lack of cognitive processing in response to the stimulus can produce false alarms (Martin et al., 2016; Owton, 2022). Nonetheless, from an evolutionary perspective (which will be discussed in more depth in Chapter 3), having an overly cautious response pattern promotes species survival (Ghai et al.,2018). As the discussion in 2.2.1 demonstrates, there is a lack of agreement on how stress types and responses are operationalised and consequently for the present study, it was necessary to activate the ‘quick and dirty’ pathway, bypassing any elements of cognitive appraisal.

The physiological markers of this alarm phase that were measured in the present study are those produced by the SNS, including heart rate, blood pressure, and increased sweat production. The products of the HPA axis response, such as cortisol were not measured as they require longer time periods to test. Moreover, the natural fluctuations of individual cortisol levels throughout the day have created some doubt regarding the usefulness of cortisol as an effective measure of stress responses (Schlotz, 2019).

Nonetheless, the HPA axis forms a critical part of the alarm phase and should therefore be included when considering the stress response. Should the stressor not be resolved immediately, the body enters the resistance phase, discussed in 2.2.3.1.2.

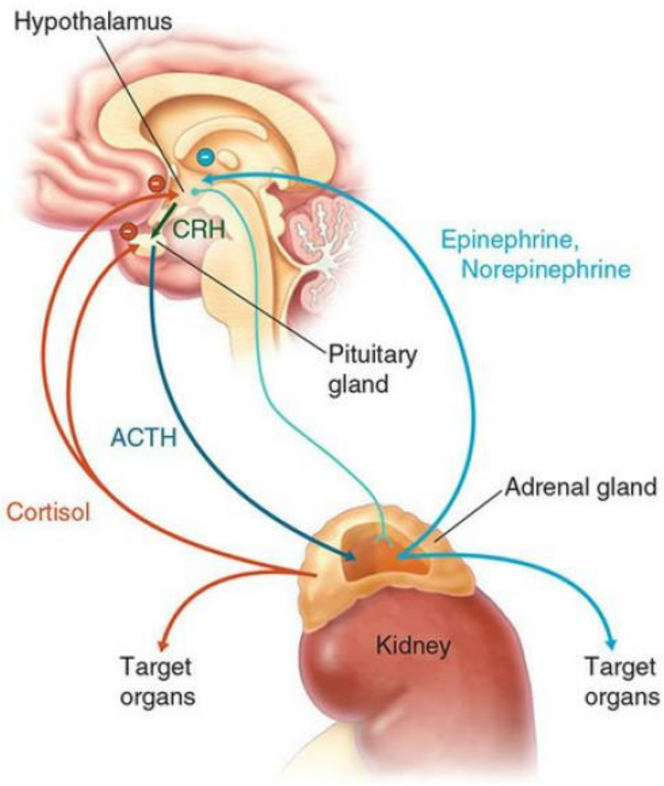
2.2.3.1.2 Resistance phase

The resistance phase of GAS is entered into when exposure to the stressor extends beyond the initial, brief, alarm response (Selye, 1956). For example, if one encounters a potentially venomous snake while on a hike, the alarm phase will occur the moment the individual realises they have encountered a potentially life-threatening animal. If the snake moves away and disappears, the threat is resolved, and the body consequently returns to its original homeostatic state. However, if the snake does not move away and the individual has to stand for an ongoing period of time, while deciding on the best course of action to avoid the threat of the snake, the resistance phase will be entered into as the threat is ongoing. During this phase, significant amounts of energy are mobilised to allow the body to withstand the ongoing stress (Selye, 1946).

The SNS response will continue in an attempt to maintain the levels of mobilised energy resources, providing the individual with the potential resources needed to fight or flee. In a less severe context, that is, one that is not necessarily life threatening, the body may activate the parasympathetic system (PNS), to try to return to a homeostatic state, as long-term activation of the SNS is unsustainable. The PNS acts synergistically with the SNS in an attempt to restore homeostatic levels of critical bodily functions such as heart rate, pupil dilation, and sweat production (Karemaker, 2017). This response is functional, firstly because it restores homeostatic levels (as far as possible), but also because this homeostatic return provides the body with a "break", should the SNS response need to be reactivated.

The second physiological response that occurs during the resistance phase is the feedback loop of the HPA axis alluded to in 2.2.3.1.1 above. While the initial HPA axis response mobilises the body for action, there is also a negative feedback loop, to maintain the amount of cortisol in the bloodstream (Heaney, 2013). As demonstrated in Figure 8, cortisol travels to target organs to mobilise stress responses, but it also travels back to the hypothalamus. The hypothalamus, upon recognising an excess amount of cortisol, will inhibit the production of CRH, which in turn leads to lowered production of ATCH and cortisol (Freberg, 2019; Garrett & Hough, 2018; Heaney, 2013). These processes of the HPA axis are depicted in Figure 7.

Figure 7 The process of the HPA stress response



Note: From "Brain & Behavior: An Introduction to Behavioral Neuroscience" by B. Garrett and G. Hough, 2018, p.556.

While this feedback loop is an essential component of the stress response, extended exposure to stress results in the HPA axis taking strain and not being able to maintain and reduce the amount of cortisol being produced effectively. Excess cortisol can be harmful in that it can supress the immune system, leading to increased susceptibility to disease and slower wound healing. Moreover, it plays a key role in the onset of major depressive disorder and diabetes, and has cardiovascular implications such as hypertension (Herbert, 2013; Herman, 2011; Jacobson, 2014; Whitworth et al., 2005). Should the conditions of the resistance phase not be conducive to restoration, the stressor continues beyond what the body can handle; or multiple further acute stressors occur, which causes a descent into the exhaustion phase. This is discussed in 2.2.3.1.3.

2.2.3.1.3 Exhaustion phase

Ultimately, when the body's energy reserves have been depleted after repeatedly attempting (and failing) to recover from the initial alarm phase, the individual has reached the exhaustion phase. According to Selye (1946), this phase could be reached after many weeks or months. Selye's research that led him to develop the GAS was conducted on rats. Therefore, at the point of positing GAS, he was not yet entirely certain of the kind of diseases or impacts that would occur in the exhaustion phase in humans (Zakreski & Pruessner, 2020). Nonetheless, he posited that issues such as ulcers, heart disease, depression, or death could be potential consequences; these consequences have been supported by recent research (Jackson, 2014; Martini et al., 2018; Selye, 1953).

In the interim, a newer biological approach to the processes involved in the maintenance of homeostasis has been proposed: allostasis (Sterling & Eyer, 1988). Although allostasis and allostatic load were not tested in the present study, the concepts form part of the most recent thinking in stress research and so to obtain a comprehensive understanding of the stress response, should be addressed (Nguyen, 2021).

2.2.3.2 Allostasis and allostatic load

In simple terms, allostasis refers to “achieving stability through change” (Ramsay & Woods, 2014, p. 226). Essentially, while homeostasis refers to the preservation of a stable internal environment in an organism despite changes in the external environment, allostasis refers to the processes involved in the maintenance of the stable environment (Nguyen, 2021). Homeostasis involves self-regulating processes, so that at any given time, the organism’s bodily systems necessary for survival (for example, core body temperature) are maintained within the strict parameters that support survival (McEwen, 2018).

However, when faced with an acute stressor, physiological changes, such as those discussed above are needed to promote survival. This inevitably leads to changes in levels of bodily systems that fall outside of their normal ranges, such as an elevated heart rate, reduction in function of reproductive systems, and dilation of pupils. If the acute stressor is resolved, these bodily systems return to levels within each respective range of ‘normal’. The “turning on” and “turning off” of these functions is initiated by an allostatic response and involves the secretion of four hormones serving as mediators: glucocorticoids, dehydroepiandrosterone, cytokines, and catecholamines (Nguyen, 2021). An in-depth discussion of the pathways and inter-connections of these hormones is beyond the scope of the present study, as these hormones were not directly assessed as part of the data collected for the study. The data collected assessed the outcome of the result of the allostatic response to an acute stressor, not the hormones involved in the allostatic response itself.

Nonetheless, the outcomes of an excess of allostatic processes is necessary for discussion as these outcomes -- allostatic state, allostatic load, and allostatic overload -- relate to the long-term health consequences of stress exposure (Fava et al., 2019; O’Connor et al., 2021). According to one of the leading modern authors of allostasis, the changed and prolonged activity levels of the four hormonal mediators are referred to as an allostatic state (McEwen, 2018). While this consistent, imbalanced level of hormone production can cause health issues, it can be maintained for a limited period of time, if a sufficient supply of food or stored fat exists to fuel homeostatic states (McEwen, 2017).

If an allostatic state is maintained for longer than energy reserves last, the cumulative result of this allostatic state will result in what is called allostatic load, and eventual allostatic overload (Guidi et al., 2020; McEwen, 2018; O'Connor et al., 2021; Ullmann et al., 2019). An allostatic load is defined as the physiological costs of maintaining allostasis; that is, the body's attempt to return critical systems to a homeostatic level (Ramsay & Woods, 2014; Ullmann et al., 2019). The state of allostatic load can also be viewed as the wear and tear that happens to a system attempting to maintain allostasis (Fava et al., 2019; McEwen, 2018). This can take the form of health issues that arise from prolonged exposure to imbalanced hormonal responses, while attempting to maintain allostasis (e.g. obesity as a result of an excess of cortisol) (Fava et al., 2019; Guidi et al., 2020).

Eventually, if the stressor is still not resolved, or if the individual's circumstances invoke chronic stress, allostatic overload occurs (O'Connor et al., 2021). The consequences of allostatic load are physiologically significant, as they can result in major health issues such as hypertension (and eventual cardiovascular failure), obesity, diabetes, a chronically supressed immune system leaving one more vulnerable to disease, certain types of cancer, or even death (Cohen et al., 2012; Fava et al., 2019; Rosemberg et al., 2020; Ullmann et al., 2019).

The relationship between states of allostatic load and allostatic overload, and Selye's (1953) proposed resistance and exhaustion phases of the GAS, has been contentious in literature (Ramsay & Woods, 2014). Some authors believe that the model and principles of allostasis should serve as a replacement to the homeostatic principles of GAS (McEwen, 2018; Sterling & Laughlin, 2015). Contrastively, others propose that allostasis and homeostasis can function as complementary approaches (Corcoran & Hohwy, 2019; Marón et al., 2019; Power & Schulkin, 2012). The latter is a view supported in the present research and as such will form part of the proposed stress response model in 2.2.3.4.

The discussion of the GAS, the associated biomarkers of each stage, and the concept of allostasis, comprise the physiological aspects of stress responses relevant to the present study. Since stress is not only a physiological concept, it is necessary to discuss a key psychological theory of stress response. To this end, the prominent theory of stress and coping proposed by Lazarus and Folkman (1984) is discussed next.

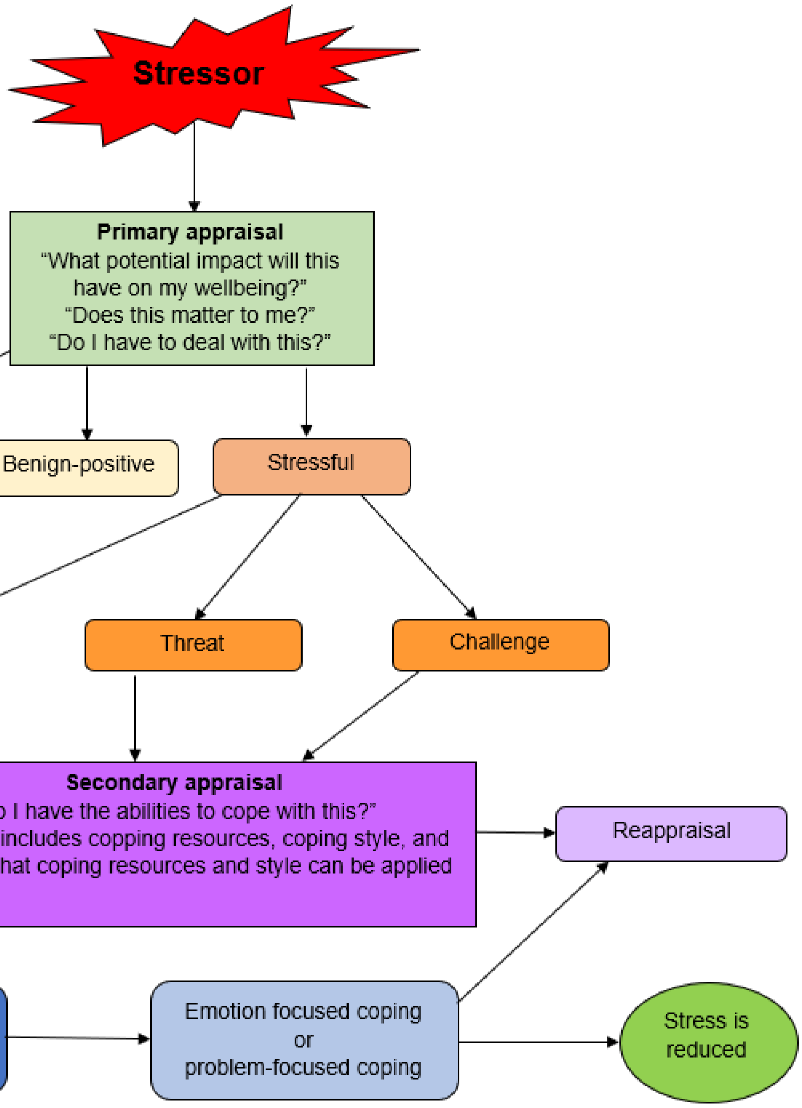
2.2.3.3 Lazarus and Folkman's Transactional Theory of Stress and Coping

Lazarus and Folkman's (1984) theory of stress, appraisal, and coping, has its roots in a response to the shortcomings of the medical definitions of stress of the time. One such issue, Lazarus and Folkman (1984) argued, was that if a stressor was something that changed the homeostasis of the organism, then essentially anything, pleasurable or not, could be considered a stressor. For example, both getting a fright by encountering a cliff edge and getting proposed to would cause similar physiological responses (an increase in the SNS activity), but the former is an unpleasant experience while the latter is positive and pleasurable.

To account for this issue, Lazarus and Folkman (1984, p. 19) proposed the following definition of psychological stress: "Psychological stress is a particular relationship between the person and the environment that is appraised by the person as taxing or exceeding his or her resources and endangering his or her well-being." The critical part of this definition is the emphasis on the relationship between the unique characteristics of the person and the nature of the environment; this is why the theory is called the transactional approach.

A high-level summary model of this theory is presented in Figure 8, after which each element will be discussed in more detail.

Figure 8 Diagrammatic representation of Lazarus and Folkman's Transactional Theory of Stress and Coping



Note. Adapted from R.S. Lazarus and S. Folkman, 1984.

The first stage of the process involves appraisal, which refers to the individual's evaluation of the environment, the meaning they ascribe to the potential person/environment transaction, and what the potential significance of this transaction is to their wellbeing (Biggs et al., 2017; Lazarus & Folkman, 1984). Differently stated, it is the process of categorising an encounter in terms of its potential impact on wellbeing (Lazarus & Folkman, 1984). This initial appraisal is called primary appraisal.

The result of the primary appraisal will be the categorisation of the encounter as either irrelevant, benign-positive, or stressful (Lazarus & Folkman, 1984). An irrelevant appraisal is one in which the encounter has no impact or implication for that person's wellbeing. For example, observing a bird landing close to where one is sitting, and then flying off again. A benign-positive appraisal is one where the encounter holds the potential for pleasure, an enhancement of wellbeing, or related positive emotions. For example, encountering a secluded waterfall while walking in nature would be appraised as benign-positive. The third type of appraisal, and that which is applicable to the present study, is the appraisal of the encounter being stressful. This is a negative appraisal which is then further broken down into three appraisals: as harm/loss, threat, or challenge.

A harm/loss appraisal is, for example, having to have a limb amputated as a result of being attacked by a shark while swimming. In this situation, the harm or loss has already occurred and is being duly appraised as such. This appraisal produces negative emotions and elicits a secondary appraisal, which is discussed below. A threat appraisal is one where potential harm or damage is anticipated (Biggs et al., 2017; Lazarus & Folkman, 1984) but has not yet happened. The example of encountering a potentially venomous snake while on a hike would similarly apply in this context as the possibility for physical harm which is imminent. According to Lazarus and Folkman (1984), a harm/loss appraisal is always fused with a threat appraisal, as the loss or harm holds negative implications for the future. Keeping with the example of losing a limb from a shark bite (harm/loss), a future without the amputated limb needs to be navigated and would hold uncertainty and potential for future negative emotions. This could appertain to learning how to write with one's non-dominant hand if the limb that was lost was the arm used for writing. In relation to the present study, anticipation of the jump scare scene (discussed in Chapter 4) was designed with the intention of creating a threat appraisal.

Finally, the third kind of stress appraisal is a challenge appraisal. While stressful, this appraisal typically produces positive emotions, as the encounter is appraised as holding potential for growth or gain. For example, being given the opportunity to go on a lengthier hike than one typically has before, would be appraised as a challenge, as the extra distance being hiked is beyond what one has done before. However, the opportunity exists to expand one's physical capabilities and to grow and gain hiking experience.

Lazarus and Folkman (1984) emphasise that threat and challenge are not appraisals at the opposite ends of a continuum; they can occur simultaneously, despite being separate constructs. For example, deciding to hike the extra kilometres or days on the invited hiking trip could be both a threat and challenge. The threat would centre around the uncertainty of the difficulty of the extra hiking distance and the potential implications of failure if it is eventually appraised as too difficult. However, the extra hiked distance represents a challenge, as the implications of succeeding in the hiking endeavour and the sense of accomplishment that would accompany the success are positive.

It should also be noted that the balance of threat versus challenge appraisals can change as the encounter unfolds. Keeping with the hiking example, should the individual reach the final portion of the hike and realise that the remaining distance is a slow walk downhill and therefore not too physically challenging, the appraisal will become more of a challenge than a threat. Conversely, should the final portion of the hike involve a strenuous climbing of a mountain, the appraisal will likely move more in the direction of threat than challenge.

Should the primary appraisal result in the encounter being deemed stressful (as harm/loss, a threat, or challenge), secondary appraisal takes place, which involves the cognitive assessment of one's abilities to cope with the stressor (Lazarus & Folkman, 1984). Three key areas are evaluated during secondary appraisal: one's coping resources (self-efficacy), one's coping style (the manner in which one has dealt with similar stressors in the past, if at all), and the estimated likelihood that the coping style resources and style can be effectively applied in the given context (Biggs et al., 2017; Lazarus & Folkman, 1984).

The interplay between these three factors plays a significant role in the coping approach that an individual will take to manage the stressor. There are two primary approaches to coping within the present theory: problem-focused coping and emotion-focused coping (Schoenmakers et al., 2015). Problem-focused coping involves the activities and things the person chooses to do to (behaviours) in an effort to resolve the situation. In essence, problem-focused coping is based on changing the way one interacts with their environment to handle the problem (Lazarus & Folkman, 1984; Schoenmakers et al., 2015). For example, in the context of the hike, problem-focused coping would involve devising strategies to take short breaks or drink extra water to cope with the physical strain. On the other hand, emotion-focused coping involves addressing the way one feels about a situation and reframing or rethinking the way a situation is appraised. It is the sum of the efforts taken to reduce the emotional consequences of the situation (Lazarus & Folkman, 1984; Schoenmakers et al., 2015). Continuing with the example of the hike, emotion-focused coping may involve something as simple as reframing the ability to hike the extra distance as non-essential to one's overall self-image, thereby reducing the emotional strain associated with the challenge.

The final relevant element of Lazarus and Folkman's (1984) theory is reappraisal, which is the process of reassessing the transaction or encounter on the basis of new information. Reappraisal can happen if the abovementioned coping strategies were ineffective, but can also occur during primary appraisal. For example, during the primary appraisal of the extended hike distance, the appraisal may have been that the situation was a threat, due to insecurities of one's own abilities. However, when reaching the final stages of the hike, the realisation that the final stress is not physically strenuous, forms the reappraisal, and the situation changes from being perceived as stressful to being benign-positive. Lazarus and Folkman's (1984) theory, although old, is still used in recent research (Nabi et al., 2022; Yoon et al., 2018; van Zomeren et al., 2019).

Although coping strategies are not being assessed in the present study, the process is important to consider as 1) regular exposure to acute stressors will result in the need for effective coping strategies, and 2) exposure to natural areas could assist, or at least supplement existing coping strategies. Critically, should the present study demonstrate that exposure to blue and green spaces is restorative, it could be argued that they serve as a form of coping. That is, by reducing acute stress arousal, coping is initiated.

With the fundamentals of the GAS, physiological stress responses, and Lazarus and Folkman's (1984) transactional model in place, a proposed integrated model of a stress response is presented next.

2.2.3.4 Integrated model of psychophysiological stress responses

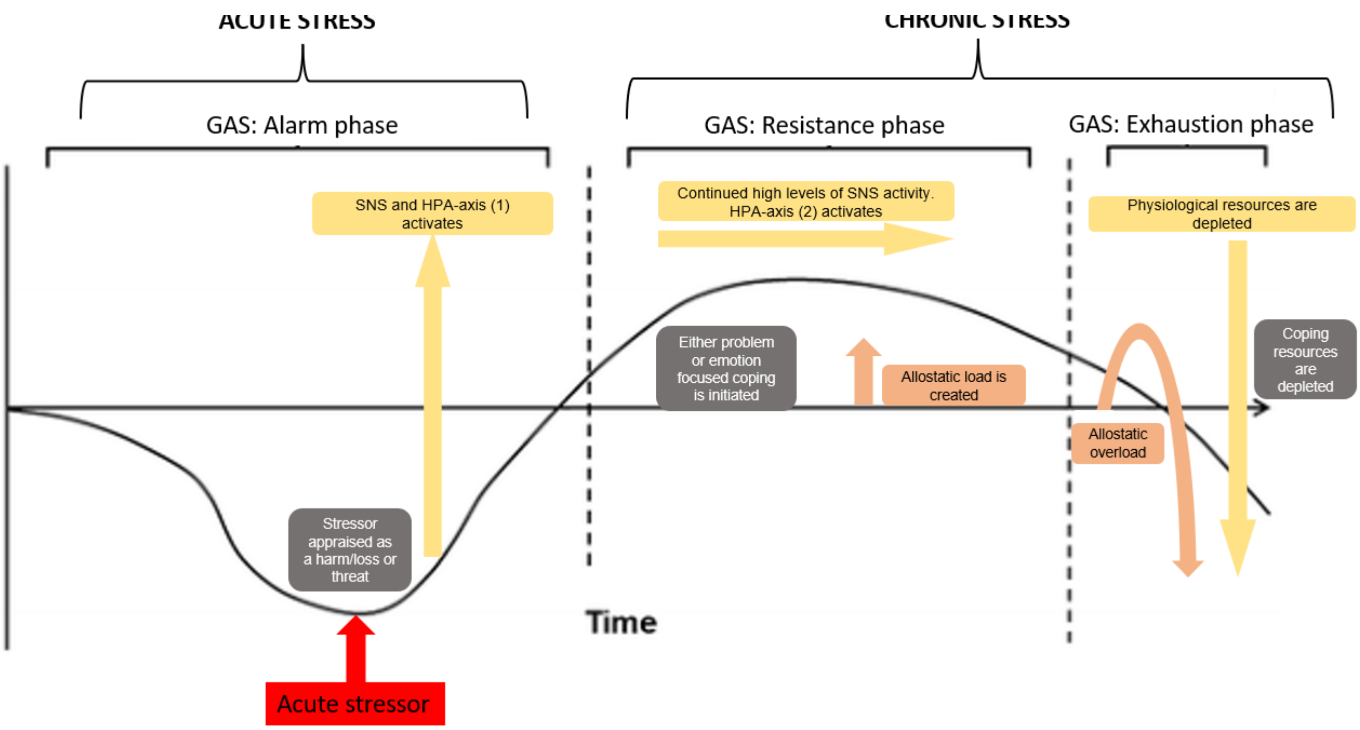
The proposed model will take a similar form as Selye's triphasic model in the sense that it is divided into three phases. In the first phase, an acute stressor occurs. This aligns with the alarm phase of the GAS and both the SNS axis and first part of the HPA-axis (as described in 2.2.3.1.1) are activated. The activation of these systems mobilises the body to fight or flee from the acute stressor. In the present study, the use of a jump scare to elicit a startle response was designed to ensure that within Lazarus and Folkman's (1984) approach, the acute stressor would be appraised as a harm/loss or threat. To align with the author's proposed typology of stress delineations, this first phase is referred to as acute stress.

In the second phase, should there be no relief from the acute stress, the body enters a phase of having to expend energy to coped with the prolonged stressor. This phase aligns with the resistance phase of the GAS. SNS responses will likely remain high, and the feedback loop of the HPA-axis (as explained in 2.2.3.1.2) will activate. This feedback loop will attempt to balance the amount of cortisol in the bloodstream, but this prolonged activation will create the start of an allostatic load. That is, the body will start to take strain from the wear and tear accrued from trying to return to a homeostatic level. In this phase, secondary appraisal will be initiated, and the individual will attempt to incorporate either emotion or problem focused coping.

If the individual is unable to resolve the stressor or the continued stressor falls beyond what the individual is able to control, the third phase will be entered into, which relates to the exhaustion phase of the GAS. In this phase, physiological resources are depleted, there is a presence of allostatic overload, and psychological coping resources are further depleted. It in this phase that the individual is most susceptible to serious illness and even death. To align with the author's proposed stress typology, both the second and third phases are considered a state of chronic stress.

These three phases are displayed in Figure 9. Yellow indicates the SNS and HPA-axis response, grey refers to Lazarus and Folkman's (1984) theory, and pink indicates allostatic activity.

Figure 9 Authors proposed psychophysiological stress response model



Note. Author's own.

It should be emphasised that the focus of the present study is on acute stress and so later integrations of this model with psychoevolutionary theory (Chapter 3) and with the results (Chapter 6) will only include the acute stress response phase. However, only discussing the first phase here without highlighting the potential deleterious effects the remaining two phases which could occur due to long-term exposure to acute stressors would have rendered an incomplete discussion. Crucially, although the present study's focus is on the effects of nature in reducing acute stress, the need for this is only fully highlighted when the consequences of a lack of early intervention are explored. The resistance and exhaustion phases of the stress response represent these consequences.

Next various stress management techniques and potential barriers to implementation are explored.

2.2.4 Stress management techniques and barriers to implementation

Due to the negative impacts of stress, interventions have been developed to help individuals cope with stress. These interventions are explained. However, the drawbacks to each are also provided to create context for the need for a low-cost, minimally invasive solution in the form of viewing nature, should the findings support the notion of stress relief by natural areas.

One such intervention is relaxation training, including progressive muscle relaxation, which involves methodically contracting and relaxing muscle groups throughout the body (Benedict, 2011; Brannon et al., 2018). One sits on a chair in a room with minimal distractions and, after taking a number of deep breaths, selects one muscle group. This muscle group is contracted as much as possible, held for 10 seconds, then gradually released, throughout which time the individual focuses on the experience of the muscle release (Brannon et al., 2018, McCallie et al., 2006).

Another possible intervention is psychotherapy, where an individual works with a psychotherapist through personal issues that may be causing stress, such as unhealthy relationships, childhood trauma, or psychopathology (Benedict, 2011). One type of psychotherapy used to manage stress is cognitive behavioural therapy (CBT), which aims to develop and modify attitudes, beliefs, thoughts, and behaviours to optimally assist in the management of stress (Hagen & Hjemdal, 2012). This can take place as one-on-one sessions with a therapist, or in a group therapy setting.

Physical exercise is also regularly recommended as a stress-relieving technique, due to its psychophysiological benefits. Exercise strengthens the cardiovascular system, acting as a buffer to the cardiovascular impacts of stress, and it is often perceived as pleasurable due to the elevated levels of dopamine, serotonin, and endorphins (Esch & Stefano, 2010; Jackson, 2013).

Similarly, mindfulness is being increasingly recognised as beneficial to health and stress relief (Wielgosz et al., 2019). While there is still some disagreement on how best to define mindfulness, two key features are generally agreed upon. The first of these features is the moment-to-moment awareness and focus on one's present experience. The second feature is that this moment-to-moment awareness should be approached with a non-judgemental attitude (Creswell, 2017; Khoury et al., 2015). This process essentially involves being fully attentive to the present moment, including one's external environment and their thoughts and feelings, and acknowledging them without judgement. The proposed mechanism for stress relief by mindfulness is that by acknowledging stress without emotional reactivity and judgement, one can improve their relationship with stressful thoughts (Khoury et al., 2015).

However, despite potential benefits of the above-mentioned interventions, there are drawbacks to each intervention that may make them implausible for individuals. Progressive muscle relaxation training programmes typically take between six and eight weeks and approximately 10 sessions with a trainer to master the technique (Brannon et al., 2018). This required length of time is not something all working individuals have at their disposal, especially if aiming to gain rapid relief from daily stressors. Moreover, this technique may be physically impractical for those with health issues such as arthritis or injuries, whereby this technique would be painful, incidentally increasing one's stress levels. Even healthy individuals may suffer from muscle cramping during this process, which similarly will produce a stressful, not stress-relieving effect.

Psychotherapy requires sessions with a qualified psychologist, which can be costly. Cognitive behavioural therapy typically takes between 12 and 20 sessions to be successful, which compounds the matter of costliness (Gaudiano, 2008). In South Africa, the feasibility of CBT is exacerbated by a lack of access to mental health care professionals. According to a recent national survey, there were only 0.97 psychologists for every 100 000 uninsured individuals (i.e. those without private medical aid) (Docrat et al., 2019). This concerning ratio highlights the need for intervention options that are effective, affordable, and quick, such as the stress reducing effects of natural areas.

While physical exercise is beneficial in managing stress, there are many instances in which it is not possible. For some, there may be insufficient space to exercise at home, and long working hours may make it unfeasible to exercise outdoors, before or after work. For others, injury or underlying health conditions such as asthma may make exercise painful or risky. Notably, research has demonstrated that in some instances, there is an inverse relationship between stress and exercise, whereby increasing stress levels are associated with a decrease in exercise (Stults-Kolehmainen & Sinha, 2014). That is, stress hampers one's efforts to engage in physical activity.

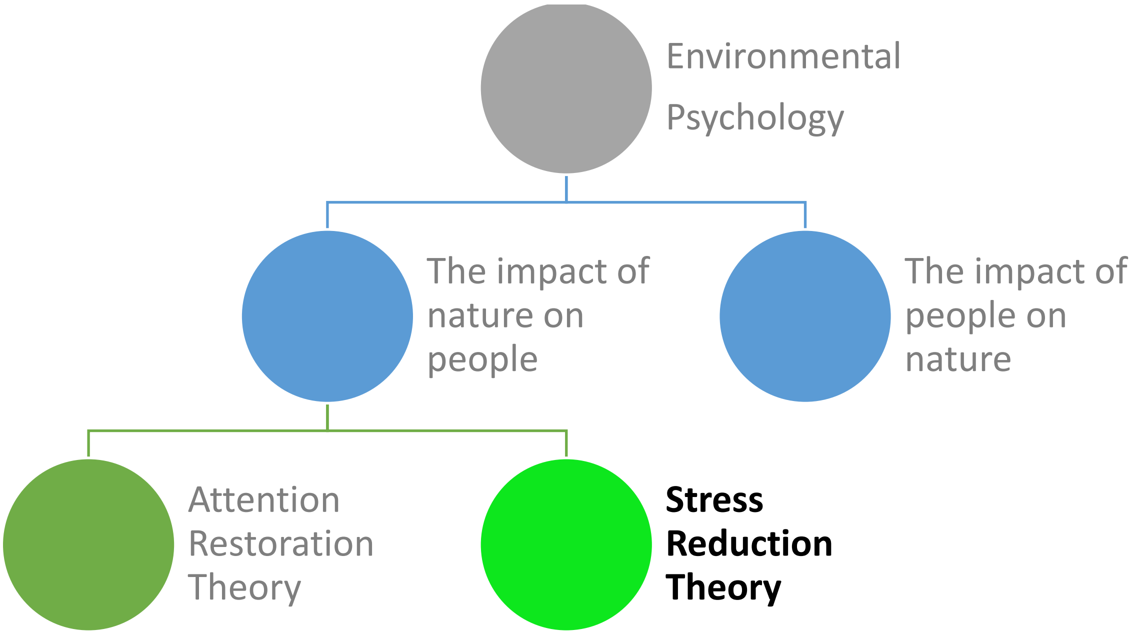
Similarly, while practising mindfulness is gaining popularity, there are some issues with its practice and the practicality thereof. Firstly, there exist potentially adverse effects of practising mindfulness, such as an increase in anxiety and similar psychopathological symptoms (Farias & Wikholm, 2016). This can happen as increased awareness of negative states could exacerbate such states, and could further allow for unpleasant, intrusive memories being remembered. Being confronted with such memories without the supervision of a mental health practitioner can be detrimental. Mastering the art of mindfulness can take weeks and some people either end up not being able to successfully use the technique or experience increased stress and depression (Wong et al., 2018).

Up to this point, reviewed literature has primarily focused on critical areas within the field of stress research and stress response theories. The present study is situated in both stress research and environmental psychology and as such, literature on the stress relieving effects of natural environments will be discussed next.

2.3 Natural areas

Research that exists on the benefits of nature to humans falls within one of the two approaches within environmental psychology, the field within which the present study is based. On the one side of these approaches exists research examining the impact people have on natural environments, and it addresses issues such as pro-environmental behaviour, respect for nature, and recycling (Steg & de Groot, 2019). On the other side is the impact nature has on people. The two key approaches within this stem from one of two theoretical branches: Attention Restoration Theory (ART) or Stress Reduction Theory (SRT) (Luo et al., 2021; White et al., 2021). The present study is situated within the SRT branch and can be visualised as follows:

Figure 10 Conceptual framework of the current field of environment psychology.



Note: Author's own.

The theory of stress reduction, which will be discussed in depth in Chapter 3, forms the theoretical underpinning of many of the papers discussed in 2.3.1 and 2.3.2. Papers based on ART examine how nature has the potential to restore cognitive, attentional capacity through the invocation of indirect attention, thus restoring direct attention capacities (Kaplan & Kaplan, 1989, Grassini et al., 2019; Liprini & Coetzee, 2017; Meredith et al., 2020). This theoretical branch is a well-covered area of study, but is not the focus of the present study, which is stress relief. Consequently, literature examining cognitive restoration, founded on the attention restoration theory, are not included in the review. Where studies examine both attention restoration and stress reduction, the relevant stress relief findings will be discussed.

There are a few key matters to discuss before moving to a discussion of the stress relieving effects of natural areas. The first matter is that the benefits of exposure to natural areas have been studied and spread over a variety of outcomes, including overall health (Markevych et al., 2017), affect (World Health Organisation, 2021), wellbeing (including variations such as overall wellbeing, psychological wellbeing, and mental wellbeing) (Chen & Yuan, 2020; Finlay et al., 2015; Thomas, 2015), exercise (Britton & Foley, 2021; Brown & Peters, 2019; Foley, 2017; Gascon et al., 2017; Kajosaari & Pasanen; 2021; Wheeler et al., 2012; White et al., 2021), quality of life (Haslauer et al., 2015), place attachment (Menatti et al., 2019; Subiza-Pérez et al., 2017; Subiza-Pérez et al., 2020), urban planning (Bratman et al., 2019; McDougall, Hanley et al., 2020), and as a platform for socialisation and social cohesion (Chen & Yuan, 2020; Dzhambov et al., 2018; Marselle et al., 2021; Subiza-Pérez et al., 2020). While it is promising that research continues to explore and unearth the wide range of benefits of nature to humans, the implication for the present study is that the focus of reviewed papers will only be on those related to stress relief and stress restoration, as this is the focus of the present study. Consequently, while it is acknowledged that there currently are lively debates in literature surrounding matters such as the need to integrate multiple sensory experiences in nature exposure (Buxton et al., 2021; Franco et al., 2017; Hedblom et al., 2019); the need for integrated human-nature interactions (Soga & Gaston, 2020; Soga et al., 2021); and the necessity of an integrated biodiversity-health framework (Marselle, Hartig et al., 2021; Marselle, Lindley et al., 2021), these fall beyond the scope of the present study.

The second matter is that as a consequence of the diverse ranges of definitions of stress as outlined in 2.2.1, literature on natural areas is not always clear on the type of stress being assessed. As will be demonstrated in the sections that follow, there is an extreme paucity of research on the acute stress relieving effects of natural areas. To the author’s knowledge, after searching Scopus, EBSCOhost, JSTOR, Sabinet, and ScienceDirect, there is further no literature that has incorporated a startle response as an initiator of acute stress in studies examining the restorative effects of nature. Nonetheless, it is necessary to gain an understanding of the literature that looks at stress relief broadly, to provide context.

Thirdly, a recent trend in literature, is the fact that blue spaces (outdoor areas where the prominent feature is water; defined in more depth in 2.3.2) were regularly inadvertently included in studies of green spaces (outdoor areas where the primary visual focus is trees, shrubs, or flowers; defined in more depth in 2.3.3) and were not accounted for as a separate type of nature (Britton et al., 2018; Foley & Kistemann, 2015; Haeffner et al., 2017; Luo et al., 2021; McDougall, Quilliam et al., 2020; Velarde et al., 2007; White et al., 2021; Wolch et al., 2014). The implication for the present study is that when a literature reviewing is conducted on the stress-relieving effects of nature, some studies could confound green and blue spaces. Thus, the impact of each individual area cannot be accounted for.

Finally, since research on the stress restoring effects of nature does not always clearly delineate blue from green spaces, some studies refer to natural environments, nature, or levels of natural biodiversity (Marselle et al., 2021). Consequently, the stress relieving effects of literature that does not clearly stipulate blue or green spaces as their natural environments, will be discussed first. This is to ensure that literature on the topic can be addressed, given the paucity of research in the field.

2.3.1 Natural Areas

Research on the benefits of natural areas, which do not specify green or blue spaces, has largely addressed the physiological benefits thereof. A 2021 study posited a conceptual framework linking biodiversity to health, based on Ulrich's (1983) SRT. Moreover, the study suggested that environments that are high in biodiversity and have a focal point, a ground surface conducive to movement, and greater plant species richness, promote recovery from stress by reducing physiological arousal (Marselle et al., 2021). Multiple scoping reviews on the benefits of exposure to natural areas have emphasised the statistically significant reductions in stress-related biomarkers. These include a decreased heart rate, blood pressure, lowered cortisol levels, reduced SNS activity and an increase in PNS activity (Bratman et al., 2019; Haluza et al. 2014, Kuo, 2015; Mantler, 2015; Meredith et al., 2020; Miyazaki et al., 2014). One particularly comprehensive review (Kondo et al., 2018) used the term "outdoor environments" and consequently covered a range of nature exposure categories, including walking, viewing, exercising, or gardening outdoors. The range of stress-related biomarkers covered was also extensive, and results demonstrated positive physiological benefits as categorised by cardiovascular system functioning, salivary, blood, and urine measures, in addition to sleep quality reports. The corroborating results of these reviews discussed provides evidence of scientific consensus that natural areas promote physiological stress recovery. It is further worth noting that one of the observed, potential reasons for so much of the extant literature taking the form of scoping or systematic reviews (as opposed to empirical research) is because these papers attempt to provide frameworks for the sake of health and public policy, and landscape design. That is, the stress relieving benefits discussed above are often incidental benefits within the greater goal of encouraging health-promoting behaviours or urban planning (Bratman et al., 2019; Frumkin et al., 2017).

Nonetheless, recent empirical work has similarly found that spending time in an outdoor, natural area for between 20 and 30 minutes produces significant decreases in salivary cortisol and salivary alpha-amylase (α-amylase) (Hunter et al., 2019). The biodiversity, or varying levels of 'naturalness' of natural areas has also been examined. Ewert and Chang (2018) conducted a quasi-experimental pre-post research study, in which they compared psychophysiological stress markers of participants before and after spending time in one of three natural sites. The sites differed in levels of naturalness; that is, one site was a wilderness-like, forested area, the second site was a municipal park, and the third was a fully urban environment of an indoor gym. The results showed that despite there not being any significant differences between groups on their salivary cortisol levels at pre- or post-testing, within-samples t-testing demonstrated a marked decrease in cortisol levels for the group that spent time in the forested area. Chang et al. (2019) conducted a nearly identical methodological study, and similarly found that those exposed to the most natural area demonstrated a significant decrease in salivary cortisol. This study is of particular relevance to the present study, as similar methodological design choices will be used (discussed in Chapter 4). These studies did not introduce a stressor and only measured stress responses, using pre-existing levels of salivary cortisol per participant as their own baseline.

Conversely, the review of psychological stress relieving effects of natural areas produced fewer findings. Of importance is to note that to the best of the author's knowledge, following an extensive review of available literature, there are currently not any psychological measures available that assess acute stress responses. Many studies reported psychological results, but these were typically affect responses, using scales that assess mood states, happiness scores, positive and negative effect, and even anxiety inventories (WHO, 2021). For example, Kondo et al.'s (2018) review of stress responses to outdoor environments listed a mood scale as a measure to assess perceived stress. One study that did use an established psychological stress measure (the PSS, discussed in more depth in Chapter 4) was conducted by Payne in 2020. Participants were asked to spend time in a natural area of their choosing and results demonstrated that the more restorative the environment was perceived to be, the lower the reported stress levels were. Both Ewert and Chang's (2018) and Chang et al.'s (2019) studies, discussed above, also used a perceived stress questionnaire, which incorporated four stress-related factors: tension, worries, joy, and demand. The authors did not compare overall perceived stress measures, but instead assessed changes of each of the factors individually. Findings demonstrate that those exposed to the most natural area reported lowered levels of demands and worries and increased levels of joy (Chang et al., 2019; Ewert & Chang, 2018).

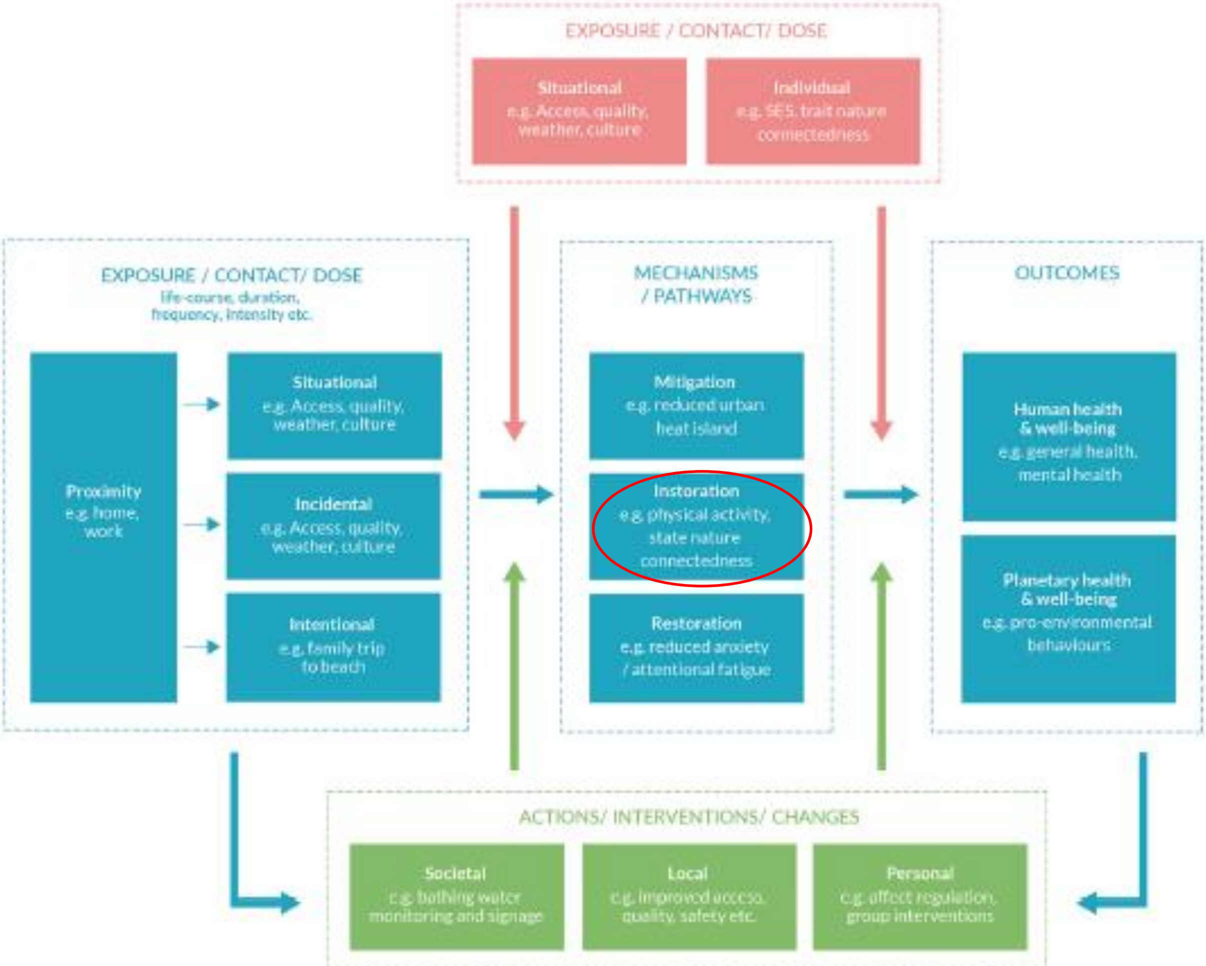
The literature on nature as a broad concept is positive in the sense of the salutary benefits to both physiological and psychological stress reduction. However, the broadness and heterogeneity of definitions of nature type and stress type make cross-study comparisons complex. It is for this reason that the present study took a focused approach in terms of delineation of natural areas and stress type being measured. Consequently, literature that has delineated blue spaces from other natural areas will be discussed next.

2.3.2 Blue Spaces

Although variations in terminologies and definitions used for blue space exist, there is agreement that blue spaces are delineated from other natural, or urban spaces as being an area predominantly involving water. One comprehensive definition, according to Grellier et al., (2017, p. 3), is that blue spaces are: “outdoor environments – either natural or manmade – that prominently feature water and are accessible to humans either proximally (being in, on or near water) or distally/virtually (being able to see, hear or otherwise sense water)”. The key element of this definition, which is applicable to the present study, is the element of the area featuring predominantly water. This emphasis is necessary, as many blue spaces will inevitably have green, or other natural areas in proximity (for example, palm trees on a beach or the forested area through which a river flows). Despite this, the element of the environment or scene that draws the attention of the individual should be water.

Currently, a large portion of research on blue spaces focuses on how these areas operate as a function of health (White et al., 2021). For example, Figure 11 below comes from a recent publication by a leading author in the field on the benefits of urban blue spaces (White et al., 2021):

Figure 11 Conceptual model of the relationship between blue space, health and wellbeing



Note: Adapted from “*Blue space, health and well-being: A narrative overview and synthesis of potential benefits* “ by M.P. White et al., 2021.

In the body of the text surrounding this framework, White et al. (2021) expand the element of restoration to include stress relief. Nonetheless, it can be seen from Figure 11 that stress reduction is one mechanism in a much larger view of the benefits of blue spaces. The small role stress relief plays in conceptualisations like this could potentially be one of the reasons there is such a paucity of research in the stress relieving effects of blue spaces. Nonetheless, the available literature on the topic at hand will be discussed next.

2.3.2.1 Blue space and stress relief

As mentioned above, due to the fact that blue space research is more recent than green space research, fewer studies exist. These studies reflect high heterogeneity in terms of the definitions of stress, and consequently the type of stress being assessed, methodological approaches (Britton et al., 2018), and approaches to stress as a psychological construct, physiological construct, or psychophysiological construct. Recent systematic reviews on the health benefits of blue spaces have noted both this dearth of literature and high heterogeneity of study design and findings, as a limitation to drawing firm conclusions (Beute et al., 2020; Gascon et al., 2017).

Therefore, to cover existing literature as thoroughly as possible, while maintaining alignment with the stress constructs discussed in 2.2, stress relief findings will first be discussed in terms of the physiological and then psychological benefits of blue spaces. Thereafter, a distinction will be made between the studies that measured stress relief after exposing participants to a stressor, and those which measured only stress responses to blue spaces. Following this, the matter of treatment exposure length will be addressed, as there is great variation in blue space literature regarding the length of time participants were exposed to the blue space. Finally, exposure type will be addressed, that is, the range of exposure types from physically being in a blue space to virtual scenes of blue spaces.

2.3.2.1.1 Physiological stress relief

When measuring the physiological markers of stress relief, two markers that are relevant to the present study have been used in recent blue space literature. These include blood pressure (systolic and diastolic), and heart rate variability (HRV) (Gidlow et al., 2016; Triguero-Mas et al., 2017b; Vert et al., 2020; White, 2013).

Only three empirical studies in the past ten years have used blood pressure as a biomarker of physiological stress relief, and none found significant reductions in blood pressure after exposure to the blue space (Triguero-Mas et al., 2017b; Vert et al., 2020; White, 2013). In the most recent study, Vert et al. (2020) used a randomised crossover approach, in which adult participants took short, regular walks in either a blue or urban area, or none at all when assigned to the control group. A battery of questionnaires and a range of biomarkers were measured, but the lack of decreased blood pressure in those who walked in a blue space was of significance. Triguero-Mas et al. (2017b) followed a similar design, that is, they also used a randomised crossover design using a sample of 26 adults, except this research also included a green space. Similarly to Vert et al. (2020), no significant reductions were found in blood pressure. White's (2013) study was conducted in a laboratory and used images of various natural areas (including blue spaces) and similarly found no significant blood pressure decreases.

HRV is another common measure in stress studies, as it provides an indication of heightened SNS activity during times of stress (Gidlow et al., 2016). Findings regarding HRV were mixed. Vert et al. (2020) report that although there were minor changes in HRV, overall, the results did not show a total rebalance of SNS and PNS activity. Suenaga et al. (2020) reported that there was a statistically significant decrease in one element of their HRV measures, however their reported results indicated that $p = .08$, which without an indication of their alpha level being anything other than typically accepted alpha levels of 0.05 or 0.01, indicates that this result was not statistically significant. Triguero-Mas et al. (2017b) found a statistically significant decrease in the blue condition of their study, while Gidlow et al. (2016) did not. The present study did not measure HRV directly, however physiological equipment was used, which provided an indication of the stress loading on the heart as calculated by HRV. This is discussed in more depth in Chapter 4 and Chapter 6.

2.3.2.1.2 Psychological stress relief

As mentioned in 2.3.1., to the author's knowledge no psychological measures of acute stress exist. Thus literature tends to either use affective measures as an indicator of stress, or scales that require participants to rate how restorative they believe the natural areas are. The most commonly used scale when assessing the restorativeness of blue spaces is the Restoration Outcomes Scale (ROS) (Korpela et al., 2008). It is a scale that primarily stems from ART and so although it was not used in the present study, it is the only scale other than the RS (which was used in this study) to address blue space psychological stress relief. To the author's knowledge, no studies to date have used the RS in blue space literature, despite it addressing restoration beyond ART. Nonetheless, the ROS has been used by the few authors who have addressed the psychological benefits of blue spaces (Gidlow, 2016; Poulsen et al., 2022; Subiza-Pérez et al., 2020 Triguero-Mas et al., 2017b). Poulsen et al. (2022) found that locals living near freshwater blue spaces, who visited the spaces regularly, reported higher ROS scores than those who visited their local freshwater blue spaces infrequently. Gidlow et al. (2016) found that there were significant differences in ROS scores between blue and urban spaces, and between green and urban spaces, with the biggest difference and largest effect size being between the former.

Conversely, de Bell et al. (2017) assessed the psychological benefits of visiting freshwater blue spaces. Although participants were given the option to report “stress reduction” or “relaxation” as their preferred reason for visiting blue spaces, the authors collapsed these responses into a category of psychological benefits. The implication of this is that even though psychological benefits were reported to be the biggest reason why people visit blue spaces, it is not possible to determine how many of those respondents were thinking of relaxation, stress reduction, or both, when responding.

2.3.2.1.3 Treatment exposure type

Exposure to blue spaces ranges across studies, in terms of the type of exposure and the length of time that participants are exposed to the blue space. Although a current common delineation for exposure type is indirect (e.g. a window view), incidental (e.g. being exposed to blue spaces as part of a commute to work), and intentional (e.g. a family taking a holiday to the beach) (White et al., 2021), for the purposes of the present study the delineation will look slightly different. This is because the focus of the present research is on intentional exposure and this intentional exposure can take three primary forms.

To this end, one type of exposure is physical involvement with the blue space. That is, for example, walking alongside a beach or a lake (Gidlow et al., 2016). It should be noted that this physical involvement does not refer to the use of blue or green spaces as a platform for exercise. Although blue spaces can be health enabling platforms for exercise – for example surfing – this is not the focus of the present study (Britton & Foley, 2021). This is largely due to the fact that, as discussed in 2.2.4, exercise can in itself have stress relieving effects. It would therefore be difficult to discern with certainty whether the blue space, the exercise alone, or the combination of both are responsible for any positive stress relieving effects (Hermanski et al., 2021). A few of the studies mentioned above required participants to spend active time in a blue area, but this did not extend beyond a slow or self-paced walk (de Bell et al., 2017; Gidlow et al., 2016; Vert et al., 2020).

A second type of exposure exists, which includes being able to view real (as opposed to virtual) blue spaces through a window (Ashbullby et al., 2013; Dempsey et al., 2018; Garrett et al., 2019; Nutsford et al., 2016, Völker & Kistemann, 2011). However, these studies do not specifically address any form of stress relief, and furthermore, according to Hermanski et al. (2021), the results of these studies do not provide consensus on whether or not physical visits to blue spaces are any more effective than viewing the blue spaces.

The third type of exposure, which is of particular relevance to the present study, is virtual viewing of natural areas. This type of viewing involves either images, videos, or virtual reality of blue spaces (Browning et al., 2021). Studies have shown that viewing blue spaces virtually, holds great potential for stress relief, in that these virtual environments produce similar stress relieving effects than their real blue space counterparts (Annerstedt et al., 2013; Browning et al., 2021; Gao et al., 2019; Nukarinen et al., 2020; Tanja-Dijkstra et al., 2018). The present study used virtual exposure to blue, green, and urban spaces (discussed in Chapter 4) and these findings provide support for the potential efficacy of non-real nature exposures.

While the findings described thus far appear to be promising in terms of stress relieving effects of blue spaces, the fact that the field of blue space research is so young means that there is great heterogeneity within the field and consequently this makes findings difficult to synthesise (Beute et al., 2020). Therefore, a brief overview of two identified, pertinent current issues within the field is warranted.

2.3.2.1.4 Critiques of blue space literature

One of the issues observed after extensive review of blue space literature is a lack of consensus on, and testing of, the definition of stress and the type of stress being measured. One possible reason for this is because, according to White et al. (2021), there is an assumption that those who seek out blue (and green) spaces are urban dwellers, who regularly experience constant high levels of stress. Although White et al. (2021) do not elaborate on this point, based on the distinctions between types of stress explored in 2.2.1, it can be deduced that it is chronic stress that is being referred to. White et al.'s (2021) supposition could potentially be why a large portion of studies on blue spaces do not induce any acute stressors, as per the present study. While White et al.'s (2021) reasoning is logical, the present study's author did not want to leave any room for non-comparability of stress levels at baseline between participants; hence inducing an acute stress response. That is, a stressor was introduced to ensure that all participants experienced a stress response and that baseline levels of stress were not left to an assumption of homogeneity.

The second issue is the treatment-dose matter. Current literature looks at exposure length of blue spaces in many different ways. For example, some studies involve spending time in blue spaces for between 20 and 180 minutes (Triguero-Mas et al., 2017b, Vert et al., 2020) down to a 10-minute slide show of blue space images (White, 2013). Given the lack of clarity around acute stress measurements in blue spaces, it is unclear what the appropriate time length of exposure to a blue space treatment should be. The present study used a one-minute exposure, as it was essential to measure the short-term physiological changes within the amount of time it would take for allostatic processes to return SNS and HPA-axis levels to a homeostatic level. Furthermore, considering the paucity of literature and lack of clarity on the matter of optimal exposure length, the one-minute period was also chosen to potentially broaden current knowledge on whether short-term exposures can provide stress-relieving benefits.

Following the discussion on clearly delineated blue spaces, the stress relieving benefits will be discussed next.

2.3.3 Green Spaces

Green spaces have been defined and studied for a much longer period than blue spaces, largely due to the fact that they were regularly viewed as synonymous with the term 'natural' (Taylor & Hochili, 2017). As was the case with blue space definitions and stress type delineations, the focus of the definition of a green space will differ depending on the disciplinary approach of the author and the purpose of the definition. For the purposes of the present study, green space will be defined as an outdoor natural area, where the predominant visual focus is vegetation, including trees, shrubs, flowers, and grass. This definition is, similarly to the blue space definition, centred on the predominant visual elements of the scene. The stress relieving effects of green spaces are discussed next.

2.3.3.1 Green space and stress relief

Although green spaces are sometimes still confounded as natural areas (which may or may not include blue spaces a slightly larger amount of research exists on the stress-relieving effects of green spaces. Given this greater scope, extant literature will be discussed in terms of the physiological stress relieving benefits of green spaces, the psychological benefits, and the type of stress being assessed.

2.3.3.1.1 Physiological stress relief

There is a greater range of physiological measurements that have been used in green space research, than in blue space research. These include blood pressure, heart rate, HRV, and EDA.

Studies that incorporate blood pressure measures have largely produced results indicative of a lack of statistically significant changes (Lanki et al., 2017; Ojala et al., 2019; Song et al., 2019; Yu et al., 2018). These studies have used urban areas as comparator groups, which the present study also did, however many of them required participants to walk in green or urban areas, and this physical activity could potentially confound the blood pressure results (Lanki et al., 2017; Ojala et al., 2019; Song et al., 2019). For example, Song et al.'s (2019) research involved six women walking in a forested area and six women walking in a city area for approximately 15 minutes. Their results showed that there were no significant differences in blood pressure means within each group before and after walking in either area, or between the two groups. However, a shortcoming of this study is that the sample size (n=12) is extremely small, especially considering that the group sizes being compared comprised of only six people each. Yu et al. (2018) used virtual reality forest and urban environments and although participants' blood pressure decreased in the forest environments and increased in the urban environments, the differences did not reach statistical significance. It should also be noted that within the forest video (which was comprised of seven clips), one of the environments videos was of a waterfall as the predominant feature. This inclusion of a blue space within a green space could have potentially impacted the results.

On the other hand, Mokhtar et al. (2018) found significant decreases in blood pressure within a group of participants who walked in a green area. Twenty participants took part in the research and on two separate days, walked in either an urban park, or a city environment. Specifically, there were statistically significant differences in diastolic blood pressure between the park and the city walks, with lower values after the park walk. These results should, however, be interpreted with caution as the sample size was small, and all participants were similarly aged male students from one faculty at a local university.

Measures of heart rate are often included alongside blood pressure and HRV data and appear to generally indicate a positive stress relieving effect of green spaces. Song et al. (2019) found that the mean heart rate was significantly lower in the group that walked in a forest, than those who walked in the city. Lanki et al., (2017) assessed the effects of viewing and walking in two types of green areas (a park and forest) and one urban area (a built-up city centre) in Finland. Although only females were used, which limits the generalisability of the findings, heart rate means were consistently lower in the two green areas in both the viewing and walking conditions, when compared to the urban area. In Japan, researchers aimed to assess the physiological responses of students viewing a Japanese garden compared to an unstructured space, which appears to be a built-up courtyard (Zhang et al., 2018). Their findings showed that the average heart rate increased in the unstructured space, but remained relatively constant in the Japanese garden.

HRV is another physiological marker often used in green space research. Song et al. (2019) conducted research in Japan and required 23 males to walk in an urban park and a city area for 15 minutes each. Despite the limitations of a small, single-sex sample, HRV results indicated that walking in the park resulted in more favourable outcomes than in the city, in that HRV data indicated lower SNS activity than in the city. In 2019 the same authors found similar results, using a sample of male adults (Song et al., 2019). Similarly to their heart rate findings, Lanki et al., (2017) found that visits to a forested area produced better HRV results than visits to the city centre. In an older study (Tsunetsugu et al., 2013), researchers compared the effects of viewing four forested areas with four urban areas and found that the forested areas produced HRV data that were indicative of lowered SNS activity, implying a reduction in acute stress responses.

EDA, sometimes reported as skin conductance level, or activity, is a less frequently used measured of stress relief in green space research. However, two studies conducted in Japan have used this measure and both found lowered EDA in green spaces, indicative of lowered SNS responses. Wang et al. (2016) followed a method similar to the one used in the present study, in that they measured participants on a number of psychophysiological variables at baseline. They introduced a stressor (a spoken English exam), and then exposed participants to videos of various scenes. Six of these scenes were reported as urban parks, and one was reported as an urban roadway scene, however inspection of the stills provided indicate that one of the urban park scenes was actually a blue space; a scene overlooking a lake. Nonetheless, results indicated that the park scenes produced the greatest skin conductance reactivity reductions, and the urban roadway produced the least reduction (Wang et al., 2016).

Zhang et al. (2018), as mentioned when discussing heart rate above, also assessed EDA when comparing the viewing of an unstructured space versus a Japanese garden. The researchers found that when viewing the Japanese garden, EDA initially declined before returning to baseline levels, but it increased steadily in the unstructured area. Although the study used only 38 people, of which the majority (n=29) were males, these results nonetheless provide evidence to support the notion that green areas are beneficial in their stress relieving effects.

2.3.3.1.2 Psychological stress relief

Similarly to the research on blue spaces, the psychological stress relieving benefits of green spaces are predominantly assessed indirectly, by assessing the perceived restorative potential of the area. The ROS has also been used in green space literature, with similar success as the blue space literature. Ojala et al. (2019) investigated the role of unique differences in orientation to natural versus urban settings and how this, along with noise sensitivity, impact psychophysiological restoration. The physiological element (blood pressure) was discussed above, and the psychological element of restoration was assessed using the ROS. The authors found that the forest and park were experienced as more restorative than the city. Similarly, Mokhtar et al (2018) found statistically significant differences between the park and city environments, where the park provided higher restorative outcomes.

The PSS as is used in the present study has also been used in research. In 2019, Holt et al. assessed the relationship between active and passive use of green spaces and health and wellbeing measures, in a sample of 207 university students in the USA. In this study, active use referred to engaging in physical activities such as running or cycling in green spaces, while passive use referred to non-physical activities such as sitting or relaxing in green spaces. Three measures were used to assess wellbeing; one of which was perceived stress. The results showed a significant relationship between active green space use and reduced stress, however there was no relationship between passive green space use and stress reduction (or any of the wellbeing measures).

Similarly, Zhao and Patuano (2021), sought to understand the relationship between green spaces and health in international Chinese students at a higher education institution in Edinburgh. Students were asked to indicate their awareness of the benefits of green spaces, the frequency of visits to green spaces, the length of time spent in green spaces, and the perceived accessibility to these green spaces. Students further responded to a range of health and wellbeing measures, including the PSS. A regression model was created to determine the extent to which frequency of visits and time spent in green spaces could predict PSS scores. The statistically significant model indicated that there was a negative association between reported stress levels and the frequency of visits and time spent in green spaces. That is, the more regularly students visited green spaces, and the longer they spent in the green space, the lower their perceived stress scores were (Zhao & Patuano, 2021).

It is important to reemphasise that the relatively small number of studies addressed in this section on natural areas, blue spaces, and green spaces is because of the lack of clear focus in literature on acute psychophysiological stress relief. As discussed, the stress relieving effects of natural areas are often discussed under broader approaches of overall health, wellbeing, or to advise public policy. Psychological stress relief (apart from the PSS) is assessed by measuring constructs associated with stress (such as mood, affect, or anxiety), but not stress itself. Furthermore, the concept of restoration is regularly addressed by taking the ART approach, or by combining and confounding approaches, despite ART and SRT being distinct theoretical approaches (Marselle et al., 2021). A recent study even appeared to confuse the two approaches by stating that the focus was on stress relief, but then used a scale based on ART in the research (Wang et al., 2019). Finally, the studies conducted within the field of the stress relieving effects of nature rarely, if ever, clarify the type of stress being assessed. Phrases such as 'long-term stress', for example, allude to chronic stress, but this is not clarified (White et al., 2021). These confounding and complicating factors influencing stress relief research by natural areas leave gaps for the present study, are discussed next.

2.4 Research Gaps

Given all the literature that has been discussed in this chapter, a gap that emerges is that there is currently no research assessing acute psychophysiological stress responses to blue spaces, locally or internationally. The fields of stress research and environmental psychology overlap, but sometimes appear to differ substantially insofar as defining and delineating stress types, stress responses, and restoration are concerned. Critically, studies that have attempted to delineate acute stress responses have employed measures that are sensitive to cognitive processing; that is, no studies have employed a startle response to ensure a fight-or-flight response. While the aviation field appears to be attuned to the impact of startle responses, research focused purely on furthering the debate on stress typologies or research on the impacts of nature on acute stress responses appear to neglect the startle response (Field et al., 2015; Martin et al., 2016; Owton, 2022). The provided discussion and delineation of stress types could potentially be useful both in stress research and in encouraging a formalisation of clear delineations of stress types in environmental research.

No research that measures stress responses to a range of natural environments exists within South African research and so beyond filling a knowledge gap internationally, this study will be the first of its kind locally. South African vegetation spans a number of biomes and so if the results of this study provide favourable support for nature as an acute stress reliever, it will serve as a foundation for further local research.

2.5 Conclusion

Chapter 2 has provided a discussion of a range of matters relating to stress, including a proposed new typology for stress types, a discussion of the extent and deleterious consequences of stress, a description of the stress response, and a proposed model of stress responses. The new typology and stress model were developed as a result of a lack of clarity and consistency in defining the psychophysiological stress response.

This chapter has also covered the stress relieving effects of natural areas that are not clearly defined as blue or green spaces, and the sparse research available on the stress-relieving benefits of blue and green spaces individually. The review has highlighted the dearth of literature in the field and has emphasised the need for further research, particularly within the young field of blue spaces.

In the following chapter, a review of SRT will be discussed, both in terms of its proposed evolutionary significance and how existing literature can be used to develop the theory further.

CHAPTER 3: THEORETICAL BACKGROUND

3.1 Introduction

In this chapter, existing theories of EP, biophilia hypothesis, and the SRT will be integrated with the proposed model of stress responses outlined in Chapter 2 (section 2.2.3.4), to gain a holistic view of stress, as measured in the present study. This theory will be used as the theoretical point of departure for the study. The chapter will be divided into four parts. The first section will deal with EP, because this will provide background to the biophilia hypothesis and SRT. Next, the biophilia hypothesis is explained, which includes a diagram of how EP and the biophilia hypothesis function together. Thirdly, the SRT is discussed, covering the key principals of the theory, in addition to its applicability to the present study. Finally, these three theories will be integrated into the proposed stress response model presented in Chapter 2 (section 2.2.3.4) to provide a comprehensive theoretical view of acute stress responses. In the present study, theories and models are demarcated as follows: a theory is a comprehensive explanation for behaviour, whereas a model is simply a visual representation of the component parts of multiple theories.

3.2 Evolutionary Psychology

EP, in the context of the present study, serves as a background to the biophilia hypothesis and the SRT, which in conjunction with section 2.2.3.4's proposed stress response model, forms the theoretical basis of the present study. It should be emphasised that the fundamentals of EP as discussed in this section serve as a background to the theories that follow. That is, the biophilia hypothesis and stress reduction theories are psychoevolutionary theories, and would therefore be lacking context if EP is not briefly explained. EP is not a stress theory; it provides the context for the stress theories to follow. Specifically, how EP is differentiated from a theory is that it does not serve to explain one specific type of behaviour. Its fundamental notion is that modern human behaviour can largely be explained by evolutionary processed; specific theories are consequently developed from this manner of thinking.

EP is an approach to psychology that is founded on Charles Darwin's (1859) theory of evolution by natural selection (Buss, 2019). The fundamental assumption of EP is that both physiological and psychological processes have an evolutionary basis (Buss, 2019). Moreover, EP is not an area of study within psychology, nor is it a specific theory of behaviour.

Rather, it is an approach to psychology, a way of thinking about psychology, which can be applied to numerous topics within it (Cosmides & Tooby, 1997; Sznycer, Tooby & Cosmides, 2011).

Cosmides and Tooby were among the first authors to formalise EP as a discipline, and their approach views the mind as a “set of information-processing machines that were designed by natural selection to solve adaptive problems faced by our hunter-gatherer ancestors” (Cosmides & Tooby, 1997, p. 1). Three key elements of an evolutionary perspective of human behaviour underlie this conceptualisation: 1) the human brain is comprised of psychological mechanisms that evolved in response to survival challenges facing our hunter-gatherer ancestors, 2) the mind is comprised of domain-specific modules that direct behaviour, and 3) these mechanisms evolved in response to features of the environment in which the hominid line is thought to have evolved -- the environment of evolutionary adaptedness (EEA) (Bolhuis et al., 2011; Cosmides & Tooby, 1997)

The first element can be succinctly captured by the phrase “our modern skulls house a stone age mind” (Cosmides & Tooby, 1997, p. 12). This statement does not posit that our minds are unsophisticated, it refers to the notion that our neural circuitry evolved to solve problems faced by our hunter-gatherer ancestors, not modern-day problems such as experiencing a jump scare while watching a horror movie (Barrett et al., 2014; Cosmides & Tooby, 1997).

The second element is the notion that the mind is comprised of domain-specific modules, which have evolved to perform specific functions (Buller, 2006; Buss 1995; Cosmides & Tooby, 1997; Tooby & Cosmides, 1992). These modules are not to be equated with physical regions of the brain, but are rather to be viewed as mental mechanisms (Buller, 2006). The domain-specificity of each module makes it uniquely equipped to solving one problem, or closely related problems. These modules are purported to be inherently equipped with knowledge of the problem and consequentially possess procedures for using this knowledge to solve the problem.

Finally, the EEA refers to features of the environment in which the hominid line is thought to have evolved; early proponents of EP identified African Pleistocene savannahs as such an environment (Bolhuis et al., 2011; Cosmides & Tooby, 1997). It has since been clarified that the EEA for any given adaption is not limited to a particular place and time, but that it is rather a statistical composite of all relevant selective pressures of past environments (Bolhuis et al., 2011; Cosmides & Tooby, 1997). The implication of EEA is that when an individual is startled, environments such as savannahs did, and would still hold potential for stress relief and restoration.

EP forms or umbrella approach under which both the biophilia hypothesis and SRT fall, since both the biophilia hypothesis and SRT stem from a psychoevolutionary approach (Gruman & Healy 2018). Regarding the present study, EP and biophilia serve as the explanatory mechanisms by which people may find exposure to natural areas as restorative. That is, having evolved in natural areas (green or blue spaces), an innate disposition to green or blue spaces exists. This is anticipated to serve as the explanatory mechanism for a preference for green and blue spaces, should such a preference exist. The biophilia hypothesis will be discussed next, and at the end of the section a diagram will be presented that shows how EP and biophilia relate to each other.

3.3 The Biophilia Hypothesis

In 1984, Edward Wilson published a book titled *Biophilia*, which attempted to define an observed tendency of humans to relate to, and affiliate with, natural processes and living beings. In this book, Wilson defined biophilia as "the innate tendency to focus on life and lifelike processes" (Wilson, 1984, p. 1).

The basic assumption of biophilia is that humans are innately predisposed to be drawn to natural settings that increased the likelihood of survival in our evolutionary history. When considering that the purpose of taking an evolutionary standpoint is that the genes that promoted the survival of the species were passed down, it stands to reason that the environments or behaviours that fostered survival would be passed down and remain present in modern day humans. Those behaviours or environments that reduced the chances of survival (for example, not fearing a predator, or living in an area with no food or water supply), would have resulted in those individuals not surviving to pass down their genes.

The natural settings that would have increased the likelihood of survival relate to the point of the EEA discussed in 3.2, and include environments containing elements such as water, also known as blue spaces, or rich biodiversity in the case of green spaces (Gruman & Healy 2018; Marselle et al., 2021). For example, being attracted to water increased the likelihood that our ancestors would be able to locate food, which regularly grows surrounding streams and lakes. If the water sources were fresh water (as opposed to sea water), it would further have provided sources for drinking and hydration. Moreover, if the water source was a river, it would have provided an escape from land predators, such as lions, that typically avoid being submerged by water.

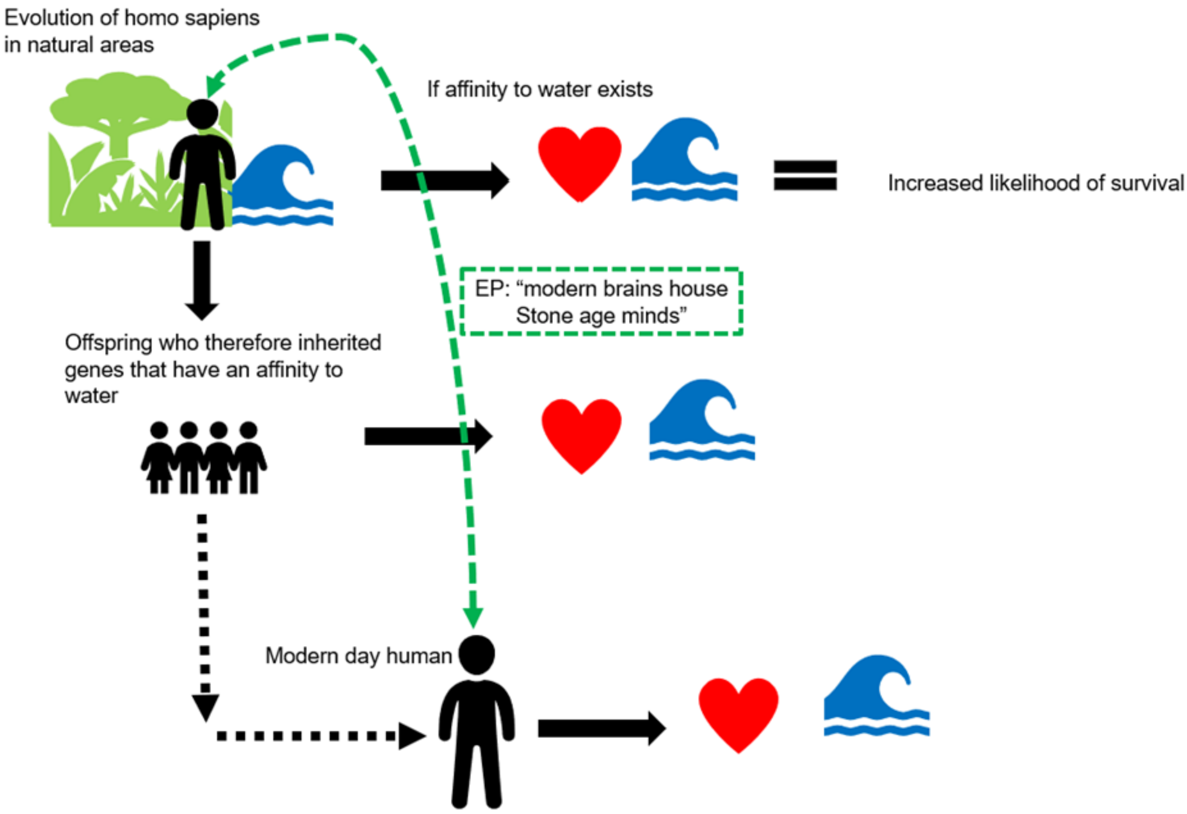
Keeping with this example, those ancestors who held biophilic tendencies to water would have been more likely to survive than those without this tendency. As a result, this biophilic tendency would have been passed down in the genes of surviving ancestors and is consequently still displayed to this day (Gruman & Healy 2018; Ulrich 1993). The evolutionary advantage that water provided, links with the principle that human brains evolved in response to survival challenges facing our hunter-gatherer ancestors, as proposed by EP. The emerging body of research regarding the perceived restorative benefits of water as discussed in Chapter 2 provides support for the notion that humans are still drawn to blue spaces (Gidlow, 2016; Poulsen et al., 2022; Subiza-Pérez et al., 2020 Triguero-Mas et al., 2017b). This is particularly applicable to scenes of natural blue spaces such as rivers and streams, as opposed to man-made blue spaces such as ponds (Luo et al., 2021; Zhao et al., 2020). In the context of the present study, the biophilia hypothesis could serve as an explanation should participants find blue spaces restorative. By viewing a blue space, the proposed mechanism that would exist is that these views would be remnant of an evolutionary history, where coming into contact with water would foster survival and therefore produce a calming effect.

A similar example relates to natural, green spaces rich in biodiversity. A biodiverse natural area would have been more likely to contain multiple sources of food and supplies that would foster survival (for example wood for creating a fire or fashioning a weapon). Those who held biophilic tendencies towards richly biodiverse areas would have consequently been more likely to survive than their non-biophilic counterparts, and were therefore able to pass these genes down. Although biodiversity is not a central element of the present study, studies have shown that environments with greater plant species richness and species richness of trees and birds are associated with higher restorativeness, as measured by positive emotions and reduced stress (Lai et al., 2019; Lindemann-Matthies & Matthies, 2018; Schebella et al., 2019; Wolf et al., 2017). The proposed mechanism for this is similar to that of the blue spaces discussed in the preceding paragraph. Since biodiverse spaces fostered species survival, coming into contact with these areas in present times would provide a sense of calm. These spaces would be reminiscent of times in our evolutionary history where there was minimal need for stress, as a food supply was available.

Authors have suggested that the innate predisposition to natural areas, as proposed by the biophilia hypothesis, is also evidenced by the behaviour of urban dwellers. For example, urban parks are becoming ever increasingly popular holiday destinations (Henderson-Wilson et al., 2017). These typically involve nature-dominated environments, such as game reserves or coastal regions, and properties with views of nature are regularly held in higher regard than those without nature views (Daams et al., 2016).

The following figure is a simplified depiction of the relationship between the biophilia hypothesis and EP, and how it relates to modern-day humans:

Figure 12 The relationship between the biophilia hypothesis and EP



Note: Author's own.

The foundational premise of the above diagram is that those who evolved in natural areas, and developed an affinity for areas that fostered survival (for example, water), would have survived to pass down these genes. These genes are consequently theorised to have been passed down to the extent that they still exist in modern day humans, informing the affinity 21st century humans still appear to have in relation to nature. The premise that modern day brains house stone age minds is therefore evident, in the sense that this affinity for nature stems from thousands of years of evolutionary processes in nature.

While EP and the biophilia hypothesis provide a sound foundation for understanding humans' connection with nature, they do not focus specifically on the stress-reducing properties of exposure to nature. The SRT is therefore discussed next, as its psychoevolutionary focus provides the conceptual underpinning of the mechanism of the stress reducing abilities of nature.

3.4 Stress Reduction Theory

The psychoevolutionary theory underpinning the present study is the SRT, and was proposed in 1983 by Roger Ulrich. Since (like EP and the biophilia hypothesis) it as an evolutionary theory, it is inherently retrospective in that it bases its fundamental assumptions on the behaviour of humans thousands of years ago. While this does not detract from the quality of the theory, it means that the theory has not undergone any significant changes or updates since its introduction, and therefore remains an old theory. Despite this, it remains the predominant theory in research addressing the stress relieving effects of nature and was consequently deemed acceptable for use (Beute et al., 2020; Luo et al., 2021; Marselle et al., 2021).

3.4.1 Defining SRT

The basic premise of SRT is that unthreatening natural views play a pivotal role in reducing psychophysiological arousal and are consequently more restorative than urban scenes. As is the case with the biophilia hypothesis, the foundational assumption of SRT is that because humans evolved in natural settings, as opposed to the built environment, they have an innate predisposition to natural settings that would have fostered the survival of the species (Ulrich, 1983). This innate predisposition being referred to is a range of biologically inherited, immediate, and unconscious affective and physiological responses to natural settings. This means that when encountering a natural setting, humans will respond positively, psychologically and physiologically, without needing to think about their response. This immediate and unconscious response was defined as affective primacy, suggesting that an individual feels an emotional response before cognitively processing a scene (Zajonc, 1980).

Although later theorists posited an opposing view, in which cognition precedes affect, the notion of affective primacy, according to Ulrich (1983), allows for the rapid initiation of fight or flight responses and would have had substantial adaptive value for our ancestors. These fight or flight responses are the subject of study in a number of studies to date (Bratman et al., 2019; Haluza et al. 2014, Kuo, 2015; Mantler, 2015; Meredith et al., 2020; Miyazaki et al 2014). These fight or flight responses are measured in the present study via the physiological measures used and are discussed in greater depth in Chapter 4.

Within the evolutionary framework, the ability for an individual to respond rapidly, without the need for cognitive processing, would have allowed for the individual to respond rapidly in an appropriate manner, increasing the likelihood of survival (Joye, 2007). For example, if an individual were to encounter a threat (a predator), this would immediately elicit negative affective responses such as fear or surprise. These would have resulted in avoidance behaviour, fostering survival. By contrast, if an individual encountered a setting that was conducive to survival and reproduction (a high vantage point with a wide line of view), this would elicit immediate positive affect, which would produce approach behaviour, similarly fostering survival (Joye, 2007). The ability of these responses to be rapidly processed, without effortful cognition, would have increased survival chances. That is, if these innate predispositions were inherited, less time would have to be spent re-learning which environments were threatening or not, consequently promoting survival. These approach and avoidance behaviours have been included, as they are measured in the present study while participants view each treatment scene.

Although this rapid processing fostered survival, there were psychophysiological consequences of encountering a threat. Such consequences would have included SNS responses such as an elevated heart rate and sweating, as well as negative emotional states (Gladwell et al., 2012). Restoration was therefore needed, especially when considering the unpredictability of how soon another threat would appear. The capacity for gaining relief from stress and restoration from expended energy developed in natural environments, and would have had major evolutionary advantages to humans. The ability to rapidly recuperate both psychologically and physiologically from a stressful situation would have been beneficial to survival, to the extent that one would be able to respond effectively to stressful situations occurring soon after the initial stressor (Thake et al., 2017; Ulrich et.al., 1991). In literature, this restoration is referred to as being both retrospective and prospective – natural areas undo lasting effects of stressors (retrospective) and prepare one for faster recovery to future stressors (Brown et al., 2013; Kuo, 2015)

Similarly to the biophilia hypothesis, a primary assumption of SRT is that natural environments are processed more easily and efficiently by humans, because the brain and sensory systems evolved in natural settings (Wohlwill, 1983). The mechanism of restoration involves the proposition that exposure to environments, that hold the properties discussed in 3.4.2, do not require significant amounts of information to be processed and so arousal levels are reduced (Thake et al., 2017; Ulrich, 1979).

The properties of natural scenes that, according to SRT, are likely to reduce stress, promote restoration and be perceived as conducive to survival are discussed next.

3.4.2 Stress reducing properties of natural scenes

According to SRT, there are six properties of natural scenes that will result in the view being preferred, or assessed as being conducive to survival, fostering acute stress restoration (Ulrich, 1983). These properties were used in the present study in that they informed the selection of the two nature treatment videos (described in Chapter 4). That is, the nature scenes that were chosen were done so using these properties as a checklist to ensure they aligned with SRT.

The first property is the view having moderate to high complexity, where complexity is defined as the number of elements in a scene that are perceived as independent (Beute et al., 2020; Ulrich, 1983). For example, in a scene of a natural area, the presence of various types of trees, shrubs, flowers, animals, and footpaths would be considered as highly complex, because each of these elements are perceived as independent. Contrastingly, a nature scene that consists of a lawn and one tree would be low in complexity. Figure 13 is a visual representation of a natural area that is high in complexity.

Figure 13 Image of a natural scene that is high in complexity

Note: From https://www.hereandtherewithpatandbob.com/2020/05/cornwall-england-where-palm-trees-grow.html

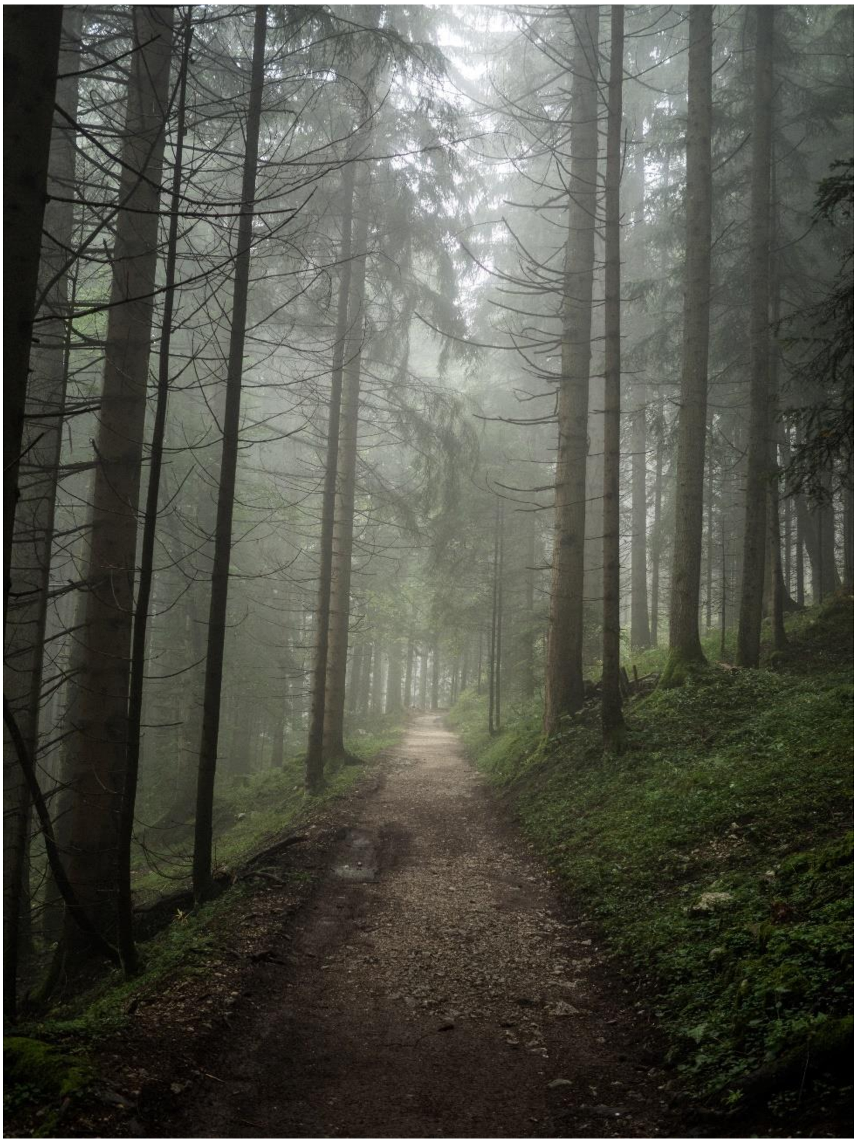
The second quality is that the complexity is structured and ordered, and a focal point can be established (Ulrich, 1983). If the highly complex environment described above were grouped, for example, by the flowers appearing together in one area, the shrubs appearing together in a different area, and a wide footpath that is visible through the middle of the scene, this scene would be considered structured with a focal point. Figure 14 depicts a garden with high complexity that is grouped with a clear focal point.

Figure 14 A garden with high complexity, grouped, with a clear focal point

Note: From https://www.audleytravel.com/blog/2011/may/10-botanical-gardens-you-should-visit

Thirdly, an environmental scene should have a moderate to high level of depth, that is unambiguous in perception (Ulrich, 1983). For example, if a scene includes a forest area with a clear path through the middle extending to the edge of the image, or video, the ability to perceive depth in the image is heightened and the scene will elicit positive responses. This is because the impression of freedom of movement is given, which could foster survival if escape is needed. Conversely, if a scene involves an impenetrable forest edge where all one can see is dense vegetation, this lack of depth will create an immediate sense of dislike, as the scene could contain hidden dangers and there is no clear avenue of escape. More recent research has supported the notion that highly dense vegetation might undermine the stress relieving effects of a natural area and instead evoke insecurity (van den Berg et al., 2014). Figure 15 is an example of an environmental scene with a clear path, providing a clear level of depth perception.

Figure 15 A forest with a clear path, providing heightened depth perception



Note: From https://unsplash.com/photos/oFxxpPKwd84

The fourth property relates to the ground surface texture and should be appraised as even, and conducive to movement, to be appraised positively. This property relates to the quality of depth described in the above paragraph, in the sense that the clear path alluded to should have even terrain and be favourable for quick movement. The reason the presence of this property elicits positive responses is because it allows for quick, safe escape. In evolutionary terms, if an individual was being chased by a lion, having to climb rugged terrain with no clear path would not have fostered survival. A clear path in a forest, conversely, would foster survival, as the individual could make a quick getaway. This property is displayed in Figure 16.

Figure 16 A natural area with ground surface texture that is conducive to easy movement

Note: From https://unsplash.com/photos/gyIRjKPXupE

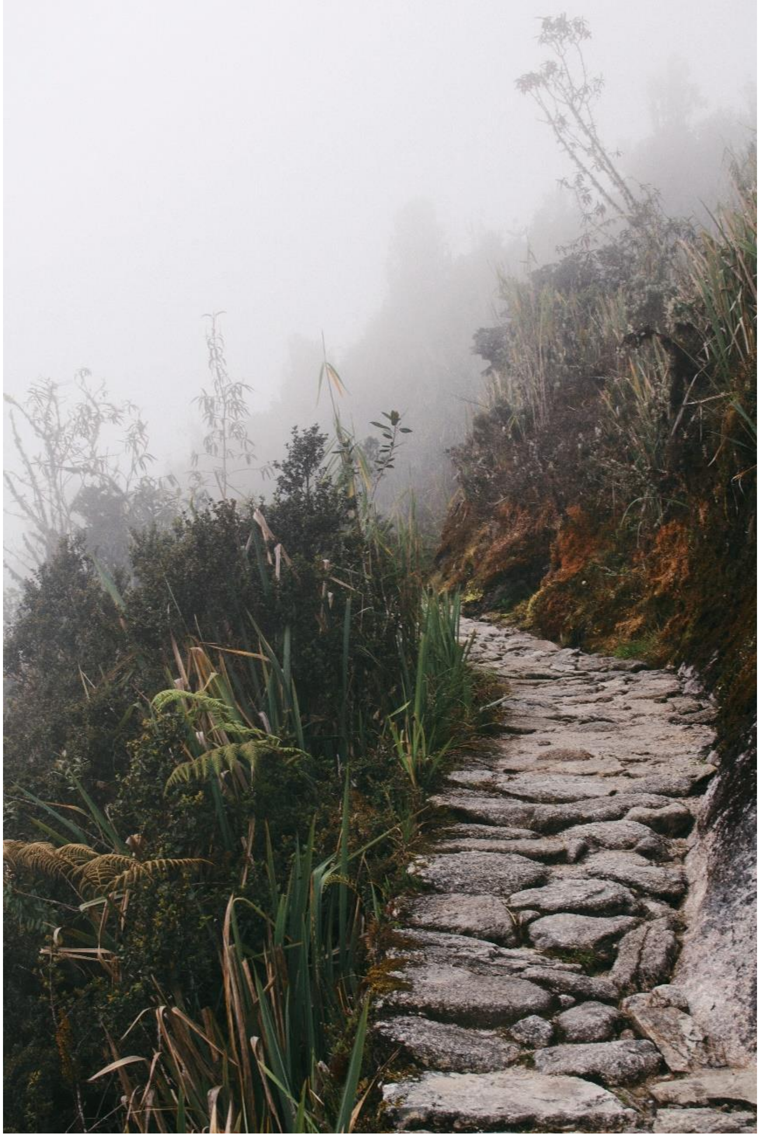
The second last property is termed the presence of a deflected vista, and in essence refers to the curving line of sight associated with rivers, valleys, and paths (Ulrich, 1983). The presence of deflected vistas suggests to the viewer that there is more information about the environment available and this perceived ability to explore the environment further and gain more knowledge about it, would have enhanced survival. Figure 17 is an example of a deflected vista where the curving paths suggest that further information about the environment can be gained.

Figure 17 A natural scene with a deflected vista

Note: Source: “*Where The Light Is*” by J. Kerrin.

Related to the presence of deflected vistas, is that the information available on immediate appraisal and as suggested by the curved line of sight, should not convey the presence of a threat. The presence of a threat would immediately elicit dislike and fear and would consequently not be perceived as restorative. If a natural scene has depth, even terrain, and a deflected vista, but the line of sight suggests a sharp drop or a lack of visibility, the view will be appraised as threatening. In Figure 18, although there is a clear path, the left edge of the scene suggests a drop and the mist at the end of the image impacts the visibility of what lies ahead. These two elements convey the possibility of a threat and would consequently likely not be perceived as restorative.

Figure 18 A deflected vista containing threatening properties



Note: From https://unsplash.com/photos/9MMd2uRpfvc

Although the above six properties were outlined as key by Ulrich (1983), an added point for consideration is the presence of water. It is discussed as a separate environmental element as not all natural scenes will necessarily include water, but it is emphasised as an element that will nearly always elicit a positive response. The exceptions to this would be, for example, a stormy sea or polluted water, as these do not promote restoration. Despite water being highlighted as a consistently positive environment, the fact that so little research has been conducted on blue spaces remains notable, as discussed in Chapter 2. Nonetheless, the present study specifically included water, a blue space, as a separate natural environment from green environments, to assess whether this theoretical proposition of pleasant water scenes being habitually restorative would be supported. Figure 19 is an example of a blue space that could be perceived as restorative, as it does not appear to contain any evident threats.

Figure 19 A blue space that does not contain any evident threats

Note: From https://unsplash.com/photos/KMn4VEeEPR8

3.4.3 SRT in the context of the present study

Although Ulrich (1983) did not specifically discuss the type of stress being referred to, the fundamental assumptions of EP and SRT relate to rapid recovery from a life-threatening encounter, via the activation of the fight or flight response. Thus, it can be deduced that these theories address acute stress relief. A recent study investigating the restorative potential of blue parks supports this notion and similarly classified the focus of SRT as acute stress relief (Luo et al., 2021). The notion of a biological preparedness to attain restoration quickly and effectively from being in natural environments, speaks to an acute stress relief response that developed over years of evolution in natural environments; however no such preparedness exists for urban and built environments. This is likely due to the relatively short amount of time humans have spent in built environments compared to natural environments, especially when considering the relatively slow pace at which evolutionary adaptive processes occur (Berto, 2014). It is for this reason that an urban environment was included as one of the experimental groups – evolutionary reasoning suggests that the urban scene will not be perceived as being as restorative as the blue and green groups.

As discussed in 2.3, research that focuses on the stress relieving effects of natural areas (when addressed from a generic "natural environments" perspective and specifically within blue and green spaces), is largely based on SRT (Beute et al., 2020; Browning et al., 2021; Gao et al., 2019; Nukarinen et al., 2020; Tanja-Dijkstra et al., 2018). The psychological element of stress relief is usually assessed by various mood state scales, while the physiological elements being measured are indicators of SNS, and HPA-axis activity. The present study therefore incorporates scales that specifically address stress relief, as experienced in the moment, general stress (by using the PSS) and a variety of physiological measures that are explained in Chapter 4. Furthermore, given the proposition by SRT that water is particularly effective in reducing stress, blue spaces were presented as a unique category.

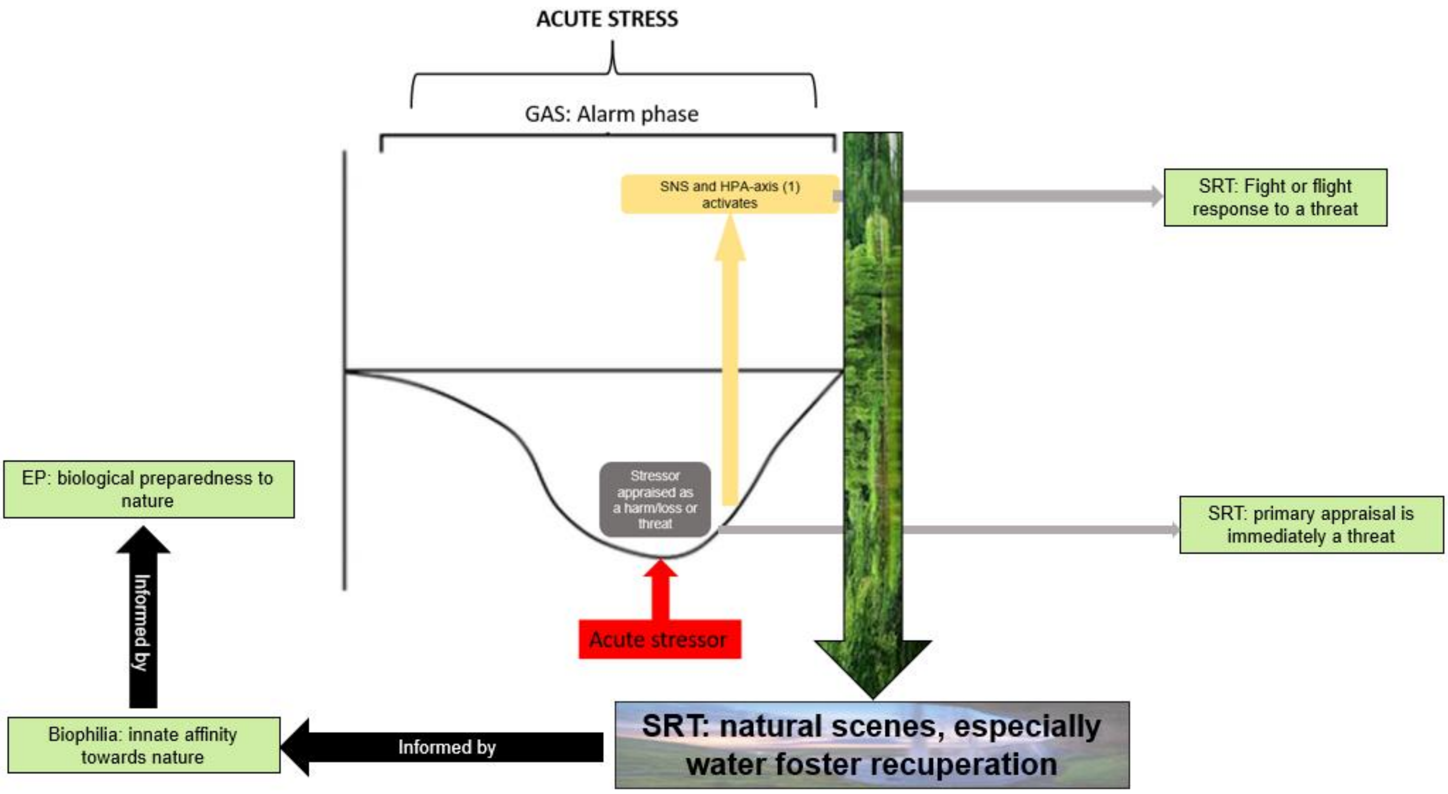
Crucially, the acute stress being measured relates to the author's proposed adapted stress typology presented in 2.2.1. The definition provided for acute stress was "A sudden, short-term event that evokes a SNS and HPA-axis response. This can be anything that, if appraised as a stressor, triggers this physiological response" (from Table 2). The proposed time frame was the moment of the event occurring, which is particularly relevant from an evolutionary perspective. That is, when faced with a threatening encounter, the psychophysiological responses were immediate, placing this firmly in the category of acute stress responses.

Although modern-day humans face different challenges and acute stressors than our ancestors, a response which has not been lost is the startle response, described in 2.2. The startle response is involuntary, immediate, and serves an evolutionarily adaptive purpose (Martin et al., 2015). One of the key features of the startle response in adults is that the eyes close immediately. This immediate eye closing served, and continues to serve, a functional purpose of protecting one's eyes. The present study's inclusion of a sudden, loud, abrasive noise to elicit an acute stress response is supported by evolutionary principles and it thus serves to reason that the stress relieving effects of nature as described by SRT would be efficient.

3.5 Integration of stress relief models

To return to the proposed integrated model of stress relief as presented in 2.2.4.4, the roles of EP, biophilia, and SRT are included in the acute stress phase to demonstrate how they play a role in stress responses and stress relief. It should be clarified that the second and third phases of the proposed stress model are not included here as the focus of the present study is on acute physiological stress responses. However, it was necessary to initially discuss all three phases as the implications of passing from the first phase to consequent phases can potentially be mitigated by the intervention of green and blue spaces, reducing later potential deleterious health consequences.

Figure 20 Integrated model of stress relief using EP, biophilia and SRT



Note: Author's own

According to the proposed model, when an acute stressor occurs, the individual enters the alarm phase of the GAS and consequently the fight or flight response is initiated. This initiation involves the activation of the SNS and the release of adrenaline by the HPA-axis to gear the body up for survival. In this first phase, the use of a startle response in the present study ensured that within Lazarus and Folkman's (1984) primary stage of appraisal, the acute stressor would bypass cognitive appraisal and result in a threat appraisal. This immediate, unconscious appraisal of the acute stressor as stressful consequently ties in with SRT's notion that in our evolutionary history, when encountering a threat such as a predator, this would automatically be processed as a negative experience. Thus, it would activate the SNS and HPA axes to survive. In this model, therefore, the SRT explains why the SNS and HPA axes are activated (this is for survival), and furthermore that the acute stressor would be automatically appraised as a threat. However, this elicitation of the startle response holds an evolutionary survival advantage and therefore can be explained by the background of EP.

Once an individual has encountered an acute stressor, the role of SRT becomes particularly prevalent in its stress-relieving propositions. Although the present study used a startle response to elicit an acute stress response, mention should be made again of the author's proposed delineation of acute stress from chronic stress in Table 2. The reason for this is to emphasise that any encounter that produces a fight or flight response can be considered as acute stress, and so the stress relieving effects of nature as proposed in this chapter may extend beyond the realm of a laboratory setting.

The role of green spaces that meet the six criteria presented by SRT in 3.4.2, and especially blue spaces, is the elicitation of stress reduction and consequently the promotion of psychophysiological restoration. The ability of SRT's propositions to function as they do is informed by the biophilia hypothesis in that humans have evolved an affinity towards natural areas. As discussed in 3.3, the biophilia hypothesis is informed and related to EP by way of this affinity being passed through surviving species members. To return to the first phase of the author's proposed integrated model, the role that green and blue spaces play in reducing acute stress reduction is that it reduces physiological responses and consequently can serve as a buffer against the individual moving into the second phase of the model, which relates to the resistance phase of the GAS. Although the second and third phases of the proposed model lie beyond the scope of the present study, it is important to recognise their existence, as the consequences of moving beyond the first, acute stress phase, can be detrimental to health (Herbert, 2013; Herman, 2011; Jacobson, 2014; Whitworth et al., 2005). Ideally, if exposure to green and blue spaces can reduce the effects of acute stress, as measured in the present study, further physiological harm can be avoided.

3.6 Conclusion

The above discussion provides the theoretical underpinnings of the present study; all of which are situated in a psychoevolutionary context. The integrated, proposed stress response model, particularly the first phase, formed the background for integration into the psychoevolutionary approaches. That is, the initial version of the model as presented in Chapter 2 outlined the proposed stress responses from a psychophysiological perspective. In this chapter, those proposed stress responses were integrated into three, related psychoevolutionary theoretical approaches, to form a fully holistic view of the acute stress response.

In terms of the new psychoevolutionary theories introduced in this chapter, EP is regarded as the underpinning to the biophilia hypothesis. This relationship was demonstrated visually. The key tenets of SRT, including the seven key properties of a stress relieving landscape (the six original properties plus the introduction of blue spaces), were discussed as to their relation to acute stress (as presented in Chapter 2 and the present study). Finally these psychoevolutionary principles were integrated into the existing proposed psychophysiological stress response model.

Should the principles of the EP, biophilia hypothesis and SRT remain relevant in present day society, one would expect to find more rapid recovery from stress when viewing natural landscapes than when viewing urban landscapes. This rapid recovery from stress could serve as an effective treatment or buffer within the first phase of the proposed psychophysiological stress response and potentially reduce the likelihood that the individual will move into the second phase, in which there are deleterious health consequences.

The following chapter includes a discussion of the methodology employed in the present study, in which the green and blue scenes used in the treatment phase of the experiment are aligned with the restorative principles suggested by SRT.

CHAPTER 4: RESEARCH METHODOLOGY

4.1 Introduction

This chapter provides a description of the methodological choices made to conduct the present study in alignment with its aims. These aims, objectives, and hypotheses will be restated, after which the experimental research design is discussed. The sampling techniques and a description of the sample, in terms of demographics, are provided to obtain a full understanding of the final sample. Following this, the measurement instruments used in the study are described; the psychological instruments are discussed first, followed by the physiological instruments. Thereafter, a brief description of the pilot study is given, followed by an explanation of the stressors and treatments used in the study. Furthermore, an account of the data collection procedure is given, after which the appropriate data analysis techniques are discussed. Finally, the chapter concludes with a comprehensive explanation of all ethical procedures followed throughout the course of the experiment.

4.2 Aims, objectives, and hypotheses

As was stated in 1.3 the aim of this study is to conduct a psychophysiological investigation into the extent to which urban, green, and blue spaces contribute to acute stress relief. In order to attain this aim, the following objectives and accompanying hypotheses were set:

- To investigate how effectively urban spaces impact acute stress, as measured by physiological and psychological measures:
    - H_1: Exposure to urban spaces significantly impacts acute stress, measured physiologically and psychologically
    - $H_{0(1)}$: Exposure to urban spaces does not significantly impact acute stress, measured physiologically and psychologically

- To investigate how effectively green spaces impact acute stress, as measured by physiological and psychological measures:
    - H_2: Exposure to green spaces significantly impacts acute stress, measured physiologically and psychologically

- $H_{0(2)}$: Exposure to green spaces does not significantly impact acute stress, measured physiologically and psychologically

- To investigate how effectively blue spaces impact acute stress, as measured by physiological and psychological measures and:
  - H_3: Exposure to blue spaces significantly impacts acute stress, measured physiologically and psychologically
  - $H_{0(3)}$: Exposure to blue spaces does not significantly impact acute stress, measured physiologically and psychologically

- To determine the extent to which the spaces under investigation impact acute stress levels the most, as measured by EDA.

The second aim of the present study is to develop a psychophysiological model of acute stress relief, integrating the findings of this study with evolutionary psychology, the biophilia hypothesis, and stress reduction theory.

4.3 Research design

Due to the fact that this study investigated the causal effects of treatments on individuals, a quantitative, experimental research design was used. According to Babbie (2016), an experimental research design requires the presence of an independent and dependent variable, a pre- and post-test, and the presence of an experimental and control group. All these factors were present in the study, as outlined below. A four-group, pre-test – post-test control group design was employed, where three of the groups were treatment groups and the fourth was the control group (Shadish et al., 2002). The treatment groups involved exposing participants to either a blue, green, or urban scene, respectively. Those in the control group received no treatment.

This design is represented in the following manner:

Figure 21 Schematic diagram of experimental design

TG1:	*PrT*	*S*	T^1	*PoT*
TG2:	*PrT*	*S*	T^2	*PoT*
TG3:	*PrT*	*S*	T^3	*PoT*
CG:	*PrT*	*S*		*PoT*

Note: In the above schematic diagram, TG = Treatment Group, CG = Control Group, PrT = Pre-test, PoT=Post-test, S = Stressor, T^1 = Treatment 1, T^2 = Treatment 2, and T^3 = Treatment 3.

An independent variable is manipulated by a researcher, to observe whether a change occurs in the dependent variable (Babbie, 2016). In the present study the three treatment conditions (T^1, T, and T^3 in Figure 1) served as independent variables (exposure to a scene), while the measured stress levels of participants (in response to the scenes) served as the dependent variable (*PoT* in Figure 21).

Although it is recognised that within pure psychological research, mixed method approaches are commonly utilised, this is not the case with psychophysiological research. Studies that examine psychophysiological stress responses typically employ at least one quantitative psychological measure and at least one physiological measure (Bhoja et al., 2020; Chan et al., 2021; Georgiou et al., 2021; Laborde et al., 2017; Mygind et al., 2019; Neureiter et al., 2017). To this end, the present study's methodology aligns with current standards in psychophysiological research and a purely quantitative methodology employing numerous psychological and physiological measures was deemed sufficient.

Within an experimental research design, a positivistic epistemology is followed. A hallmark of positivism is the assumption that there is an external, tangible reality that can be measured (Bezuidenhout et al., 2014). This reality is governed by laws and in the recognition of this, one can test and observe causal changes in variables. This objective view of reality aligns with the present study as psychophysiological variables are being manipulated with the assumption that the observed changes can be generalised to the greater population (Bezuidenhout et al., 2014).

4.4 Sampling

4.4.1 Sampling Technique

Non-probability convenience sampling is a sampling technique in which members of the population do not have a statistically equal probability of being selected. Furthermore, convenience sampling involves selecting participants who are readily accessible and willing to participate in a research study (Gravetter & Forzano, 2018). This sampling strategy was employed in the present study. Inclusion criteria for those interested in participating required being between 18 and 35 years of age, and not meeting any of the exclusion criteria. The latter included having smoked within 12 hours prior to participation, having epilepsy (or any other condition that could be triggered by the sounds/visuals of the videos), taking medication that impacts blood pressure, or being diagnosed with PTSD within a year prior to participation. These exclusion criteria were incorporated for two reasons. Firstly, since physiological variables are being measured, it is important not to confound the test results with external impacts of smoking and medication. Secondly, the criteria of not having epilepsy or being diagnosed with PTSD is for the sake of protecting participants. Since the fundamental principle of ethical research is to do no harm to participants, these criteria were included to avoid causing known harm.

Participants were identified through several means. The study was widely advertised across the University of Pretoria's (UP) Hatfield campus and on social media. On campus, the researcher, after receiving necessary permissions from the Departments of Psychology and Physiology, used the first five minutes of each of the undergraduate classes in one week to advertise the study. Lecturers, from the Departments of Psychology and Physiology, assisted with this process, by advertising the study in classes the researcher was unable to attend. The lecturers also uploaded the study advertisement on ClickUp, UP's student intranet. An advertisement for the study was also printed and placed on notice boards in areas on campus that have high volumes of student traffic. Off campus, the researcher advertised the study on her personal social media, including Facebook and WhatsApp.

Individuals interested in participating in the study were directed to a website, developed by the researcher to provide more information on the study. On this site, individuals could submit their email addresses for participation (https://ruthsphdproject.wixsite.com/info). These individuals were then emailed a link to a site where they could select a date and time for participation (https://www.signupgenius.com/).

In the end, a sample of 122 was obtained. Participants were then randomly assigned to each of the treatments referred to in section 4.8. Some participants, however, withdrew from the study and as result, the group sizes were affected, resulting in 31 participants in the blue group, 30 participants in the green group, 29 participants in the urban group, and 28 participants in the control group.

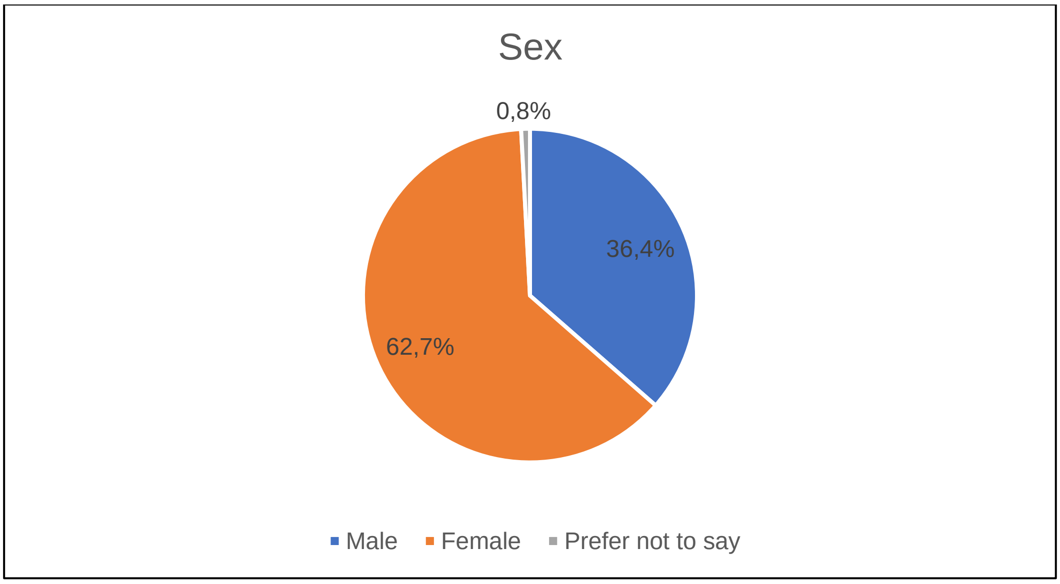
4.4.2 Description of Sample

The final sample obtained in the study consisted of 118 respondents, who varied on a number of demographic characteristics. This biographical information is presented in detail below.

4.4.2.1 Sex of Participants

Figure 22 below indicates that almost two thirds (62.7%; *n* = 74) of the respondents were female, while 36.4% were male (*n* = 43). One participant preferred not to disclose their gender.

Figure 22 Sex of respondents



4.4.2.2 Age of Respondents

As can be seen in Table 3 below, the majority of participants (58.5%) were aged between 21 and 23. Participants between the ages of 18 and 20 comprised 30.5% of the sample, and participants between 24 and 35 years comprised the remaining 11%.

Table 3 Age of respondents

Age				
	Frequency	Percentage	Valid Percent	Cumulative Percentage
18-20	36	30.5	30.5	30.5
21-23	69	58.5	58.5	89.0
24-26	5	4.2	4.2	93.2
27-29	4	3.4	3.4	96.6
30-32	2	1.7	1.7	98.3
33-35	2	1.7	1.7	100.0
Total	118	100.0	100.0	

4.5 Measurement Instruments

The present study employed numerous measurement instruments, assessing both psychological and physiological responses to the stressor and treatments. These instruments are described in detail below.

4.5.1 Psychological

The following questionnaires were used to assess the psychological tenets of stress and restoration, as discussed in Chapter 2.

4.5.1.1 Demographic questionnaire

Before commencement of the study, participants were required to complete a form that contained three demographic questions, and four screening questions (see Appendix C).

The demographic questions addressed sex and age and are demonstrated in 4.4.2. The screening questions, as indicated in 4.1.1., included having smoked within 12 hours prior to participation, having epilepsy (or any other condition that could be triggered by the sounds/visuals of the videos), taking medication that impacts blood pressure, or being diagnosed with PTSD within a year prior to participation. If a potential participant met any of the exclusion criteria, they were excluded from the study. None of the participants were excluded from the study as a result of the screening questions.

4.5.1.2 Nature Relatedness Scale

The NRS was used to assess the extent to which participants have an affective, cognitive, and physical connection to nature. This scale was used to determine whether there were any significant differences between groups, regarding their connectedness to nature, as such differences could confound the perceived restorativeness of the treatment.

The scale was developed in 2008 by Nisbet, Zelenski, and Murphy in response to a perceived lack of existing scales to fully capture the individual differences in people's sense of connection to nature. The scale is underpinned by the biophilic assumption that throughout evolutionary history, humans have developed an innate need, or love for, connection with the natural environment (Wilson, 1984). Although the scale was developed in the context of focusing on environmentally responsible behaviours, the questions provide insight into how connected individuals feel with nature, with the tentative premise being that those who do not feel connected may not experience the treatments as restoratively as those who do feel connected.

The original scale consisted of 21 Likert scale items, however in 2013, Zelenski and Nisbet created a 6-item version of the scale as it had become apparent that the 21-item version was cumbersome in some research contexts. The NRS-6 has demonstrated good reliability across conditions (α =0.85 to α = 0.89) (Soga et al, 2017; Zelenski & Nisbet, 2014). The present study thus used the 6-item version of the scale, demonstrating good reliability (α = .81). Scoring for the NRS is on a five-point scale, where 1 = disagree strongly and 5 = agree strongly.

4.5.1.3 Perceived Stress Scale

The PSS was developed by Cohen and colleagues in 1983 as a means of measuring the extent to which individuals appraise situations in their lives as stressful (Cohen et al., 1983). The fundamental factors assessed by the scale include the extent to which individuals perceive their lives as unpredictable, uncontrollable, and overloading. The scale was originally comprised of 14 items, but subsequent testing revealed that a 10-item version of the scale displayed slightly better psychometric properties than the 14-item version: α = .78 (Cohen & Williamson, 1988). The 10-item version has been most frequently used in research, as a result of its simplicity of items, ease of administration, and good psychometric properties (Jovanović & Gavrilov-Jerković, 2015; Lee, 2012). Scoring of the PSS is on a five-point scale where 1 = never, and 5 = very often.

Internationally, the 10-item version has been administered and validated in countries such as Turkey (α = .84), China (α = .83), Greece (α = .82), Sweden (α = .84 and .90 for two separate samples), the elderly in USA (α = .82), Iran (α = .83 and α = .72 in two separate studies), Denmark (α = .84), Germany (α = .84), and Spanish speakers in the USA (α = .84) (Andreou et al., 2011; Eklund et al., 2014; Eskildsen et al., 2015; Ezzati et al., 2014; Khalili et al., 2017; Klein et al., 2016; Leung et al., 2010; Maroufizadeh et al., 2014; Örücü & Demir, 2009; Perera et al., 2017).

The present study used the 10-item version of the scale, and it displayed good reliability. At pre-test, α = .82; and at post-test, α = .86.

4.5.1.4 Restoration Scale

The self-report restoration scale (SRRS, or RS) was developed in 2003 by Han to assess the perceived restorativeness of environments on dimensions other than attention restoration; an already well-investigated domain (Hartig et al., 1997). The theoretical foundation of the scale was based on previous research, that demonstrated that the restorative environments positively impact individuals' emotions, reduces physiological arousal, and improves cognition (Hull & Michael, 1995; Kaplan & Kaplan, 1989; Ulrich, 1993). In addition to these elements, Han (2003) included a behavioural element, designed to assess expected approach or avoidance tendencies. This behavioural element aligns with the approach and avoidance behaviours discussed in Chapter 3, aligning the scale with SRT. The scale contains 17, nine-point Likert items that comprise four dimensions, namely: the emotional dimension (five items), the physiological dimension (four items), the cognitive dimension (five items), and the behavioural dimension (three items) (Han 2003). For the emotional subscale, the statements associated with the extremes of the scale differ per item (e.g. 1 = depressed and 9 = elated; 1 = fatigued and 9 = energetic). For the physiological, cognitive, and behavioural subscales, 1 = not at all and 9 = very much so.

The emotional dimension of the scale was based on Lorr and Wunderlich's (1988) five-mood scale which, in recognising the bipolar nature of emotion, asks people to rate their emotion on five dimensions: depressed-elated, unsure-confident, grouchy-good natured, anxious-relaxed, and fatigued-energetic (Han, 2003). Participants are asked to imagine that they were in the projected scene and then rate the effect that the landscape has on them in terms of the five aforementioned dimensions.

The physiological dimension includes four of the physiological variables that are often used in physiological research on stress: respiration, muscle tension, sweating, and heart rate

(Karemaker, 2017). Participants are asked to rate, from "not at all" to "very much so" how the landscape elicits these responses (Han, 2003). One of the reasons this scale was selected was the inclusion of these four self-reported dimensions. Han (2003) discusses the importance of future research, combining this self-reported scale with direct physiological measures, which is what the present study did.

The cognitive dimension builds on Kaplan and Kaplan's (1989) theory of attention restoration and cognitive states, using simpler terms than the jargon used in the original theory. Consequently, the five items require the respondent to describe the influence of the landscape on their cognition with respect to being interested in the scene, feeling attentive to the scene, a decrease in mental fatigue, feeling concentrated, and feeling reflective of oneself (Han, 2003).

Finally, the behavioural dimension includes three statements reflecting approach behaviour, and respondents are asked to indicate the extent to which they disagree. These three statements include exploring the landscape further, visiting the landscape more often, and staying in the scene for longer (Han, 2003).

The scale was initially tested in two phases, using five experiments, to assess the scale's internal validity, convergent and discriminant validity, convergent and divergent construct validity, and reliability, all of which were found to be adequate (Han, 2003). The scale, including various shortened versions thereof, has been used successfully with reliability outcomes ranging from $\alpha = .501$ to $\alpha = .98$ (Han, 2007; Han, 2009; Han, 2018; Han & Hung, 2011; Han & Hung, 2012; Hung & Han, 2010; Memari et al., 2017; Nicolosi et al., 2020; Vassiljev et al., 2010; Zhao et al., 2020).

Each of the subscales of the RS in the present study performed well in terms of their reliability statistics. For the emotional and physiological subscales, $\alpha = .91$; the cognitive subscale was $\alpha = .87$; and the behavioural subscale's Cronbach's alpha was $\alpha = .96$.

4.5.1.5 Follow-up questionnaire

The follow-up questionnaire (FwUp) was a four-item Likert scale questionnaire designed by the researcher to supplement the existing scales, and glean data about the stressor, stress levels, and perceived restorativeness of the treatment. These questions were developed to further enable the researcher to compare acute stress levels of all participants, including those in the control group who did not receive treatment and would consequently not be able to answer the RS.

The first question asked participants to indicate how stressed, overall, they felt at that moment (1=not at all, 5=extremely). This question was included at the end of the PSS in the pre-testing condition to compare acute stress before and after testing. The second question, included only in the post-testing condition, required participants to indicate how frightening they perceived the stressor to be (1=not at all, 5=extremely). Similarly, the third question related to how restorative the treatment was perceived to be. The question was not included in the control group's post-test. Finally, participants were asked to consider how stressed they felt before the experiment and then rate how stressed they felt afterwards. Answer options included "less stressed than before", "about the same", and "more stressed than before". These questions were included with the intention of corroborating data obtained from the other psychological scales and physiological measures. The FwUp was compiled with the assistance of a statistician. Since each of these questions were individually designed to either complement another scale or physiological measure, and not function as a holistic, independent scale, inter-item correlations for these questions were not calculated.

4.5.2 Physiological

The instruments employed to assess participants' physiological responses to stress included the BioNomadix®, the Viport™, and a digital sphygmomanometer. The BioNomadix® was employed to measure galvanic skin conductance; the Viport™ measured CSI and heart rate; and the sphygmomanometer measured blood pressure and heart rate.

4.5.2.1 BioNomadix®

BioNomadix®, a product of BIOPAC Systems, is a system of wireless devices that are capable of assessing a multitude of physiological markers, including ECG, EEG, EMG, EOG, EGG, EDA, pulse, respiration, temperature, cardiac output, heel and toe Strike, clench force, acceleration, and range of motion (BioNomadix, 2020). For the purpose of the study, ECG, EDA, pulse, and respiration were measured. However, only EDA is reported on in Chapter 5, as it provides an indicator of the SNS system beyond what was collected by the rest of the physiological instruments used in this study.

The EDA transmitter is strapped to the inside of the participant's left wrist by a stretchable Velcro strap. Two electrodes are placed on the base of the participant's palm (after the area has been wiped with an alcohol swab) and these are connected to the transmitter by short wires.

The ECG transmitter is placed on the chest above the bust, as close to the heart as possible. The transmitter is secured by a stretchable Velcro strap that extends the circumference of the individual's chest. Two electrodes are placed right below each clavicle and are similarly attached to the transmitter by two short wires.

Finally, the respiration transmitter is placed adjacent to the ECG transmitter, secured by an additional stretchable Velcro band. This respiration band is secured tightly enough to detect chest movement while breathing but is conversely loose enough to not restrict respiration.

Data from these transmitters is transmitted wirelessly to a BioNomadix receiver that is plugged into the researcher's laptop. Data are logged in real time by Acq*Knowledge*, BIOPAC's software that allows for viewing, recording, measuring, and transforming data (BIOPAC, 2020). The full set up of the BioNomadix® equipment used in the present study is depicted in Figure 23.

Figure 23 BioNomadix Equipment

Note: Assembly of BioNomadix® equipment as demonstrated by the researcher.

4.5.2.2 Viport™

The Viport™ is a mobile ECG device that provides an indication of the current stress loading of the heart by transforming HRV data into a CSI (Energy-Lab Technologies, 2005). The device is small and triangular, and is placed on the left side of the participant's chest, above the heart. The three metal electrodes of the Viport™ are moistened with conductive gel and once the participant is seated and relaxed, the device takes two minutes to obtain a reading. A CSI reading of less than 25% is indicative of a normal stress load (Du Toit et al., 2013). Figure 24 is a generic image of the placement of the Viport™ on a male's chest. No pictures were taken of participants using the Viport™ during the study to protect their privacy, as the apparatus had to be placed on a bare portion of their chest.

Figure 24 Viport

Note. Placement of Viport on a male's chest, by P. Rudak, 2009.

4.5.2.3 Blood pressure

Systolic and diastolic blood pressure was measured using an electronic sphygmomanometer (the Medic Elite 1219). In instances where participants had a systolic pressure of 130 or higher, and a diastolic pressure above 80, the researcher strongly recommended the participant seek medical advice as these figures form the lower limits of hypertension (American Heart Association, 2017). Figure 25 similarly represents a generic image of the use of an electronic sphygmomanometer as it was used in the present study.

Figure 25 Electronic sphygmomanometer

Note: Image of an electronic sphygmomanometer being used.

4.6 Pilot study

The experimental procedure was piloted on a sample of five individuals, who met the participation criteria. Three of these participants were registered psychologists completing their PhDs. Their involvement in the pilot was requested, so they could provide actionable feedback with their background in psychology. Participants were invited to provide feedback throughout the process, to enhance the efficiency of the process. The first three participants were exposed to the first stressor of the study (see 4.7). They, however, indicated that this stressor was not frightening enough for them to experience an acute stress response, and observing the physiological data corroborated this. The researcher then decided to add a second stressor which was a popping balloon to coincide with the introduction of the first stressor. This second stressor was chosen as it produced a sudden loud noise, consistent with the description of a startle response provided in 2.2.3.1.1.

The remaining two volunteers then experienced both stressors and confirmed that the additional measure was frightening enough to produce an acute stress response, but not so frightening that they felt any fear or negative consequences after the treatment was administered. The use of a pilot study thus allowed the researcher to streamline the process, train the research assistant on procedural matters, and prepare administratively for data collection.

4.7 Stressors

As a result of the findings of the pilot study, two stressors were used to induce an acute stress response. The stressors were introduced simultaneously. The primary stressor was a 40-second clip from the movie *The Descent* (Marshall, 2005). The portion of the movie that was used depicted three women in a cave, who are looking for an exit. The scene is shot from the perspective of one of the women holding a video recorder. The woman moves the camera in various directions and as she turns back to her original point, a humanoid suddenly appears, screeching, close to the camera.

The second stressor, as mentioned in 4.6, was the sudden loud noise from a balloon being popped at the back of the testing room at the moment the humanoid appeared in the movie clip.

4.8 Treatments

In alignment with the aim of the study, there were three treatments. The three treatments consist of a video of a blue space, a video of a green space, and a video of an urban space. All treatment videos were from a first-person perspective, to enhance the sense of immersion in the environment. Videos were obtained from YouTube and permission was granted by the various content creators to use their videos.

The video of the blue space was a montage of clips of walking along a beach alongside the sea. The individual filming the clip was walking along the shore and so at times one could see and hear gentle waves gently breaking and receding. Tropical trees lined the opposite side of the beach. Figure 26 is a screen shot of part of this video.

Figure 26 Still frame from blue space video

Note. Still frame from "*World Nature Video; Virtual Walks - Paradise Beaches For Indoor Walking, Treadmill And Cycling Workouts"*, 2013.

The green space video was from the perspective of a person walking on a path through a forest. There was a clear, straight path being walked and the path was lined on both sides with tall, evergreen trees. One could hear the paced footsteps of the individual walking and birds could be heard in the background. Figure 27 is from the green space video.

Figure 27 Still frame from green space video

Note. Still frame from "*4K Relaxation Channel; 4K Virtual Forest Walk - 5 Hours Walking in the Woods, Grand Ridge Trail, Issaquah*" WA, 2018.

The urban space video was from the perspective of an individual walking through the streets of New York. The video started where the individual was crossing between two taxis and continued down a pavement next to a busy street. The individual walks past numerous people talking, a jackhammer can be heard in the background and one can see multiple digital billboards at the final intersection of the clip. Figure 28 is from this urban video, as the person videoing reaches the final, busy intersection.

Figure 28 Still frame from urban space video

Note: Still frame from "*Urban: Wanna Walk; New York City Videowalk, Times Square Manhattan 【4K 】*"; 2018.

4.9 Data collection procedure

Data were collected by the researcher and a trained research assistant in a small lecture hall in the University of Pretoria's Department of Physiology.

Participants arrived at their allocated time and were given the demographic and screening questionnaire to complete. Once it was ensured that the participant did not meet any of the exclusion criteria, they were given the PSS and NRS to complete. Following the completion of these questionnaires, blood pressure and CSI measurements were taken, forming the pre-test. Once these were completed, the BioNomadix® equipment was fastened to the participant as described in 4.5.2.1 above.

After ensuring the BioNomadix® equipment was functioning correctly, the research assistant turned off the lights and started the video. For each treatment group, the video was an edited combination of the stressor moving directly into the treatment clips as discussed in 4.8. For the control group, the video contained only the stressor clip, followed by a minute sitting in silence.

While the relevant stressor-treatment video was being played, the researcher was tracking the BioNomadix® data on Acq*Knowledge*, ensuring markers were placed within the software at the moments of the beginning of the video, the jump scare, and the end of the treatment, respectively. As indicated in 4.7, at the moment of the jump scare on the video, the research assistant popped the balloon.

Once the stressor-treatment video (or stressor-one-minute silence) video was completed, the research assistant turned the lights back on and the BioNomadix® equipment was removed. Blood pressure and CSI were once again measured. Finally, participants in the treatment groups completed the PSS, RS, and follow-up questionnaire, while those in the control group completed only the PSS and follow-up questionnaire. Once all questionnaires had been checked for completeness, the participant left, and data collection was thusly completed.

4.10 Data Analysis

The data obtained were analysed using the Statistical Package for the Social Sciences (SPSS), version 28. The data were cleaned and checked for outliers. The first tests that were run were to check the normality of the data distribution and the reliability of scales where relevant (Pallant, 2016). Thereafter, descriptive statistics were run on all the data; this included separate descriptives for the measures used pre- and post-test. A number of parametric inferential tests were run. These are discussed next along with their relevant design assumptions.

A one-way analysis of variance (ANOVA) is a parametric test that enables the researcher to compare the means of three or more separate groups on one continuous variable (Field, 2018). There are three primary assumptions of a one-way ANOVA. The first is that the observations (data points) are independent from each other (Field, 2018). In the present study this means that no participant's score was either impacted by another participant's score, or that any participants participated in any more than one of the experimental groups. The second assumption is that the population from which the data are drawn are normally distributed. The third assumption is that there exists homogeneity of variances: that each of the groups come from populations with equal variances (Field, 2018). In the present study this test was used to determine if there were any statistically significant differences between the four groups on a number of variables: NRS scores, RS scores (the overall RS scores and each of the subscales), the second, third, and fourth follow-up question, and the EDA deltas.

Further to the one-way ANOVA, two-way mixed ANOVAs were conducted to determine whether there were any statistically significant differences between experimental groups on their PSS scores, systolic and diastolic blood pressure, heart rate, and CSI in addition to determining any within-group changes from pre-test to post-test (Field, 2018). In this study a 2 x 4 ANOVA was used where the between-groups measure represented the four experimental groups, and the within-groups measure were the pre- and post-scores. The assumptions for this test are the same as those provided for the one-way ANOVA, with the addition of the assumption of sphericity (Field, 2918). Sphericity assumes that the variance between any pair of scores is roughly equal to the variance between any other pairs (Field, 2018; Pallant, 2016).

A multivariate analysis of variance (MANOVA) is used to compare the means of two or more groups on more than one dependent variable (Pallant, 2016). In the present study, this analysis allowed for the comparison between the three treatment groups (blue, green, and urban) on the subscales of the RS. There are a number of assumptions for conducting a MANOVA. Beyond the assumptions of the one-way ANOVA, it is assumed that the data are sampled randomly and that residuals have multivariate normality (Field, 2018). Thirdly, it is assumed that there are no outliers in the dataset. The assumption of multivariate normality and the presence of outliers will be checked by examining Mahalanobis distances (Pallant, 2016). The next assumption is that of linearity, which refers to a linear relationship between each pair of dependent variables. The penultimate assumption relates to multicollinearity and singularity. Within this assumption, there should be a moderate correlation between the dependent variables, however there should not be correlations greater than $r = .8$ as this indicates that the two variables are likely measuring the same construct (Pallant, 2016). Finally, the MANOVA assumes homogeneity of variance-covariances matrices. This means that there should be similar variances both within each group and across any pairs of the dependent variable outcomes (Field, 2018).

Following the MANOVA, a simple multiple regression was conducted on the RS scores to determine the extent to which each of the treatment groups (the independent variables) could predict change in overall restoration scores (the dependent variable). The first assumption that needs to be met is that the sample size cannot be smaller than the calculated minimum sample size as generalisability will be limited. According to Tabachnick and Fidell (2014), a minimum sample size can be calculated using the formula $N \geq 50 + 8m$ (where m is the number of independent variables). In the present study, there were three treatment groups, and so this formula becomes $N \geq 50 + 8x3$. The minimum sample size required for a multiple regression in this study is therefore 74. Similarly to the requirements of a MANOVA, it is assumed that the independent variables are not too highly correlated (not greater than $r = .9$).

Multiple regression is furthermore highly sensitive to outliers and so it assumed that there are none. Outliers are checked during the data cleaning process. The final assumption is with regards to normality, linearity, and homoscedasticity of residuals (Tabachnick & Fidell, 2014). The residuals (the difference between the predicted and observed dependent variable scores) should be normally distributed, they should have a linear relationship with predicted dependent variable scores, and the variance of the residuals should be the same for each of the dependent variable scores (Pallant, 2016; Tabachnick & Fidell, 2014). These assumptions are checked from the residuals scatterplots which are generated in the multiple regression output.

A single-sample t-test was conducted on the EDA data to determine whether existing differences between pre- and post-test conditions were statistically significant. The Acq*Knowledge* software used to capture the EDA data did not allow for the export of individual data points, but rather provided delta scores from baseline to post-test. To this end, the single-sample t-test assessed the statistical significance of the delta scores. The assumptions of a single-sample t-test are that the data should be independent observations and that the population from which the sample is drawn has a normal distribution (Gravetter & Forzano, 2018).

The final analyses conducted were Pearson correlations. Correlations assess the strength and direction of the relationship between two or more variables (Gravetter & Forzano, 2018). The key assumptions for parametric correlations (Pearson correlation) include the necessity of interval or ratio scale data, that each data point is independent of one another, that the data are normally distributed, and that the relationship between the variables is linear (Pallant, 2016). In the present study, Pearson correlations were conducted on all variables measured – a correlation matrix was created for all psychological and physiological variables.

4.11 Ethical Considerations

The following ethical matters were addressed in accordance with the American Psychological Association (APA) Ethical Principles of Psychologists and Code of Conduct manual (2017).

Permission to conduct the study was obtained from the University of Pretoria's Department of Humanities Research and Ethics committee. This approval included permission from the Dean of Humanities to advertise and include students within the Humanities department (see Appendix G). Further to this, approval was received from the Registrar's office to advertise the research study across UP's Hatfield campus, with the goal of attracting the interest of the maximum number of participants.

The information sheet provided to participants explained the purpose and duration of the research, and outlined all procedures to be followed. It was explained that participants could withdraw at any time without consequence, and it was emphasised that due to the purpose of the research, a small amount of discomfort would be experienced. The nature of the stressor was explained as fully as possible and it was emphasised that the stressor clip would not include any violence, any graphic or sexual content and it was not religious in any way. The information sheet included the fact that an additional stressor would be used to elicit a stress response, but that it would not harm the participant in any way. The researcher's contact details were included. No incentives for participation were offered.

Confidentiality was ensured by not requiring participants to provide any identifying information as part of data collection, apart from the three demographic variables discussed.

Since a jump scare by nature has to be unexpected, a minimal amount of deception was used by not informing participants that the additional stressor would be the balloon pop. As discussed above, participants were aware that an additional stressor would be used; it was the details of this stressor that were not included. As soon as the BioNomadix® data collection was complete, participants were told what the additional stressor entailed. This debriefing therefore happened as soon as practically possible, and participants were asked whether they needed any further debriefing from a mental health professional external to the study. None of the participants indicated that they did, but the researcher re-emphasised that her contact details were on the information sheet should they wish to seek additional help after their participation.

All data collected during the course of the study will be stored at the University of Pretoria's Department of Psychology for a minimum of 15 years.

4.12 Conclusion

This chapter has provided an overview of the methodological choices and designs used in the present study. A four-group, pre-test – post-test control group experimental design was employed to assess potential changes in each of the groups, on a range of psychophysiological measures. The final sample size consisted of 118 participants, of which 31 were in the blue treatment group, 30 were in the green treatment group, 29 were in the urban treatment group, and 28 were in the control group. These unequal group sizes were as a result of four participants dropping out of the initial sample of 122. The data collection instruments and procedures were explained, which included a small pilot study to address any potential limitations before commencing with data collection. A range of data analysis techniques were employed and all relevant ethical considerations that were taken during the study were discussed. The results of the analysis of the data collected are described in Chapter 5.

CHAPTER 5: RESULTS

5.1 Introduction

This chapter displays the results of the psychological and physiological testing that was done via the data collection procedures that were outlined in 4.9. The chapter is divided into main sections: the psychological data results and the physiological data results. The psychological results are presented first, as the psychological data were collected first during the experiment, and include both descriptive and inferential statistics of the NRS, the PSS, the RS, and four self-developed follow-up items (FwUp 1-4). The physiological results reflect both the descriptive and inferential statistics of diastolic and systolic blood pressure, heart rate, CSI, and EDA. As explained 4.4.1, the sample sizes for each group are as follows: blue (n = 31), green (n = 30), urban (n = 29), and control (n = 28). These samples sizes will therefore not be repeated in the results that follow.

5.1.1 Psychological Results

As discussed in 4.5.1, the present study utilised a number of psychological questionnaires to obtain a holistic insight into participants' perceptions of the stressor (the jump scare movie clip and balloon pop) and subsequent treatments (the blue, green, or urban videos). The questionnaires included the PSS, the NRS, the RS, and four self-developed follow-up items (FwUp 1-4). The latter were developed to provide more information on stress levels at the time of these being asked, in terms of how frightening the jump scare was, how restorative the treatment videos were, and a retrospective reflection of how perceived stress levels changed. As was mentioned in 4.9, the PSS was administered both before and after the treatment. The NRS was administered pre-treatment only, while the RS was administered post-treatment only to those in the treatment groups. Moreover, of the FwUp questions, one was asked both pre- and post-intervention, and the rest were asked post-intervention only (see Appendix E).

The psychological data were assessed for normality and since the data were normally distributed, parametric statistics were used throughout. The alignment of the assumptions of each test with the results will be discussed at each test result.

The following section will address the data of the NRS, including the descriptive and inferential statistics that were conducted. This scale is addressed first as it was employed purely to determine whether the experimental groups displayed any significant differences in their self-reported measures of connection to nature. Any differences on this measure would have impacted the interpretation of remaining data (insofar as the group/s displaying greater restoration could have been the consequence of nature connectedness, not the treatment).

5.1.2 Nature Relatedness Scale

As mentioned in 4.5.1.3, the NRS is a six-item scale, designed to determine the extent to which individuals feel connected to nature. The descriptive statistics of the NRS will be presented first, after which the results of a one-way ANOVA will be presented, with the aim of determining whether statistically significant differences exist between groups' NRS scores.

5.1.2.1 Descriptive Statistics of NRS

Basic descriptive statistics for each of the experimental groups and control group on the NRS are presented in Table 4. Given that a total possible score for this scale was five, means closer to five indicate greater perceived relatedness to nature.

Table 4 Descriptive statistics of the NRS per experimental group

Descriptives							
				95% Confidence Interval for Mean			
	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
Blue	3.75	.97	.17504	3.40	4.11	1.33	5
Green	3.71	.86	.15612	3.39	4.02	1.67	5
Urban	3.81	.75	.13908	3.53	4.10	1.50	4.67
Control	4.10	.56	.10868	3.88	4.32	2.50	5
Total	3.83	.81	.07498	3.69	3.98	1.33	5

Following this initial insight into the descriptive statistics of each group, a one-way ANOVA was conducted.

5.1.2.2 One-way ANOVA of experimental groups on NRS scores

A one-way ANOVA was conducted to assess whether there were any statistically significant differences between the three experimental groups and control group on the NRS scores.

Table 5 One-way ANOVA of experimental groups on NRS scores

One-way ANOVA					
	SS	df	Mean Square	F	Sig.
Between Groups	2.61	3	.870	1.33	.267
Within Groups	73.70	113	.652		
Total	76.31	116			

As can be seen in Table 5, there were no significant differences between the groups on their NRS scores ($p > .05$). Therefore, no post-hoc comparisons were conducted.

5.1.3 Perceived Stress Scale

As discussed in 4.5.1.2, the PSS assessed perceived stress. This scale was administered both pre- and post-treatment, with the intention of determining whether there were any changes in perceived stress following treatment (or in the absence of treatment for the control group). To achieve this goal, a two-way mixed ANOVA was conducted. This analysis allowed the researcher to determine whether there were any significant differences between the within-groups factor (the pre and post measurements) and the between-groups factor (each of the experimental groups).

With respect to the assumptions of this test, the requirement of the independence of observations was met as no one participated in more than one experimental group, and the pre and post tests were conducted at two separate stages. The assumption of the normality of the population from which the sample was drawn could not be determined, however the PSS scores were normally distributed. The homogeneity of variances and assumptions of sphericity are addressed below.

5.1.3.1 Two-way mixed ANOVA: PSS

The descriptive statistics of the PSS at both pre-test and post-test stages are presented in Table 6 below, according to each experimental group. Similarly to the NRS, the maximum possible score for the PSS was five, and so higher scores indicate greater perceived stress.

Table 6 Descriptive statistics of the PSS at both time intervals of experimental groups

Descriptive statistics			
	Group	Mean	Std. Deviation
PSS (Pre)	Blue	3.28	.310
	Green	3.35	.369
	Urban	3.32	.299
	Control	3.24	.312
	Total	3.30	.322
PSS (Post)	Blue	3.2032	.30385
	Green	3.2767	.34808
	Urban	3.2207	.28458
	Control	3.2679	.31978
	Total	3.2415	.31251

Following these descriptive statistics, Mauchly's Test of Sphericity was used to determine whether the assumption of sphericity had been violated. Given that there are only two conditions of the within-subjects factor, sphericity has been met (Field, 2018), which is supported by the results in Table 7 below. It should be noted that given the experimental design of the present study, all variables that have been measured and pre- and post-treatment were only measured twice and therefore sphericity is not a concern. All further instances of two-way mixed ANOVAs will consequently not include the results of Mauchly's Test of Sphericity, as the results are identical to Table 7 below.

Table 7 Mauchly's Test of Sphericity for PSS

Mauchly's Test of Sphericity[a]							
					Epsilon		
Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
PSS	1.000	.000	0	.	1.000	1.000	1.000

[a]. Design: Intercept + Group
Within Subjects Design: PSS

The homogeneity of variances can be assessed by inspecting the significance values of the PSS scores at pre- and post-test in Table 8. Given that at both time points $p > .05$, it can be concluded that this assumption has been met.

Table 8 Levene's test for homogeneity of variances of PSS

Levene's Test of Equality of Error Variances[a]

		Levene Statistic	df1	df2	Sig.
PSS (Pre)	Based on Mean	.514	3	114	.673
PSS (Post)	Based on Mean	.973	3	114	.408

[a]. Design: Intercept + Group
Within Subjects Design: PSS

Since the assumptions for this two-way mixed ANOVA were met, the next step is to assess whether there was any interaction effect between the groups and the time difference. The significance of the interaction is assessed in Table 9 below.

Table 9 Test of within-subjects effects of the PSS

Tests of Within-Subjects Effects

Source		Type III SS	df	Mean Square	F	Sig.	Partial Eta Squared
PSS	Sphericity Assumed	.177	1	.177	4.934	.028	.041
PSS * Group	Sphericity Assumed	.126	3	.042	1.171	.324	.030
Error (PSS)	Sphericity Assumed	4.080	114	.036			

There is no significant interaction ($p > .05$), which means the main effects of the within-subjects factor (time) and between-subjects factor (groups) can be assessed individually. The main effects of time can also be seen in Table 9, and it is evidenced that it was statistically significant ($p = .028$). The effect size of this result is indicated by the partial eta squared value and is $\eta^2 = .041$. According to Cohen's (1988) guidelines, an effect of around .01 is a small effect, around .06 is a moderate effect, and around .14 is a large effect. The obtained effect size is therefore small, approaching medium.

To assess the changes in scores within each group, pairwise comparisons were conducted. These results are presented in Table 10 and demonstrate that there was a significant increase in the means of the urban group, although this small increase only reached significance by a small margin ($p = .054$, which $\approx .05$).

Table 10 Pairwise comparisons of PSS scores across time intervals

Pairwise Comparisons

Group	(I) PSS	(J) PSS	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a] Lower Bound	Upper Bound
Blue	1	2	.077	.048	.110	-.018	.173
Green	1	2	.070	.049	.155	-.027	.167
Urban	1	2	.097	.050	.054	-.002	.195
Control	1	2	-.025	.051	.622	-.125	.075

[a]. Adjustment for multiple comparisons: Bonferroni.

The main effects of the groups are presented in Table 11, and it can be seen that there is no statistically significant effect of the groups ($p > .05$). This implies that there were no significant differences between the experimental groups on their PSS scores. Furthermore, the effect size of this result is .009, which is small (Cohen, 1988).

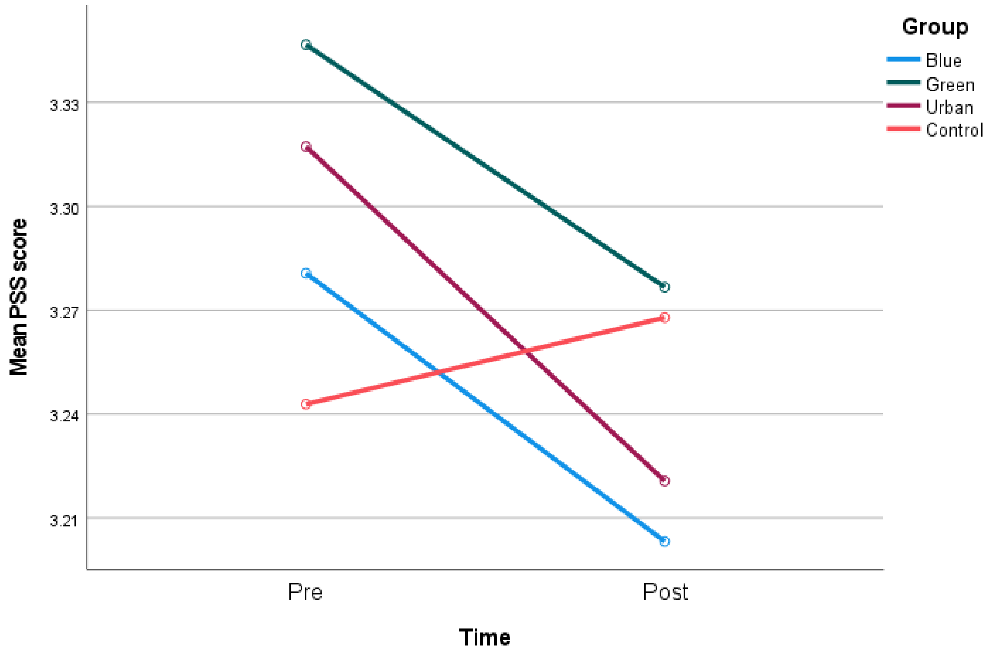
Table 11 Test of between-subjects effects of the PSS

Tests of Between-Subjects Effects

Source	Type III SS	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	2519.097	1	2519.097	14952.985	.000	.992
Group	.165	3	.055	.326	.806	.009
Error	19.205	114	.168			

Finally, a profile plot of the change in PSS scores from pre- to post-test is presented in Figure 29. The control group’s mean increased, while the remaining three groups’ means decreased. The urban group demonstrated the sharpest decrease.

Figure 29 Estimated marginal means of PSS scores per experimental group



5.1.4 The Restoration Scale

Next, the data of the RS were analysed. As discussed in 4.5.1.4, this scale required participants to rate how restorative they perceived the treatment scene to be on emotional, physiological, cognitive, and behavioural dimensions. This scale was only used post-treatment for the three treatment groups, as the control group did not view any scenes. For this reason, the total number of participants in the analyses of these data were 90, as opposed to the sample size of 118 in the other analyses. The physiological subscale was negatively worded and as such was reverse scored before conducting any analyses of it.

A MANOVA was conducted to determine whether there were any differences between treatment groups on each of the subscales of the RS. Each group comprised the three levels of the independent variable while the subscales comprised the four levels of the dependent variable.

In addressing the assumptions of MANOVA, the subscale correlations are presented first. Thereafter, the results of the MANOVA will be presented, followed by the results of the standard multiple regression analysis.

As highlighted in 4.9, MANOVA is sensitive to outliers. In the present study there was only one score that fell as an outlier; however this was not a major deviation. The critical value for Mahalanobis distances was 18.47, and the outlier's score was 21.864. The score was therefore retained for analysis. The scatterplots of the data presented linearly (see Appendix H and therefore the assumption of linearity was not violated. Finally, the dependent variables need to correlate moderately (r > .5) but not greater than r = .8. The results presented in Table 12 confirm that this assumption has been met.

Table 12 Subscale Pearson correlations of RS

Group		1	2	3	4
1	Emotional	—			
2	Physiological	.573**	—		
3	Cognitive	.727**	.407**	—	
4	Behavioural	.757**	.544**	.736**	—

**. Correlation is significant at the 0.01 level (2-tailed).

Given that the assumptions of MANOVA have been met, the following subsection provides the results of the MANOVA.

5.1.4.1 MANOVA

First, Table 13 presents the descriptive statistics of each of the independent variables (the treatment groups) per dependent variable (each RS subscale). For each of the subscales, higher scores (closer to a maximum possible score of nine) indicate greater perceived restoration. The scoring for the physiological subscale was reversed and so higher scores indicate lower acute stress responses.

Table 13 Descriptive statistics of RS subscales per group

Descriptive statistics			
	Group	Mean	Std. Deviation
Emotional	Blue	6.5806	1.30981
	Green	6.5133	1.48712
	Urban	4.8000	1.66733
	Total	5.9844	1.68782
Physiological	Blue	7.3387	1.56731
	Green	7.1583	1.80694

	Urban	5.4368	2.07912
	Total	6.6657	1.99588
Cognitive	Blue	6.3935	1.67131
	Green	6.6533	1.37959
	Urban	5.2207	1.77792
	Total	6.1022	1.71503
Behavioural	Blue	7.7204	1.74292
	Green	6.6333	2.26476
	Urban	4.8046	2.50795
	Total	6.4185	2.47563

Next, the equality of covariances for the MANOVA are presented in Table 14. To test whether the variances in each group are roughly equal, the p-value for the below test should be greater than .05. It can be seen in Table 14 that this assumption has been met (p = .098).

Table 14 Box's Test of Equality of Covariance Matrices for MANOVA

Box's Test of Equality of Covariance Matrices[a]	
Box's M	30.525
F	1.424
df1	20
df2	27002.907
Sig.	.098

[a]. Design: Intercept + Group

Since the assumption of the homogeneity of covariances has been met, the results of the multivariate tests displayed in Table 15 can be interpreted with confidence.

Table 15 MANOVA multivariate tests

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Intercept	Pillai's Trace	.960	504.102[b]	4.000	84.000	.000	.960
Group	Pillai's Trace	.405	5.397	8.000	170.000	.000	.203

[a]. Design: Intercept + Group
[b]. Exact statistic

The results of Pillai's Trace multivariate test indicates that there exist statistically significant differences between the three treatment groups (p < .05). The effect size for this test is .203, which is large effect (Cohen, 1988). Consequently, Bonferroni's post-hoc test was conducted to determine where these differences lay. These results are presented in Table 16.

Table 16 Bonferroni's post-hoc tests for RS

Multiple Comparisons

Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Emotional	Blue	Green	.0673	.38189	1.000	-.8649	.9996
		Urban	1.7806*	.38522	.000	.8403	2.7210
	Green	Blue	-.0673	.38189	1.000	-.9996	.8649
		Urban	1.7133*	.38831	.000	.7654	2.6613
	Urban	Blue	-1.7806*	.38522	.000	-2.7210	-.8403
		Green	-1.7133*	.38831	.000	-2.6613	-.7654
Physiological	Blue	Green	.1804	.46712	1.000	-.9599	1.3207
		Urban	1.9019*	.47119	.000	.7517	3.0522
	Green	Blue	-.1804	.46712	1.000	-1.3207	.9599
		Urban	1.7216*	.47497	.001	.5621	2.8810
	Urban	Blue	-1.9019*	.47119	.000	-3.0522	-.7517
		Green	-1.7216*	.47497	.001	-2.8810	-.5621
Cognitive	Blue	Green	-.2598	.41415	1.000	-1.2708	.7512
		Urban	1.1729*	.41776	.018	.1530	2.1927
	Green	Blue	.2598	.41415	1.000	-.7512	1.2708
		Urban	1.4326*	.42111	.003	.4046	2.4606
	Urban	Blue	-1.1729*	.41776	.018	-2.1927	-.1530
		Green	-1.4326*	.42111	.003	-2.4606	-.4046
Behavioural	Blue	Green	1.0871	.56002	.166	-.2800	2.4542
		Urban	2.9158*	.56491	.000	1.5368	4.2949
	Green	Blue	-1.0871	.56002	.166	-2.4542	.2800
		Urban	1.8287*	.56944	.006	.4386	3.2188
	Urban	Blue	-2.9158*	.56491	.000	-4.2949	-1.5368
		Green	-1.8287*	.56944	.006	-3.2188	-.4386

Based on observed means.
The error term is Mean Square(Error) = 4.782.
*. The mean difference is significant at the .05 level.

The results of Bonferroni's tests indicate a number of statistically significant differences. For the emotional subscale, the blue group (M = 6.59) demonstrated significantly greater restoration than the urban group (M = 4.8), and the green group (M = 6.51) similarly demonstrated significantly greater restoration than the urban group ($p < .001$). For the physiological subscale, both the blue (M = 7.34) and green (M = 7.16) groups displayed significantly greater restoration than the urban group (M = 5.44; p < .001). On the cognitive subscale, both blue (M = 6.39) and green (M = 6.65) groups displayed significantly greater restoration than the urban group (M = 5.22; p < .001). Finally, on the behavioural subscale, the blue (M = 7.72) and green (M = 6.63) groups similarly displayed significantly greater restoration than the urban group (M = 4.80; p < .001).

5.1.4.2 Standard multiple regression of treatment groups on overall RS scores

Finally, a standard multiple regression was conducted, to determine how much of the variance in overall restoration scores could be explained by each of the treatment group types. The blue group was used as the reference category. Firstly, the correlations between the variables in the model will be presented, followed by the model summary, which indicates how much variance in overall restoration scores can be explained by the model. The ANOVA output table provides an indication of the statistical significance of the model, and the coefficients table displays which of the treatment groups included in the model contributed to the prediction of overall restoration scores (Pallant, 2016).

The sample size of this analysis was 90 individuals, which exceeds the minimum sample size of 74 as calculated when discussing the assumptions of this test in 4.10. There were no outliers, and given that the independent variables are categorical, there is no correlation between them. The purpose of Table 17 is therefore to investigate the correlations between the treatment groups and overall restoration scores.

Table 17 Correlations between variables in the multiple regression model

Group		1	2	3	4
1	RS (Overall)	—			
2	Blue	.293*	—		
3	Green	.207	-.513*	—	
4	Urban	-.507	-.500*	-.488*	—

*. Correlation is significant at the 0.05 level (1-tailed).

As can be seen in Table 17, the urban treatment group was strongly negatively correlated to overall restoration scores (r = -.507), the blue treatment group (r = -.500), and the green treatment group (r = -.488). All of these correlations were statistically significant.

Furthermore, there was a statistically significant negative correlation between the blue and green treatment groups (r = -.513). Next, the model summary of the multiple regression is presented.

Table 18 Multiple regression model summary

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.509[a]	.259	.242	1.40651

[a]. Predictors: (Constant), Urban, Green
[b]. Dependent Variable: RS (Overall)

The R square value given in Table 18 suggests that .259, or 25.90% of the variance in overall restoration scores can be explained by the model.

Table 19 Multiple regression ANOVA result

ANOVA[a]

Model	SS	df	Mean Square	F	Sig.
Regression	60.071	2	30.035	15.183	.000[b]
Residual	172.110	87	1.978		
Total	232.180	89			

[a]. Dependent Variable: RS_Overall
[b]. Predictors: (Constant), Urban, Green

Table 19 indicates that this model is statistically significant (F (2, 87) = 15.183, p < .001. The coefficients presented in Table 20 provide further insight into which of the groups, when using blue as the comparator group contributed to this significant model.

Table 20 Multiple regression coefficients

Coefficients[a]

Model	Standardized Coefficients Beta	t	Sig.	95,0% Confidence Interval for B Lower Bound	95,0% Confidence Interval for B Upper Bound	Collinearity Statistics Tolerance	Collinearity Statistics VIF
(Constant)		27.334	.000	6.403	7.407		
Green	-.052	-.493	.623	-.894	.538	.762	1.312
Urban	-.532	-5.032	.000	-2.551	-1.106	.762	1.312

When assessing the standardised coefficients of Table 20, it is evident that the urban group is making the largest, and only statistically significant difference to the model ($\beta = -.532$, $p < .001$). This result is not surprising, given the strong, negative correlation between the urban group and overall restoration scores found in Table 17. Multicollinearity was not a concern in the model, as both VIF values are less than 10.

5.1.5 Follow-up questions

Four follow-up questions were developed (FwUp1, FwUp2, FwUp3, and FwUp4), with the intention of gaining insight into the self-reported stress levels of the individual at the time of asking these. This insight pertained to how frightening the stressor was perceived to be, how restorative the treatment was perceived to be, and how stressed the individual believed they were, in comparison to their stress levels before the experiment.

Question FwUp1 was “Overall, how stressed do you feel at this moment?” and was asked both before and after the stressor and treatment were administered to enable a pre-post comparison. Question FwUp2 was “How frightening did you perceive the stressor to be?”, with the goal of understanding the extent to which participants appraised the stressor as stressful. Question FwUp3 was asked only to those in treatment groups (and not the control group) and was “If you watched a video after the stressor, how restorative did you perceive the scene to be?” This question was included to be a supplement to the RS discussed in 5.1.4 to assess firstly the extent to which the individual found the treatment to be restorative and secondly to enable a comparison between treatment groups, as was done in 5.1.4. The relevant statistical analyses of each question will be discussed next.

5.1.5.1 Follow-up 1 (FwUp1)

The first follow-up question was asked both before and after the intervention, to determine whether self-reported stress levels changed as a result of the experiment. The descriptive statistics of this question per group are first presented, after which the results of the two-way mixed ANOVA are presented. Given that the experimental conditions for this question were the same as those for the PSS, all test assumptions remain the same. The assumption of homogeneity of variance is addressed in Table 22.

5.1.5.2 Two-way mixed ANOVA: FwUp1

The descriptive statistics of FwUp1 for each of the experimental groups at pre- and post-test are provided in Table 21.

Table 21 Descriptive statistics of FwUp1 at both time intervals of experimental groups

Descriptive Statistics

	Group	Mean	Std. Deviation
FwUp1 (pre)	Blue	2.52	.962
	Green	2.33	.922
	Urban	2.41	.907
	Control	2.79	1.228
	Total	2.51	1.011
FwUp1 (post)	Blue	1.94	.727
	Green	2.27	.868
	Urban	2.62	.820
	Control	2.68	1.056
	Total	2.36	.912

To address the assumption of the homogeneity of variances, the significance of Levene's test at pre- and post-test are provided in Table 22.

Table 22 Levene's test for homogeneity of variances of FwUp1

Levene's Test of Equality of Error Variances[a]

		Levene Statistic	df1	df2	Sig.
FwUp1 (pre)	Based on Mean	.909	3	114	.439
FwUp1 (post)	Based on Mean	2.042	3	114	.112

a. Design: Intercept + Group
Within Subjects Design: FwUp1

The significance values of Levene's test were greater than .05 at both time points and consequently it can be determined that this assumption was not violated.

Since the assumptions for this two-way mixed ANOVA have been met, the interaction effect is next examined. This result is presented in Table 23.

Table 23 Test of within-subjects effects of FwUp1

Tests of Within-Subjects Effects							
Source		Type III SS	df	Mean Square	F	Sig.	Partial Eta Squared
FwUp1	Sphericity Assumed	1.104	1	1.104	2.898	.091	.025
FwUp1 * Group	Sphericity Assumed	4.849	3	1.616	4.243	.007	.100
Error (FwUp1)	Sphericity Assumed	43.426	114	.381			

From Table 23, it can be seen that there is a statistically significant interaction effect ($p = .007$). This result furthermore has a large effect size ($\eta^2 = .1$) (Cohen (1988). The implication of this result is that the individual main effects have to be interpreted with great caution. This is due to the fact that the main effects are being confounded by their relationship to one another (Pallant, 2016). The individual main effect of the FwUp1 was not statistically significant ($p = .091$).

Nonetheless, pairwise comparisons were conducted to assess the mean differences of each group from pre- to post-testing. These results are presented in Table 24 and indicate that there was a statistically significant decrease in mean scores within the blue group ($p < .001$).

Table 24 Pairwise comparisons of FwUp1 scores across time intervals

Pairwise Comparisons							
						95% Confidence Interval for Difference[b]	
Group	(I) FwUp1	(J) FwUp1	Mean Difference (I-J)	Std. Error	Sig.[b]	Lower Bound	Upper Bound
Blue	1	2	.581*	.157	.000	.270	.891
Green	1	2	.067	.159	.676	-.249	.382
Urban	1	2	-.207	.162	.204	-.528	.114
Control	1	2	.107	.165	.517	-.220	.434

*. The mean difference is significant at the .05 level.
[b]. Adjustment for multiple comparisons: Bonferroni.

Table 25 presents the results of the between-subjects effects for the FwUp1. It can be seen that there were no statistically significant differences between the experimental groups ($p > .05$). There was nonetheless a small to medium effect size of this test, where $\eta^2 = .054$ (Cohen, 1988).

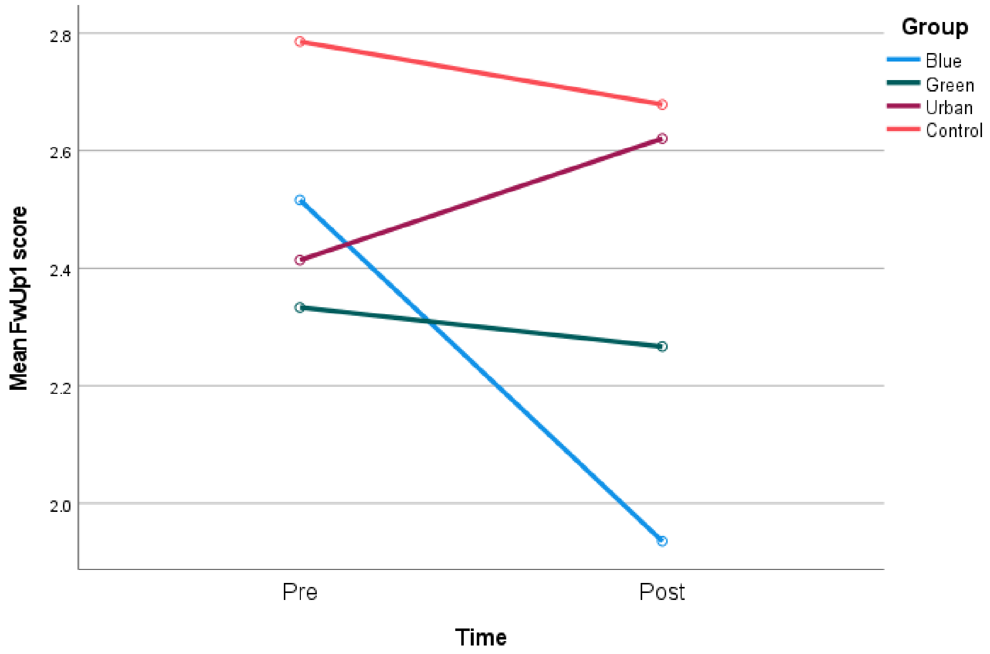
Table 25 Test of between-subjects effects of FwUp1

Tests of Between-Subjects Effects

Source	Type III SS	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	1407.400	1	1407.400	1006.525	.000	.898
Group	9.143	3	3.048	2.180	.094	.054
Error	159.404	114	1.398			

The profile plots of this test (Figure 30) provide further insight into the results above. Firstly, the interaction effect can clearly be seen in the way in which the line of blue group's score crosses the lines for the urban and control groups. Secondly, despite the interaction effect, the lack of significance of within-subjects effects can be partially explained by the opposing directions of change. While both the control and green group's means reduce slightly, the blue group demonstrates a drastic reduction while the control group has an increase in means.

Figure 30 Estimated marginal means of FwUp1 scores per experimental group



5.1.5.3 Follow-up 2 (FwUp2)

The second follow-up question aimed to investigate the extent to which participants perceived the stressor as frightening. The descriptive statistics for this question (divided per group) are presented, following which are the results of a one-way ANOVA, assessing any differences between groups on this measure. The purpose of conducting the one-way ANOVA was to determine whether being in any of the treatment (or control) groups played a role in the appraisal of the stressor as frightening.

Table 26 Descriptive statistics for FWUp2 per experimental and control group

Descriptives

				95% Confidence Interval for Mean			
	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
Blue	3.42	1.025	.184	3.04	3.80	1	5
Green	3.50	1.042	.190	3.11	3.89	1	5
Urban	3.38	1.015	.188	2.99	3.77	1	5
Control	3.14	1.268	.240	2.65	3.63	1	5
Total	3.36	1.083	.100	3.17	3.56	1	5

The results of the one-way ANOVA are presented in Table 27 below.

Table 27 One-way ANOVA of FWUp2 per experimental and control group

One-way ANOVA

	SS	df	Mean Square	F	Sig.
Between Groups	2.026	3	.675	.569	.637
Within Groups	135.305	114	1.187		
Total	137.331	117			

It is evident from Table 27 that there were no significant differences between experimental groups on their perception of how frightening the stressor was. Consequently, no post-hoc tests were conducted.

5.1.5.4 Follow-up 3 (FwUp3)

The third follow-up question asked participants to rate how restorative they perceived the treatment video to be, if they were in any of the treatment groups. Similarly to FwUp2, the descriptive statistics for this question will be presented first, followed by a one-way ANOVA assessing any differences between treatment groups. It should be noted that despite the results of the RS scale being presented above, this question was included as an additional measure to assess perceived restoration of the treatment videos. Furthermore, it was included to assess whether similar results would be found, when comparing the outcomes of the RS to FwUp3. Similarly to the RS output, this question was only asked to those who were in a treatment group, and therefore n = 90, not n = 118 as with all other results analysing the entire sample.

Table 28 Descriptive statistics for FWUp3 per treatment group

Descriptives							
				95% Confidence Interval for Mean			
	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
Blue	3.84	.860	.154	3.52	4.15	1	5
Green	3.73	.868	.159	3.41	4.06	2	5
Urban	2.31	.930	.173	1.96	2.66	1	5
Total	3.31	1.118	.118	3.08	3.55	1	5

The output of the one-way ANOVA of treatment groups is presented in Table 29 below.

Table 29 One-way ANOVA of FWUp3 per treatment group

One-way ANOVA					
	SS	df	Mean Square	F	Sig.
Between Groups	43.022	2	21.511	27.414	.000
Within Groups	68.267	87	.785		
Total	111.289	89			

It is evident in Table 29 that there were statistically significant differences between treatment groups on FwUp3 ($p < .001$). The results of Tukey's HSD post-hoc analyses are presented in Table 30 to determine the groups between which these significant differences occurred.

Table 30 Post-hoc multiple comparisons of FWUp3 between treatment groups

Multiple Comparisons

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Blue	Green	.105	.227	.888	-.44	.65
	Urban	1.528*	.229	.000	.98	2.07
Green	Blue	-.105	.227	.888	-.65	.44
	Urban	1.423*	.231	.000	.87	1.97
Urban	Blue	-1.528*	.229	.000	-2.07	-.98
	Green	-1.423*	.231	.000	-1.97	-.87

*. The mean difference is significant at the 0.05 level.

Similarly to the results of the RS, there were statistically significant differences between the blue and urban groups, and between the green and urban groups. The means of the blue group (M = 3.84) and green group (M = 3.73) were statistically greater than the mean of the urban group (M = 2.31). Similarly to the RS overall results, this implies that the blue treatment was perceived as most restorative, followed by the green treatment. The urban treatment was perceived as least restorative. The effect size for this result is $\eta^2 = 0.39$, which is considered a large effect size (Cohen, 1988).

5.1.5.5 Follow-up 4 (FwUp4)

The final follow-up question asked participants to consider how stressed they felt before the experiment, and then rate their current stress levels. This question was designed as an additional measure to compare how perceived stress levels had changed over the course of the experiment. As with all the previous follow-up questions, the descriptive statistics for each experimental group will be presented first, followed by the one-way ANOVA, to test for statistically significant differences between groups.

Table 31 Descriptive statistics for FWUp4 per experimental group

Descriptives							
				95% Confidence Interval for Mean			
	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
Blue	1.68	.475	.085	1.50	1.85	1	2
Green	1.80	.551	.101	1.59	2.01	1	3
Urban	2.21	.675	.125	1.95	2.46	1	3
Control	2.32	.612	.116	2.08	2.56	1	3
Total	1.99	.634	.058	1.88	2.11	1	3

In order to determine whether the means presented in Table 31 differed significantly, the results of a one-way ANOVA are presented in Table 32.

Table 32 One-way ANOVA of FWUp4 per experimental group

One-way ANOVA					
	SS	df	Mean Square	F	Sig.
Between Groups	8.552	3	2.851	8.454	.000
Within Groups	38.440	114	.337		
Total	46.992	117			

Since Table 32 indicated that there were statistically significant differences between groups ($p < .05$), Bonferroni's post-hoc analysis was conducted (Table 33) to determine where these differences occurred (Field, 2018).

Table 33 Post-hoc multiple comparisons of FWUp4 between experimental groups

Multiple Comparisons

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Blue	Green	-.123	.149	1.000	-.52	.28
	Urban	-.529*	.150	.004	-.93	-.13
	Control	-.644*	.151	.000	-1.05	-.24
Green	Blue	.123	.149	1.000	-.28	.52
	Urban	-.407*	.151	.049	-.81	.00
	Control	-.521*	.153	.005	-.93	-.11
Urban	Blue	.529*	.150	.004	.13	.93
	Green	.407*	.151	.049	.00	.81
	Control	-.115	.154	1.000	-.53	.30
Control	Blue	.644*	.151	.000	.24	1.05
	Green	.521*	.153	.005	.11	.93
	Urban	.115	.154	1.000	-.30	.53

*. The mean difference is significant at the 0.05 level.

The post-hoc analysis presented in Table 33 demonstrates that there are statistically significant differences between the blue and urban groups, between the blue and control groups, between the green and urban groups, and between the green and control groups. The means of the blue group (M = 1.68) and green group (M = 1.80) were statistically lower than the means of the urban group (M = 2.21) and control group (M = 2.32). This suggests that the group receiving the blue treatment reported feeling the least stressed after the experiment, followed by the green treatment. The group viewing the urban scene had the third highest post-experiment levels and the control group was most stressed, having received no treatment. The effect size for this result is $\eta^2 = 0.18$, which is considered a large effect size (Cohen, 1988).

Following the presentation of all the psychological results, the results of the physiological responses measured will be discussed in section 5.2, and subsequent subsections thereof.

5.2 Physiological

In order to assess the physiological responses to various scenes, three instruments were used. As discussed in Chapter 4, section 4.5.2, these included an electronic sphygmomanometer to assess blood pressure, the Viport™ to assess heart rate and CSI, and the Biopac to assess EDA.

The physiological results will be presented according to the physiological marker, as opposed to the instrument, to ensure logical flow. The data were assessed for normality and since all data were normally distributed, parametric statistics were conducted.

5.2.1 Blood pressure

As discussed in 4.5.2.3 blood pressure is comprised of diastolic and systolic pressure. Similarly to the PSS and FwUp1, two-way mixed ANOVAs were conducted to determine whether there were any significant differences between groups and time points on diastolic and systolic pressure, respectively. The assumptions for this test have been addressed in 4.10, and so only the homogeneity of variances is provided in each instance.

5.2.1.1 Two-way mixed ANOVA: Diastolic blood pressure

The descriptive statistics for diastolic pressure per experimental group at both time points are presented in Table 34. Higher average scores indicate higher diastolic blood pressure.

Table 34 Descriptive statistics of diastolic blood pressure at both time intervals of experimental groups

Descriptive statistics			
	Group	Mean	Std. Deviation
Dia (Pre)	Blue	76.94	9.125
	Green	70.07	12.624
	Urban	74.79	11.666
	Control	74.63	10.652

	Total	74.11	11.234
Dia (Post)	Blue	76.00	9.893
	Green	75.83	17.475
	Urban	74.00	10.447
	Control	74.11	10.274
	Total	75.03	12.351

The results of the assumption of homogeneity of variance test are presented in Table 35.

Table 35 Levene's test for homogeneity of variances: diastolic blood pressure

Levene's Test of Equality of Error Variances[a]

		Levene Statistic	df1	df2	Sig.
Dia (pre)	Based on Mean	.806	3	113	.493
Dia (post)	Based on Mean	1.804	3	113	.150

a. Design: Intercept + Group
Within Subjects Design: Diastolic BP

Both significance values of the results in Table 35 are greater than .05, therefore the assumption of homogeneity of variance has not been violated. Following this confirmation of a lack of violation of assumptions, the potential interaction effect is next addressed, in Table 36.

Table 36 Test of within-subjects effects of diastolic blood pressure

Tests of Within-Subjects Effects

Source		Type III SS	df	Mean Square	F	Sig.	Partial Eta Squared
Diastolic BP	Sphericity Assumed	45.172	1	45.172	.588	.445	.005
Diastolic BP * Group	Sphericity Assumed	476.204	3	158.735	2.067	.109	.052
Error (Diastolic BP)	Sphericity Assumed	8676.368	113	76.782			

The significance value of the interaction effect was greater than .05 (p = .109) which implies that the individual contributions of the main effects can be assessed. The effect size of this interact is $\eta^2 = .052$, which is a moderate effect size (Cohen, 1988). It is shown in Table 34 that the within-subjects effect was not statistically significant (p = .445) which implies that the passage of time did not significantly affect diastolic blood pressure overall. The pairwise comparisons presented in Table 37 demonstrate that while the blue, urban, and control groups' respective means decreased, albeit insignificantly, the green groups mean increased by a statistically significant amount (p = .012).

Table 37 Pairwise comparisons of diastolic blood pressure across time intervals

Pairwise Comparisons

Group	(I) Dia BP	(J) Dia BP	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
						Lower Bound	Upper Bound
Blue	1	2	.935	2.226	.675	-3.474	5.345
Green	1	2	-5.767*	2.262	.012	-10.249	-1.284
Urban	1	2	.793	2.301	.731	-3.766	5.352
Control	1	2	.519	2.385	.828	-4.206	5.243

*. The mean difference is significant at the .05 level.
b. Adjustment for multiple comparisons: Bonferroni.

The between-subjects effects are presented in Table 38. Similarly to the within-subjects effects, the between-subjects effect was not significant (p = .594), and the effect size small (η^2 = .017). Consequently, there were no differences between the groups on their measures of diastolic blood pressure.

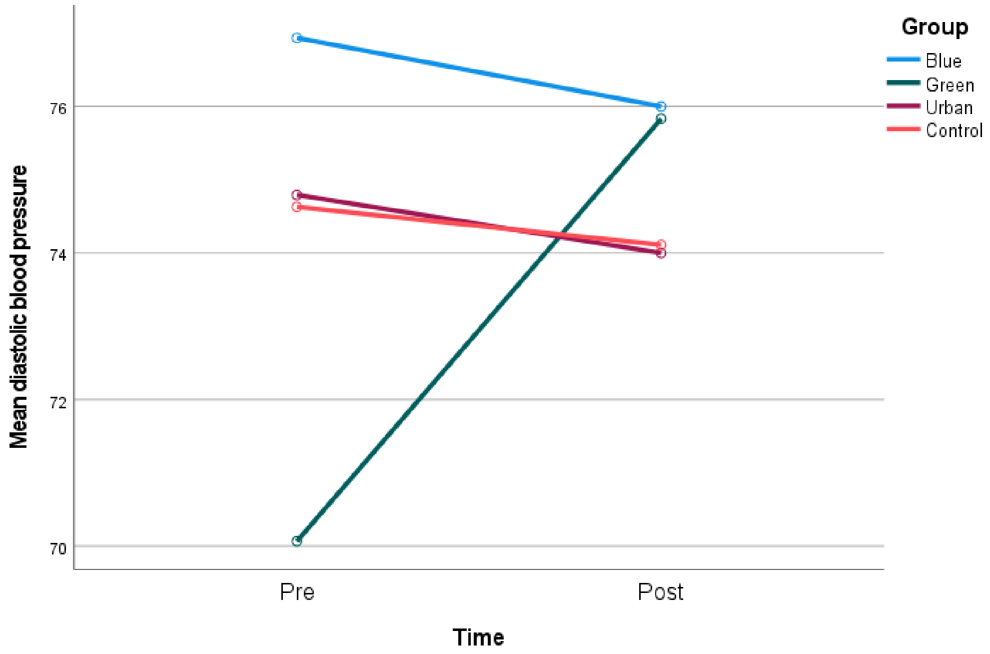
Table 38 Test of between-subjects effects of diastolic blood pressure

Tests of Between-Subjects Effects

Source	Type III SS	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	1296963.313	1	1296963.313	6428.706	.000	.983
Group	384.649	3	128.216	.636	.594	.017
Error	22797.257	113	201.746			

The profile plots (Figure 31) of the above demonstrate the change in diastolic blood pressure over time. These plots support the pairwise comparisons and demonstrate that while the blue, urban, and control groups' means decreased slightly, the green groups' mean increased drastically.

Figure 31 Estimated marginal means of diastolic blood pressure per experimental group



5.2.1.2 Two-way mixed ANOVA: Systolic blood pressure

The descriptive statistics of systolic blood pressure of the experimental groups at pre- and post-test are provided in Table 39. Higher average scores indicate higher systolic blood pressure.

Table 39 Descriptive statistics of systolic blood pressure at both time intervals of experimental groups

Descriptive statistics			
	Group	Mean	Std. Deviation
Sys (pre)	Blue	124.68	10.575
	Green	119.47	19.736
	Urban	120.41	17.289
	Control	122.37	21.605
	Total	121.75	17.528
Sys (post)	Blue	122.03	12.200
	Green	115.93	17.247
	Urban	118.72	15.757
	Control	116.33	15.064
	Total	118.33	15.158

To address the assumption of homogeneity of variances, the results of Levene's test are presented in Table 40.

Table 40 Levene's test for homogeneity of variances: systolic blood pressure

Levene's Test of Equality of Error Variances[a]

		Levene Statistic	df1	df2	Sig.
Sys (pre)	Based on Mean	3.081	3	113	.030
Sys (post)	Based on Mean	.710	3	113	.548

[a]. Design: Intercept + Group
Within Subjects Design: Systolic BP

The results of Levene's test indicate that while the assumption of homogeneity has been met for systolic blood pressure at post-test (p = .548), this is not the case for the pre-test data (p = .03). While this assumption has been violated, according to Pallant (2016) ANOVAs tend to be fairly robust to violations of this assumption, given the groups have reasonably similar sizes. In the present study the groups vary by only one participant each and so the violation of this assumption will not be treated as critical.

Consequently, the interaction and within-subjects effects are addressed next, in Table 41.

Table 41 Test of within-subjects effects of systolic blood pressure

Tests of Within-Subjects Effects

Source		Type III SS	df	Mean Square	F	Sig.	Partial Eta Squared
Systolic BP	Sphericity Assumed	705.100	1	705.100	6.952	.010	.058
Systolic BP * Group	Sphericity Assumed	145.373	3	48.458	.478	.698	.013
Error (Systolic BP)	Sphericity Assumed	11460.867	113	101.424			

Inspection of the results of the within-subjects test reveal that there is no statistically significant interaction between time and groups (p = .698). Further inspection of the main effects of within-subjects demonstrates that a significant effect is present (p = .01). This result implies that there are differences in systolic blood pressure across time. The effect size for this result is $\eta^2 = .058$, which according to Cohen (1988) is a moderate effect size.

The pairwise comparisons presented in Table 42 provides insight into the statistically significant main effects of within-subjects as provided in Table 41. The control group demonstrated a statistically significant decrease in means from pre- to post-testing (p = .030).

Table 42 Pairwise comparisons of systolic blood pressure across time intervals

Pairwise Comparisons

Group	(I) Sys BP	(J) Sys BP	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
Blue	1	2	2.645	2.558	.303	-2.423	7.713
Green	1	2	3.533	2.600	.177	-1.618	8.685
Urban	1	2	1.690	2.645	.524	-3.550	6.929
Control	1	2	6.037*	2.741	.030	.607	11.467

*. The mean difference is significant at the .05 level.
b. Adjustment for multiple comparisons: Bonferroni.

The main effects of the groups are presented next in Table 43. Inspection of the results of Table 43 indicates that there were no statistically significant between-subjects effects (p = .499), implying that there are no significant differences between experimental groups on this variable. There was further a small effect size for this test (η^2 = .021).

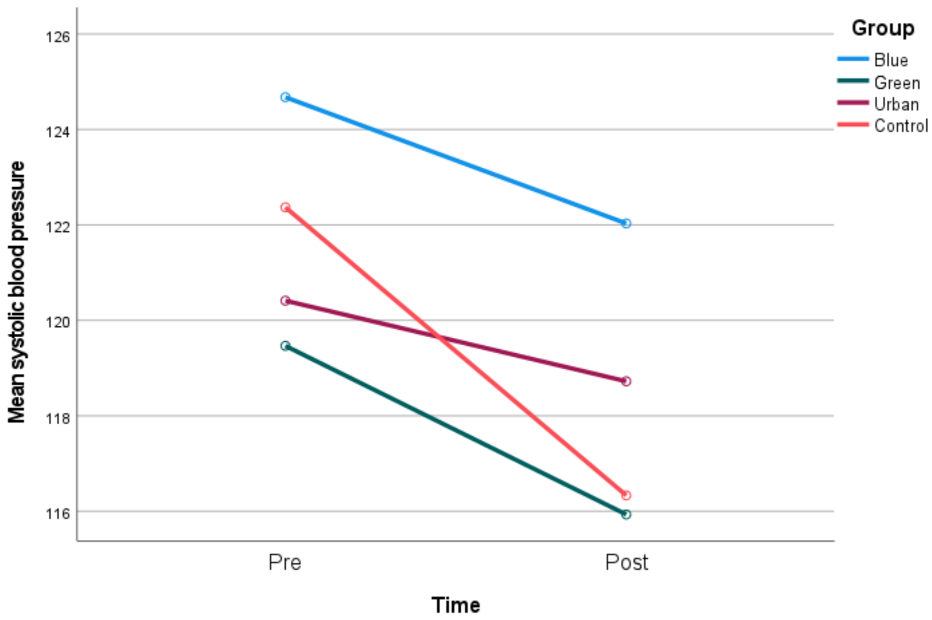
Table 43 Test of between-subjects effects of systolic blood pressure

Tests of Between-Subjects Effects

Source	Type III SS	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	3360435.053	1	3360435.053	7650.072	.000	.985
Group	1048.240	3	349.413	.795	.499	.021
Error	49637.333	113	439.268			

Finally, the profile plots in Figure 32 provide further insight into the obtained results. While all groups' means decreased from pre- to post-testing, the control group decreased the most dramatically, while the urban group appears to have experienced the smallest decrease in means.

Figure 32 Estimated marginal means of systolic blood pressure per experimental group



5.2.2 Heart rate

The second biomarker that was assessed, was the heart rate of participants. Similarly to blood pressure, the results of the two-way mixed ANOVA are presented, starting with the descriptive statistics displayed in Table 44. Higher scores indicate a higher heart rate, indicative of an acute stress response.

5.2.2.1 Two-way mixed ANOVA: Heart rate

The results of the descriptive statistics for heart rate are displayed in Table 44.

Table 44 Descriptive statistics of heart rate at both time intervals of experimental groups

Descriptive statistics			
	Group	Mean	Std. Deviation
HR (pre)	Blue	78.10	19.574
	Green	81.67	13.966
	Urban	80.28	16.996
	Control	75.21	14.487
	Total	78.86	16.432
HR (post)	Blue	78.10	20.006
	Green	78.63	13.379
	Urban	76.93	14.400
	Control	75.04	12.940

	Total	77.22	15.399

The homogeneity of variances are assessed by inspecting the significance values of the heart rate scores at pre- and post-test in Table 45 below.

Table 45 Levene's test for homogeneity of variances: heart rate

Levene's Test of Equality of Error Variances[a]					
		Levene Statistic	df1	df2	Sig.
HR (pre)	Based on Mean	.101	3	114	.959
HR (post)	Based on Mean	.308	3	114	.820

[a]. Design: Intercept + Group
Within Subjects Design: HR

From the results in Table 45 above it is evident that the assumption of homogeneity of variances has not been violated; the smallest p-value is .820 which is meaningfully greater than .05. Consequently, the results of the within-subjects effects can be interpreted with confidence. These results are presented in Table 46.

Table 46 Test of within-subjects effects of heart rate

Tests of Within-Subjects Effects							
Source		Type III SS	df	Mean Square	F	Sig.	Partial Eta Squared
HR	Sphericity Assumed	158.300	1	158.300	15.283	.000	.118
HR * Group	Sphericity Assumed	142.852	3	47.617	4.597	.004	.108
Error (HR)	Sphericity Assumed	1180.813	114	10.358			

The significance value of the interaction between groups and time is .004 (η^2 = .108), which indicates a statistically significant interaction. This finding implies that the individual main effects should be interpreted with caution. This is as a result of the main effects being confounded by their relationship to one another (Pallant, 2016). Although caution should be applied to the interpretation hereof, the individual main effect of heart rate was statistically significant (p = .000). Table 47 demonstrates the differences in means for each group; there were statistically significant reductions in means for both the green and urban group (p = .000).

Table 47 Pairwise comparisons of heart rate across time intervals

Pairwise Comparisons

Group	(I) HR	(J) HR	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
Blue	1	2	.000	.817	1.000	-1.619	1.619
Green	1	2	3.033*	.831	.000	1.387	4.680
Urban	1	2	3.345*	.845	.000	1.671	5.019
Control	1	2	.179	.860	.836	-1.525	1.883

*. The mean difference is significant at the .05 level.
b. Adjustment for multiple comparisons: Bonferroni.

It should be noted that as presented in Table 44, the means for the blue group at both pre- and post-test were exactly 78.10. Given the low likelihood of this outcome, an additional t-test was conducted to double check this result. The results of the t-test confirmed this outcome.

The main effects of the groups are presented in Table 48, and it can be seen that there were no significant between-subjects effects ($p = .679$) and a small effect size ($\eta^2 = .013$). This indicates that there were no significant differences between the experimental groups on their heart rate scores.

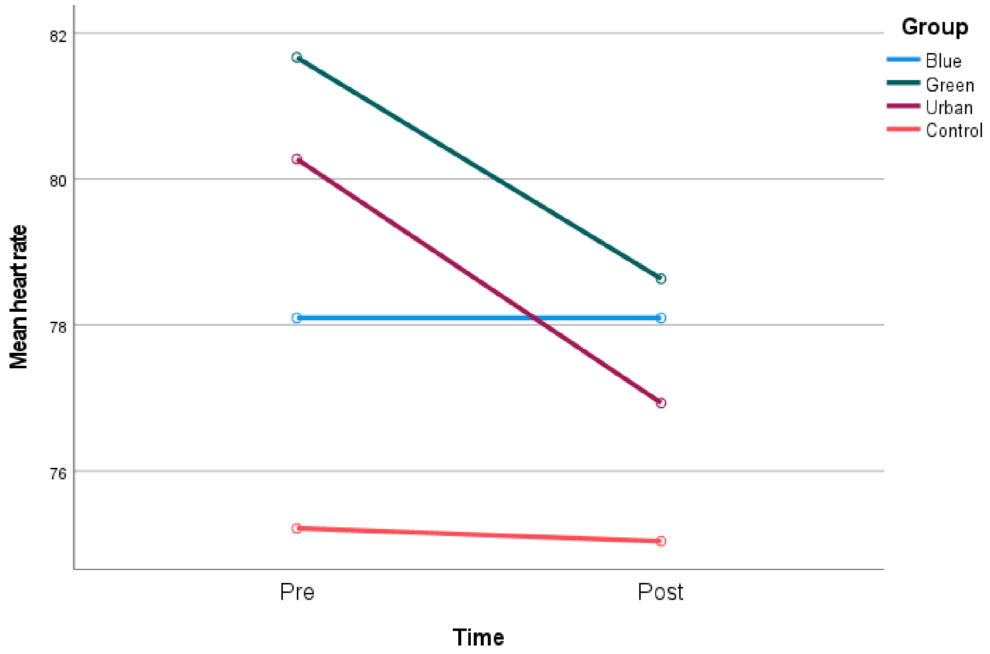
Table 48 Test of between-subjects effects of heart rate

Tests of Between-Subjects Effects

Source	Type III SS	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	1433532.013	1	1433532.013	2854.565	.000	.962
Group	761.583	3	253.861	.506	.679	.013
Error	57249.574	114	502.189			

The profile plots presented in Figure 33 illustrates the above results. While the green and urban groups' means decreased noticeably, the control group's mean decreased only slightly, while the blue groups' mean remained exactly the same.

Figure 33 Estimated marginal means of heart rate per experimental group



5.2.3 Cardio Stress Index

As mentioned in 4.5.2.2 and 4.9, the CSI of participants was measured using the Viport™ pre-treatment and post-treatment. Since the CSI is calculated as a percentage, the descriptive statistics presented in Table 49 are expressed as percentages. The results of the two-way mixed ANOVA are presented below. Higher scores indicate a higher stress loading on the heart.

5.2.3.1 Two-way mixed ANOVA: CSI

The descriptive statistics of CSI at pre- and post-test are displayed in Table 49.

Table 49 Descriptive statistics of CSI at both time intervals of experimental groups

Descriptive statistics			
	Group	Mean	Std. Deviation
CSI (pre)	Blue	36.5161%	29.55432%
	Green	37.6333%	21.56383%
	Urban	37.5172%	23.72103%
	Control	30.6786%	19.41754%

	Total	35.6610%	23.85111%
CSI (post)	Blue	31.0968%	26.24418%
	Green	28.5333%	21.65996%
	Urban	30.1034%	24.75645%
	Control	24.1786%	18.07198%
	Total	28.5593%	22.84341%

The results of Levene's test for homogeneity of variances is displayed in Table 50. It can be seen that this assumption was not violated, as both p-values are greater than .05.

Table 50 Levene's test for homogeneity of variances: CSI

Levene's Test of Equality of Error Variances[a]

		Levene Statistic	df1	df2	Sig.
CSI (pre)	Based on Mean	1.890	3	114	.135
CSI (post)	Based on Mean	1.694	3	114	.172

[a]. Design: Intercept + Group
Within Subjects Design: CSI

The results of the within-subjects effects are considered next, to first ascertain whether there is an interaction effect between the groups and time.

Table 51 Test of within-subjects effects of the PSS

Tests of Within-Subjects Effects

Source		Type III SS	df	Mean Square	F	Sig.	Partial Eta Squared
CSI	Sphericity Assumed	2976.851	1	2976.851	10.009	.002	.081
CSI * Group	Sphericity Assumed	110.248	3	36.749	.124	.946	.003
Error (CSI)	Sphericity Assumed	33907.141	114	297.431			

Since the p-value of the interaction term is .946 (η^2 = .003), it can be determined that there is no interaction effect. Therefore, main effects of the within-subjects are interpreted with confidence; there is a statistically significant effect (p = .002). There is therefore a significant difference across time points for CSI. The pairwise comparisons in Table 52 illustrate that there was a statistically significant reduction in the means of the green group (p = .043).

Table 52 Pairwise comparisons of CSI across time intervals

Pairwise Comparisons

Group	(I) CSI	(J) CSI	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
Blue	1	2	5.419	4.381	.219	-3.258	14.097
Green	1	2	9.100*	4.453	.043	.279	17.921
Urban	1	2	7.414	4.529	.104	-1.558	16.386
Control	1	2	6.500	4.609	.161	-2.631	15.631

*. The mean difference is significant at the .05 level.
[b]. Adjustment for multiple comparisons: Bonferroni.

Following this, the between-subjects effects are investigated to determine whether there are significant differences between groups on their CSI measures. These results are presented in Table 53.

Table 53 Test of between-subjects effects of CSI

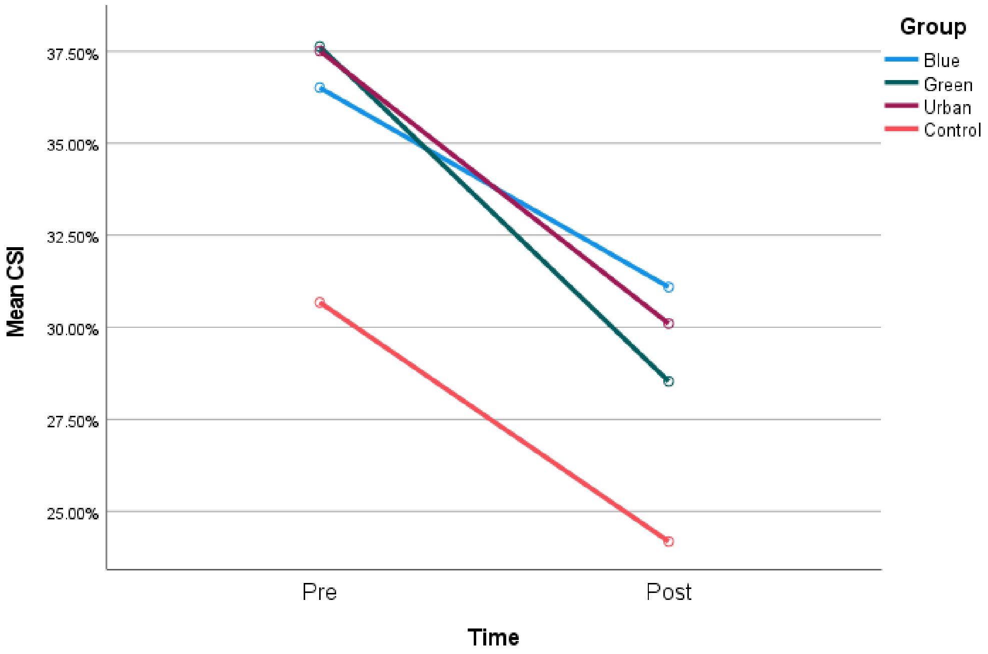
Tests of Between-Subjects Effects

Source	Type III SS	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	241802.083	1	241802.083	299.742	.000	.724
Group	1630.247	3	543.416	.674	.570	.017
Error	91963.889	114	806.701			

Inspection of the results of Table 53 reveal that there is no statistically significant between-subjects effect ($p = .570$) and there is a small effect size ($\eta^2 = .017$).

Finally, the profile plots (Figure 34) can be inspected to gain insight into the results above. The significant effect of time can be seen in the way the means of all groups drop fairly drastically, with the most drastic reduction in the green group. Of interest is that the control group’s CSI was noticeably lower than all other groups at pre-test.

Figure 34 Estimated marginal means of CSI per experimental group



5.2.4 Electrodermal Activity

Participants' EDA was measured, using BIOPAC's BioNomadix® equipment. As mentioned in 4.9, the equipment measured EDA continuously, but markers were inserted on the data on the tracking software at three points: the start of the jump scare clip, at the moment of the jump scare, and at the end of the treatment video. To determine the extent of restoration, the difference in EDA scores was measured from the moment of the jump scare to the end of the treatment video. The BioNomadix® analysis software, Acq*Knowledge*, does not have functionality for outputting the values of those two points, but it does provide a delta score – the difference in EDA between the two indicated points. These delta scores were extracted for each participant and were used for analysis.

The descriptive statistics of these EDA delta scores are presented first, following which the results of the single group t-tests and ANOVA are displayed.

5.2.4.1 Descriptive statistics of EDA delta scores per group

The results of the descriptive statistical analysis of the delta scores for each group are presented in Table 54 below. In this case, a higher delta score indicates a greater change from pre- to post- experiment.

Table 54 Descriptive statistics of EDA delta scores per group

Descriptives

	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
				Lower Bound	Upper Bound		
Blue	-.9603	2.31541	.41586	-1.8096	-.1110	-5.14	6.64
Green	-1.7313	5.75322	1.05039	-3.8796	.4170	-21.09	5.74
Urban	.1786	3.83984	.71304	-1.2820	1.6392	-8.28	9.47
Total	-.2117	2.75166	.52002	-1.2787	.8553	-9.06	4.99

5.2.4.2 Single-sample t-test of EDA per group

Following the analysis of the descriptive statistics, a single-sample t-test was conducted per group, to determine whether the EDA delta scores were statistically significant. A single-sample t-test was used (as opposed to a paired-sample t-test) regarding the different scores already obtained, since two points were not compared.

Table 55 Single-sample t-test of EDA per group

Single-sample t-test

	t	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Blue	-2.309	30	.028*	-.96026	-1.8096	-.1110
Green	-1.648	29	.110	-1.73	-3.88	.42
Urban	.250	28	.804	.18	-1.28	1.64
Control	-.407	27	.687	-.21	-1.28	.86

*. The mean difference is significant at the .05 level.

It can be seen from Table 55 that there was a statistically significant difference in EDA scores within the blue group ($p < .05$). The negative t-score obtained indicates that the delta score reflected a decrease in EDA activity, from the moment of the jump scare to the end of the treatment.

5.2.4.3 One-way ANOVA of EDA deltas per group

Following the within-group comparison, a one-way ANOVA was conducted, to determine whether there any significant differences between the four groups on their EDA delta scores.

Table 56 One-way ANOVA of EDA deltas per group

One-way ANOVA					
	SS	df	Mean Square	F	Sig.
Between Groups	63.06	3	21.02	1.379	.253
Within Groups	1738.00	114	15.25		
Total	1801.06	117			

Evident in Table 56, there were no statistically significant differences between groups on their EDA deltas ($p > .05$). Consequently, no post-hoc comparisons were conducted.

5.2.5 Correlation matrix of all variables

The final analysis undertaken was to produce a correlation matrix of all variables measured in the present study. Table 57 presents the Pearson correlation matrix of these variables.

Table 57 Pearson correlation matrix of all variables

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	PSS(Pre)	—																			
2	PSS(Post)	.644**	—																		
3	FwUp1(Pre)	.329**	.385**	—																	
4	FwUp1 (Post)	.096	.105	.558**	—																
5	Emotional (RS)	.118	.004	.069	-.186	—															
6	Physiological (RS)	.165	.033	.065	-.295**	.573**	—														
7	Cognitive (RS)	.178	.094	-.026	-.146	.727**	.407**	—													
8	Behavioural (RS)	.028	-.028	.040	-.122	.757**	.544**	.736**	—												
9	FwUp2	.142	.132	.048	.141	.022	-.128	.119	.036	—											
10	FwUp3	.176	.075	-.020	-.249**	.691**	.395**	.648**	.682**	.227*	—										
11	FwUp4	-.248*	-.200	-.336**	.211*	-.286**	-.231*	-.258*	-.168	.061	-.345**	—									
12	Diastolic BP (pre)	.043	.067	-.016	.022	-.025	-.084	-.109	-.111	-.085	-.103	-.028	—								
13	Diastolic BP (post)	-.118	.004	-.033	.147	-.049	-.104	-.021	-.060	-.111	-.022	.178	.436**	—							
14	Systolic BP (pre)	.049	.116	.124	.028	.044	.041	.056	.084	-.166	.078	.005	.505**	.436**	—						
15	Systolic BP (post)	-.012	-.024	-.027	-.005	-.057	-.049	-.045	-.006	-.192*	.008	.189	.378**	.679**	.634**	—					
16	Heart rate (pre)	-.040	-.055	.009	.084	-.037	-.041	-.076	-.133	.132	-.045	-.021	.244**	.285**	.198*	.067	—				
17	Heart rate (post)	-.060	-.040	.027	.090	-.015	-.008	-.064	-.077	.127	-.038	-.011	.258**	.285**	.200*	.077	.957**	—			
18	CSI (pre)	-.071	-.175	-.076	.003	-.003	-.132	.016	-.039	.160	.111	.044	.072	.046	.062	.069	.429**	.413**	—		
19	CSI (post)	-.116	-.115	-.098	.063	-.104	-.171	-.018	-.017	.107	.074	.112	.175	.316**	.151	.170	.514**	.548**	.467**	—	
20	EDA delta	.061	-.021	.102	.171	-.180	-.199	-.096	-.135	.073	-.071	.138	.001	-.014	-.026	.040	-.117	-.094	.019	-.022	—

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 57 demonstrates that there were numerous statistically significant correlations between the variables measured in the present study. The relevant correlations will be addressed in Chapter 6.

5.3 Conclusion

This chapter contains the results of both the psychological and physiological testing that was done to assess stress levels, the change in stress levels throughout the course of the experiment, and the perceptions of the restorative potential of three treatments. These results include descriptive statistics and various forms of inferential statistics testing the PSS, NRS, RS, psychological follow-up questions, diastolic and systolic blood pressure, heart rate, CSI, and EDA responses.

Taking both the psychological and physiological results into account, the results in this chapter indicate that blue spaces are the most effective treatment for acute stress. Blue and green spaces were deemed most restorative, and the greatest reduction in EDA was within the blue group. The next chapter will focus on a more detailed discussion of these findings.

CHAPTER 6: DISCUSSION OF FINDINGS, LIMITATIONS OF STUDY, RECOMMENDATIONS FOR FUTURE RESEARCH AND CONCLUSION

6.1 Introduction

Chapter 5 presented the psychophysiological results of the conducted data analysis. To this point, this thesis has demonstrated urban areas are not only deleterious to health, but they also do not appear to hold restorative benefits. Furthermore, the scant available literature on the stress relieving effects of blue and green spaces has shown that green and blue spaces support stress relief, although this stress relief has been conceptualised in numerous ways. This chapter will discuss and integrate these results into existing literature and theory, to generate a comprehensive explanation of the obtained results. The limitations of the study are then perused, followed by recommendations for future research and the study's conclusion.

6.2 The impact of urban areas on acute stress

This section will consider the results of the group exposed to the urban video. The physiological results will be discussed first, followed by the psychological results. These results will provide a holistic view of the impact of urban areas on acute stress levels.

6.2.1 Psychological results

Psychologically, urban spaces as measured in the present study, tended to show a negative impact on acute stress levels, to the extent that they produced the poorest restorative outcomes.

The first psychological measure assessed was the NRS. As discussed in Chapter 4, section 4.5.1.3, the NRS is based on the biophilic assumption (Wilson, 1984) that throughout evolutionary history, the innate human need, or love for, connection with the natural environment have developed. It was included to determine whether any of the treatment groups displayed a statistically significant greater or lesser affiliation to nature. The reason for assessing this is that if one group showed demonstrably higher affinities to nature, their perceived restoration of the treatment area may have been confounded by this higher disposition to nature, and not the scene itself. A one-way ANOVA was therefore conducted, and the results demonstrated that there were no statistically significant differences between any of the groups on their levels of nature relatedness. In essence, this finding confirms that none of the groups held a statistically greater, or lower biophilic affiliation to nature, and the remainder of the results can be interpreted without this being a potentially confounding factor. Since these lack of differences between groups apply to all groups, the results of the NRS are not repeated in following sections.

The next psychological measure was the PSS, which provides an indication of the extent to which individuals perceive their lives as unpredictable, uncontrollable, and overloading (Cohen, et al., 1983). The results of the within-subjects effects of the two-way mixed ANOVA of the PSS indicated that while there were time difference effects, there were no between-groups effects. This implies that none of the groups differed significantly on their pre to post scores of the PSS. The results showed that there was a statistically significant (albeit slight) increase in means of the urban group from pre- to post-testing. This implies that not only do urban spaces not decrease stress; they increase stress. This result supports literature as far back as 1981 when Ulrich posited that urban areas may aggravate rather than restore stress. This increase in stress can be further be contextualised within SRT. Considering that urban areas, in general, do not have the six properties of natural scenes that will result in the view assessed as being conducive to survival, it can be theorised that stress levels would increase in the case of escaping a stressor. That is, not only do urban areas not promote stress relief; they can be further viewed as increasing stress if restoration is required but not found.

Within the MANOVA results, urban areas consistently produced the lowest mean restoration scores across all subscales. The physiological subscale included self-report dimensions that overlap with measures used in acute stress reduction studies: respiration, muscle tension, sweating, and heart rate (Karemaker, 2017). The results of Bonferroni's post-hoc test showed statistically significant differences between the three treatment groups, and the urban group reported significantly poorer perceived physiological responses when compared to the green and blue groups. The results of the physiological subscale suggest that exposure to urban spaces is not perceived as providing physiological stress relief and restoration. These results align with the psychoevolutionary approach, that suggests that urban areas do not promote physiological stress relief, given that they are not the environments our ancestors evolved in (Berto, 2014).

The behavioural subscale relates to the approach and avoidance behaviours, as highlighted by SRT (see 3.4.1), that occur after initial appraisal of an environment. The items on the scale provide an indication of the extent to which the individual demonstrates approach behaviours. The results of Bonferroni's post-hoc test analyses indicated that the urban group displayed the statistically lowest amount of approach behaviours. The urban group's scores were statistically significantly different from the green and blue groups and this difference was in the form of a lower group mean. This finding aligns with the premises of SRT, in the sense that environments that do not display restorative potential are likely to be avoided. Given that humans did not evolve in urban environments, such environments likely do not display opportunities for stress reduction and are consequently avoided.

The emotional subscale and cognitive subscales of the RS produced similar results. Similarly to the overall scores, the urban group differed statistically from both the green and blue groups, presenting the lowest mean on both the emotional and cognitive subscales. Although emotional and cognitive responses were not the focus of the present study, these subscales were not excluded, as they provide supplemental information to the restorative potential of each of the treatment areas.

The findings of the urban area within the RS is unsurprising, given that urban spaces have either been used as a stressor in past literature, or have been found to be the least restorative when compared to other, natural environments (Marselle et al., 2021). It also aligns with the psychoevolutionary approach discussed in Chapter 3. This approach posits that, when faced with an acute stressor, urban areas will not provide restoration from acute stress, as humans have not developed an affinity to urban areas. This is due to the relatively slow pace of evolution, and the short amount of time humans have been living in cities, given the length of our evolutionary history (Berto et al., 2014).

A standard multiple regression was conducted to determine the extent to which each of the treatment scenes can predict overall restoration, and the model accounted for 25.90% of the variation in overall restoration scores. The urban group made the largest, and only statistically significant prediction to the model (beta = -.532, $p < .001$) (see Table 28). However, as mentioned in 5.1.4.2 this prediction can be explained by the strong, statistically significant negative correlation to both the blue ($r = -0.500$) and green ($r = -0.488$) groups respectively (see Table 17). This finding supports the notion that urban spaces are perceived as the least restorative. Furthermore, the strong negative correlations with the green and blue groups created a statistically significant regression model. As mentioned, the RS has not been frequently used in blue and green space acute stress relief research and so there is no previous research to contextualise the present findings. Nonetheless, when considering the six key properties of restorative scenes as proposed by SRT, it is evident that the busy urban scene used in the present study did not contain these properties and was consequently not considered restorative.

The follow-up questions (FwUp) were created as supplemental measures to assess acute stress levels, and in the case of the second follow-up question, to determine how frightening the stressor was appraised to be.

FwUp 1 asked participants to rate how stressed they felt before the experiment and then afterwards. These results were compared to determine whether there were any significant differences in self-reported stress levels after exposure to each of the treatment scenes, both within and between groups. The results of the two-way mixed ANOVA indicated a statistically significant interaction effect between time and groups. This implies that the changes in time are dependent of the level of interaction with time. While this means the results should be interpreted with caution, it was noteworthy that the urban group was the only group to display an increase in means across time. That there existed an interaction effect, that the control group was included in the main effects, and that the increase was not statistically significant mean that one cannot interpret this increase with confidence. It is simply noted as it was the only group whose mean moved in the opposite direction to the remaining two groups.

FwUp 4 similarly asked participants to rate how stressed they felt after the experiment, while considering how stressed they felt before the experiment. The FwUp 4 results demonstrated that participants in the urban group felt significantly more stress after the experiment, when compared to the green and blue groups. These results reiterate that urban spaces may contribute towards an increase in stress levels and support the PSS findings of an increase in reported stress.

FwUp 3 acted as a supplementary question to the RS, in that it asked participants to rate how restorative they perceived the treatment video to be. These results indicated that the group exposed to the urban scene rated the video as statistically significantly less restorative than the green or blue groups and consequently confirms that urban scenes do not promote restoration. These findings makes sense evolutionary speaking, given that we have not evolved to find urban environments restorative. The results provide further support to literature that highlights the negative, non-restorative properties of urban areas (Marselle et al., 2021).

FwUp 2 looked at how frightening participants found the stressor to be. Similarly to the NRS, this was included to assess whether any groups that found the stressor to be more or less frightening could confound results. That is, if a group perceived the stressor as significantly less frightening, the potential restorative impacts may be less, as they would have less stress to recover from. However, the results of the ANOVA showed no statistically significant differences between groups and therefore one can surmise that the perceived scariness of the stressor did not act as a confounding variable in perceived restoration. As with the NRS, since these results apply to all groups, this result will not be discussed again.

6.2.2 Physiological results

Across the physiological variables, urban areas did not impact acute stress levels in a statistically significant manner. There were no statistically significant changes in diastolic or systolic blood pressure from before the start of the experiment to the end. This result supports previous findings by Mokhtar et al (2018) and Yu et al. (2018), who found that spending time in urban spaces did not yield any blood pressure changes.

There were, however, statistically significant differences in heart rate measures within the urban group. Interestingly, this difference was in the form of a decrease from pre- to post measures. Heart rate is an indicator of SNS activity and, given that urban areas have been showed to promote stress (and consequently SNS activity), not reduce it, this finding is unexpected (Brannon, et al., 2018). This finding is also in contradiction to the psychoevolutionary approach, that purports that humans have developed a biological preparedness to natural environments, but do not have such a preparedness for urban environments and consequently will not find urban areas restorative (Berto, 2014). Of the physiological measures, this was the only result that suggested an increase in restoration and differed from what was expected, from a theoretical and literature standpoint, and is consequently an anomaly.

The CSI results somewhat contradict the heart rate results. The CSI, as measured by the Viport, measures the HRV of an individual and converts this into a measurement of the stress loading of the heart (Henning, 2014). To the best of the author's knowledge, CSI has not been used in green or blue space relief research, but is particularly helpful in the present study, in that it produces an accurate, clear measurement of the stress on the heart. There were no significant differences in CSI within the urban group from baseline to post-test, suggesting that urban spaces do not significantly impact acute stress relief. These findings, although different from the heart rate results, align with the psychoevolutionary approach that urban areas do not promote restoration from acute stress (Berto, 2014).

In terms of EDA, while the single-sample t-test did not reveal any statistically significant differences from baseline to post treatment, it was the only group that showed a positive delta score. This was indicative of a small increase. The lack of statistical significance of these results means that this increase cannot be interpreted with confidence, but it is nonetheless interesting to note. In Wang et al's 2016 study, the researchers introduced a stressor, then exposed participants to seven different scenes, ranging from an urban roadway scene to various types of urban parks. EDA was being measured throughout the experiment and the urban road scene produced the least reduction in electrodermal activity. The present study supports Wang et al's (2016) results to an extent, in that it can be concluded that urban areas do not promote acute stress reduction.

Overall, the physiological results discussed above suggest that exposure to urban spaces does not have a statistically significant impact on acute stress, and they do not promote acute stress reduction.

To integrate the physiological and psychological results, it can be concluded that viewing an urban scene does not significantly impact acute stress levels and that urban areas are perceived as the least restorative environments. Apart from the unexpected mean heart rate reduction, the physiological results did not suggest any statistically significant changes, and the psychological results were indicative of a lack of restoration. Although the non-significant findings contradict literature that demonstrates poorer physiological responses to urban areas (Wang et al., 2016), the lack of restorative effects is expected and is supported by literature (Zhang et al., 2018). Research has shown that living in urban areas are linked to poorer mental health outcomes and are a risk factor for the development of mental disorders; these poor outcomes provide potential context as to why the urban scenes were not perceived as restorative (Abbott, 2012; Krefis et al., 2018; Lecic-Tosevski, 2019; Reece et al., 2021; Ventriglio et al., 2021).

The implication of these results is that if one experiences an acute stressor, viewing an urban scene will not promote psychophysiological stress reduction. Moreover, should the stressor proceed, the urban area will not provide a restorative buffer in this regard.

6.3 The impact of green areas on acute stress

The results of the impact of green spaces on acute stress are largely non-remarkable, in that they do not produce significant changes. Physiologically, there are minimal changes from pre- to post viewing conditions. However, the psychological results overarchingly demonstrate that green spaces provide greater acute stress restoration than urban spaces.

6.3.1 Psychological results

The psychological results of the green space group align with the physiological results, in that minimal changes in acute stress levels were recorded.

The within-subjects effects and pairwise comparisons of the PSS showed no significant differences from pre-experimental to post-experimental conditions; these results align with Holt et al. (2016) but differ from Zhao and Patuano (2021). Holt et al. (2019) found that active use of green spaces was related to a reduction in PSS scores, but that passive green space use was not. Although the present study did not require individuals to be physically present in green spaces, research supporting the notion that virtual viewing of nature produces similar results as being physically present in the environment (Annerstedt et al., 2013; Browning et al., 2021; Gao et al., 2019; Nukarinen et al., 2020; Tanja-Dijkstra et al., 2018). To this end, one could conceivably purport that the participants were passively present in green spaces and the current results therefore align with Holt et al (2016). The current findings are in contradiction to Zhao and Patuano's (2021) research, which demonstrated that frequent visits to green spaces and longer periods of time spent in green spaces were negatively associated with perceived stress levels. This contradiction between the present study and Zhao and Patuano's (2021) research can be explained by the fact that participants only had one, one-minute opportunity to view a green space. Longer exposure to the green space could potentially have resulted in the present findings being more closely aligned to previous research.

The restoration scale outcome showed similar results across the subscales – the green space differed significantly from the urban space, but not from the blue space. With regards to the relationship to urban spaces, the green space was perceived as being consistently more restorative than the urban space. Although there is not literature with which to integrate the restoration scale specifically, the notion that green spaces are more psychologically restorative than urban spaces is aligned with previous research (Chang et al., 2019; Ewert & Chang, 2018; Mokhtar et al., 2018; Ojala et al., 2019). These studies used various conceptualisations of the term "restoration" but overall found that participants experienced greater restorative outcomes in green spaces than in urban spaces. As discussed, the videos that were chosen were done so to align as closely as possible with the tenets of a stress relieving environment, as outlined by Ulrich (1983). Thus, the present finding lends support to the psychoevolutionary psychophysiological model presented.

In terms of the follow up questions, the pairwise comparison of FwUp 1 at pre- and post-testing did not yield significant changes, which implies that the video of the green space did not significantly impact acute stress levels, at least on this measure. Given that there was a significant interaction effect of time and groups in this particular test, the results of this pairwise comparison would in any case have to be interpreted cautiously. Conversely, on FwUp 4, the results showed that when compared to the urban group, participants believed they were less stressed after the experiment than before. These two findings together suggest that while participants did not feel that their levels of stress had changed significantly across the course of the experiment, the green video still produced a greater overall perceived reduction than that of the urban group. There were no significant differences with the blue group on FwUp 4, which implies that the presence of water did not significantly impact the extent to which participants believed their stress levels had changed across the study.

The results of FwUp 3 largely supported the findings of the RS, where the green space group found perceived the treatment video to be significantly more restorative than the urban space video. Similarly to FwUp 4, there were no significant differences with the blue group, indicating that both green and blue spaces are perceived as equally restorative.

When considering the psychological and physiological results in conjunction with each other, the green space video did not appear to produce significant impacts on acute stress reduction. Although exposure to green areas is demonstrated to be more restorative than urban areas, this finding does not hold when comparing green spaces to blue spaces. The greater perceived restoration of the green space, than urban spaces, aligns with and supports psychoevolutionary principles that the relatively slow rate of evolutionary processes has not caught up with the rapid rate of urbanisation and so we do not hold an affinity for urban areas. Moreover, this finding provides support for the biophilia hypothesis and demonstrates that there is nonetheless an affinity to green spaces.

6.3.2 Physiological results

The results of the blood pressure measurements were mixed. While there was a statistically significant increase in diastolic blood pressure, there were no statistically significant changes in systolic blood pressure. This result is surprising, given how diastolic and systolic pressures work in tandem to produce an overarching blood pressure result. That is, it would be expected that a change in one would correspond to a change in the other. Without the opportunity to physically investigate each of these blood pressures further, this result unfortunately remains unexplained.

Literature tends to report blood pressure as a holistic score, and so to an extent, these results align with recent studies that found a lack of significant changes in blood pressure, before and after being exposed to green spaces (Lanki et al., 2017; Ojala et al., 2019; Song et al., 2019; Yu et al., 2018). Although it was noted in Chapter 2, section 2.3.3.1.1 that participants in the research by Lanki et al. (2017), Ojala et al. (2019), and Song et al. (2019) were required to walk in green spaces, the physical activity which may potentially have confounded results. Yu et al.'s (2018) research did not require physical activity, but produced a similar lack of blood pressure changes. The outcome of the present study did however differ from Mokhtar et al.'s (2018) research, that found significant decreases in blood pressure when walking in a green space. As noted in 2.3.3.1.1,, shortcomings of Mokhtar et al.'s (2018) study involved having a small sample size with a highly homogenous sample (all males from the same university department). This means that their results should be interpreted with caution. Therefore, the present study's findings appear to be well-aligned with previous research.

In comparison to the blood pressure results, there was a statistically significant reduction in heart rate, indicative of a decrease in acute stress levels, which aligns with the proposed psychoevolutionary model. According to the proposed model, exposure to green spaces that present the six properties of an environment conducive to survival (see 3.4.2), will have a positive physiological stress reducing effect. Since the green space video was chosen to align as closely as possible to these six properties, the results support the psychoevolutionary proposition of an acute stress relieving effect of green spaces. Furthermore, these results are in accordance with recent studies indicating a decreased heart rate after exposure to green spaces (Lanki et al., 2017; Song et al., 2019; Zhang et al., 2018). However, the presence of the interaction effect of within- and between-subjects means this result cannot be interpreted without caution.

Similarly to the heart rate results, there was a statistically significant reduction in CSI scores from pre- to post-testing. Although CSI differences have not previously been discussed in relevant literature, research using HRV as a measure of physiological stress reduction has shown that exposure to green spaces produced lower HRV, indicative of lowered SNS activity (Lanki et al., 2017; Song et al., 2019; Tsunetsugu et al., 2013). The present findings therefore lend further support to literature and psychoevolutionary considerations of acute stress reduction in green spaces.

In contrast to the CSI findings, there were no statistically significant differences in EDA within the green group, although there was a slight mean decrease. This result suggests that green spaces do not statistically significantly impact acute stress responses, insofar as EDA is concerned. This finding is contrary to previous studies, which have suggested that viewing green spaces produces a significant decrease in EDA (Wang et al., 2016; Zhang et al., 2018). However, Wang et al.'s (2016) research confounded blue and green spaces in one of the stills, by including a lake as part of the green spaces. As will be demonstrated in 6.4.1, blue spaces promote effective acute stress restoration and so this confounding of natural areas could have impacted the EDA results. Nonetheless, this result was unexpected and implies that green spaces do not have a statistically significant effect on EDA measures of acute stress.

The physiological measures of the group exposed to the green space video have evidenced mixed results of the impact on acute stress levels, where diastolic blood pressure increased, systolic blood pressure did not change, heart rate and CSI decreased, while EDA also remained unchanged. These mixed results lend a small amount of support to the proposed psychoevolutionary psychophysiological stress response model and indicate that in terms of heart rate, green spaces may serve as a buffer to acute stress.

When considering the mixed results from baseline to post-testing conditions, in terms of the physiological changes and the FwUp 1, an anecdote that was relayed to the researcher near the end of the study could potentially shed some light on the issue. Despite the video being chosen to align as closely as possible with SRT principles, one of the last participants made a passing remark that the sound of the person walking through the forest sounded more like the hooves of a horse than footsteps and so they were consequently distracted. This was not apparent to the researcher during initial selection of videos, during the pilot study or by any other participants, so it was an unexpected comment. While it is not possible to retrospectively assess whether other participants had similar views and therefore the extent to which this may have impacted the results, it is worthwhile noting.

6.4 The impact of blue areas on acute stress

The results of the impact of blue areas on acute stress levels overall produced the most novel findings. While the physiological markers did not generally demonstrate major changes, this is the first study to incorporate heart rate and EDA results in blue space literature and consequently provides new insights. Psychologically, blue spaces produce the greatest restoration and consequently hold the greatest potential to serve as a stress-relieving space.

6.4.1 Psychological results

The results of the PSS within the blue space group are aligned with the results of the green group – there were no statistically significant differences across measurement points. Given the dearth of literature on blue spaces and stress relief, it is unsurprising that there is no previous research with which to contextualise this result. As was proposed with the results of the urban group, it is possible that the reason for this lack of difference was simply due to the fact that one minute was not a long enough time period to significantly impact the extent to which participants perceived their lives as uncontrollable or overwhelming.

On the physiological subscale of the RS, the blue group differed significantly from the urban group, but not from the green group. Nonetheless, the blue group had the highest mean on this subscale, supporting the EDA results that blue spaces provide the most physiological relief from stress. The fact that this result aligns with the EDA result is promising; it implies that not only are blue spaces perceived as providing the most physiological stress relief, the EDA results support this.

The behavioural subscale similarly differed significantly from the urban group, but not the green group, but nevertheless had the highest mean. This highest mean relates to the approach and avoidance behaviours outlined by Ulrich (1983) and supports the notion that those who viewed the blue scene displayed the highest approach behaviours. Given the psychoevolutionary proposition that we have an innate love for natural areas, especially water (as per the SRT), this result is to be expected.

In terms of the emotional and cognitive subscales, the blue group similarly differed from the urban, but not green group. On the emotional subscale the blue group had the highest mean, implying that blue spaces provide positive emotional responses, while it did not have the highest mean for the cognitive subscale (the green group's mean was marginally higher). A potential explanation for this is related to the concept of affective primary (as outlined in 3.4.1) (Zajonc, 1980). A space that hold restorative potential will bypass cognitive processing and will result in an immediate positively toned emotional response. A previously mentioned, although emotion and cognition fall beyond the scope of the present study, this notion of affective primacy is a possibility worth exploring in future studies.

The results of the FwUp 1 question lend further support to the EDA results. The blue group was the only group to show a statistically significant difference from pre-testing to post-testing. This mean difference (M = .581) was furthermore more than double the next greatest mean difference (M = -.207) of the urban group. This statistically significant reduction indicates that on self-rated measures of perceived acute stress, exposure to blue spaces was highly effective. Unfortunately, the presence of an interaction effect of within- and between-groups introduces the need for caution when considering these results.

Nonetheless, FwUp 4 bore similar results to the green space group, in that there were statistically significant differences to the urban group. The phrasing of the FwUp 4 question meant that the lowest mean indicated the greatest perceived reduction in stress. To this end, the blue group had the lowest mean, which indicates that when asked to consider their stress levels at the moment when compared to before the experiment, they believed their stress levels had reduced the most.

6.4.2 Physiological results

Similarly to the urban group, and partially to the green group, there were no statistically significant differences on measures of either systolic or diastolic blood pressure, at pre-experiment and post-experimental stages. This result is consistent with data obtained from the three previous studies that used blood pressure as a marker for physiological stress relief. Triguero-Mas et al. (2017b) and Vert et al. (2020) exposed participants to blue spaces, by requiring them to take short walks in the blue areas, while White (2013) used virtual exposure. While this lack of significant differences does not align within the psychoevolutionary theory, it aligns with recent studies.

The results of the heart rate measurement yielded a highly unexpected result, which is that mean scores were exactly the same at pre- and post-stages. Initially the researcher thought that this result may have been due to a calculation error, but the data were rechecked and measured twice after discovering this result (once by the researcher and once by an external statistician) and the same result was yielded. The presence of the interaction effect within the FwUp1 further complicates the interpretation of this result. Nevertheless, as emphasised in 2.3.2.1, there is an extreme paucity of research on the impact of blue spaces on acute stress relief and as such, to the author's knowledge there is no existing literature with which to compare the present results. This also implies that the present study is the first to measure heart rate as an indicator of blue spaces on acute stress relief, providing new knowledge to the field of blue space research. The finding does not, however, align with the psychoevolutionary proposition of the positive stress relieving effects of blue spaces. This finding is unexpected, given the emphasis that psychoevolutionary approaches have placed on the survival benefits that blue spaces provided our ancestors. This finding alone does not negate the restorative benefits of blue spaces presented next, but it does raise questions. It is possible that despite following strict experimental protocol, the timing of the heart rate measures was too close together or too far apart to detect significant changes. It is also possible that, given that the video was of a coastal area, participants did not hold the same biophilic attraction to the space as, for example, a lake or waterfall may have. Given that the biophilia hypothesis and SRT propose that water held evolutionary benefits because of the possibility of accessing fresh drinking water and surrounding trees and shrubs that serve as food sources, the ocean may not have held that same promise.

Similarly to the urban group, there were no statistically significant differences in CSI measures across measurement points. The literature regarding HRV on blue spaces presented mixed results and so this finding aligns with two previous studies (Gidlow et al., 2016; Vert et al., 2020), but does not align with Triguero-Mas et al. (2017b). In this regard, it would appear that there is no common finding relating to the impacts of blue spaces on HRV (measured as CSI in this study). It has been highlighted that the field of blue space research is an emerging field, and so these mixed results may simply be a consequence of this. More research may result in clearer trends of the impact of blue spaces on HRV and CSI.

Finally, blue spaces demonstrated a statistically significant impact on acute stress levels as measured by EDA. There was a statistically significant decrease in EDA, which indicates that blue spaces assist in the reduction of SNS activity. The relationship between EDA and SNS has been discussed in (2.3.3.1.1) and this finding consequently supports the psychoevolutionary proposition, that blue spaces promote acute stress relief. Furthermore, EDA has not yet been used in blue space research and so this finding adds new knowledge to the field. This is a new finding, which indicates a positive stress reducing benefit of blue spaces on EDA measures.

Overall, the analyses on the physiological impacts of blue spaces on acute stress yielded mixed results. The lack of significant differences in blood pressure is aligned with previous research, while the lack of significant differences regarding heart rate is a new finding in the field. Given that the field of blue space research is relatively young, the mixed findings of CSI are expected, while the significant reductions in EDA levels provide new insight into the stress relieving effects of blue spaces.

The integrated psychophysiological results of the blue space group have presented promising findings in terms of the stress-relieving benefits of blue spaces. Although there were no statistically significant differences on the majority of the physiological measures, the EDA results present novel findings and are supportive of the psychoevolutionary psychophysiological stress reduction approach. The psychological results supported this and were similarly indicative of the greatest restorative potential.

6.5 Correlations of results

The results of the correlations of all results yielded some interesting insights. The diastolic blood pressure at pre-experiment stage was significantly correlated with the diastolic blood pressure at post-experiment stage. This result is however not surprising since the results of the pairwise comparisons indicated that there were no significant differences between measurement occasions. Both pre- and post- measurements of diastolic blood pressure correlated highly with pre- and post- systolic blood pressure measurements. These findings indicate that blood pressure measurements were closely related across the study. This supports the predominant lack of statistically significant findings in blood pressure measurement changed discussed above.

Heart rate at both measurement points correlated highly with each other, supporting the overall lack of significant differences across groups. However, heart rate at pre- and post-measurement both correlated strongly with pre- and post-measurements of CSI. Although heart rate and CSI (transformed HRV) are not the same thing, they are related in the extent to which they give an indication of SNS activity. These results suggest that both measures were giving similar indications of SNS activity.

The EDA delta values did not correlate with any of the other measures however this is unsurprising since the result was a single value indicative of an increase or decrease. That is, the remaining physiological measures had separate measurement means at pre- and post-measurement states and therefore correlating a delta value with a single value of the other measures would likely not have yielded correlations, as was evident. This was furthermore the case when considering the correlations of EDA to the psychological variables – there were no statistically significant results.

The results of the correlations between psychological measures yielded results that support the use of the FwUp items in that they correlated to the scale items that measured the same underlying construct. For example, the FwUp 1 pre-measurement results correlated with the PSS pre-measurement output. Given that both scales asked participants to rate how stressed they were, this correlation suggests that participants answered consistently. In a similar vein, the FwUp 1 post-measurement results correlated with the PSS post-measurement scores. The fact that FwUp 2 did not correlate with any of the other psychological items make sense given that that question was designed to assess how frightening the stressor was, and was not related to restoration. Interestingly, FwUp2 correlated weakly with post- systolic blood pressure. There is no theoretical basis, or physiologically sound reason for this correlation so it can therefore be considered a statistical anomaly.

Crucially, FwUp 3 correlated positively, strongly, and statistically significantly with each of the RS subscales. This result further provides evidence that participants responded in a consistent and that FwUp 3 served as an efficient supplementary question to the RS. There were significant, negative correlations between FwUp4 and the following: FwUp3; the cognitive, physiological, and emotional RS subscales; FwUp1 (pre); and PSS (pre). Since lower scores on the FwUp4 indicated less stress (than before the experiment), these negative correlations are encouraging as they relate to higher restoration (of the RS and FwUp3). Moreover, the negative correlations with FwUp1 (pre) and PSS (pre) suggest that lower self-report stress levels after the experiment are associated with higher pre-testing stress scores (as indicated by FwUp1 and PSS (pre)). Apart from the unexplained correlation between FwUp2 and post- systolic blood pressure, the correlation matrix overwhelmingly provides support for the notion that participants responded in a consistent manner and that the self-developed follow-up measures measured the same constructs as the established measures. The summary of all results will be discussed next.

6.6 Summary of results

Overall, the results of the present study have lent support for blue spaces being the most restorative natural areas, followed by the green space, and then finally followed by the urban space. The lack of restoration found by the urban responses largely aligned with current literature and theory, regarding the fact that urban areas are conducive to stress, not stress reduction. In this regard, the results appear to reinforce the notion that urban spaces should not be used as a resource when seeking restoration from acute stress. From an evolutionary standpoint, we have not yet adapted to find urban areas restorative, and so while we may benefit from the ease of access to electricity, fresh water, and convenience stores, the phrase "our modern minds house a Stone Age skull" rings true (Cosmides & Tooby, 1997, p. 12).

The fact that the green space group did not differ significantly from the blue space group was unexpected, as biophilic and SRT principles suggest that waterscapes would promote the greatest amount of stress relief and would consequently differ from the green space. One possible reason for this result comes from Marselle et al. (2021) who emphasised that from an SRT perspective, an environment that is high in biodiversity, has a focal point, a ground surface conducive to movement, and great plant species richness promote might recovery from stress by reducing physiological arousal. The blue space video that was used in the present study was a first-person perspective of an individual walking on a beach. Although this scene was, as with the green space video, chosen to align as closely as possible with SRT principles, the beach scene had largely only palm trees at the edge of the scene and therefore was not high in biodiversity of plant species richness.

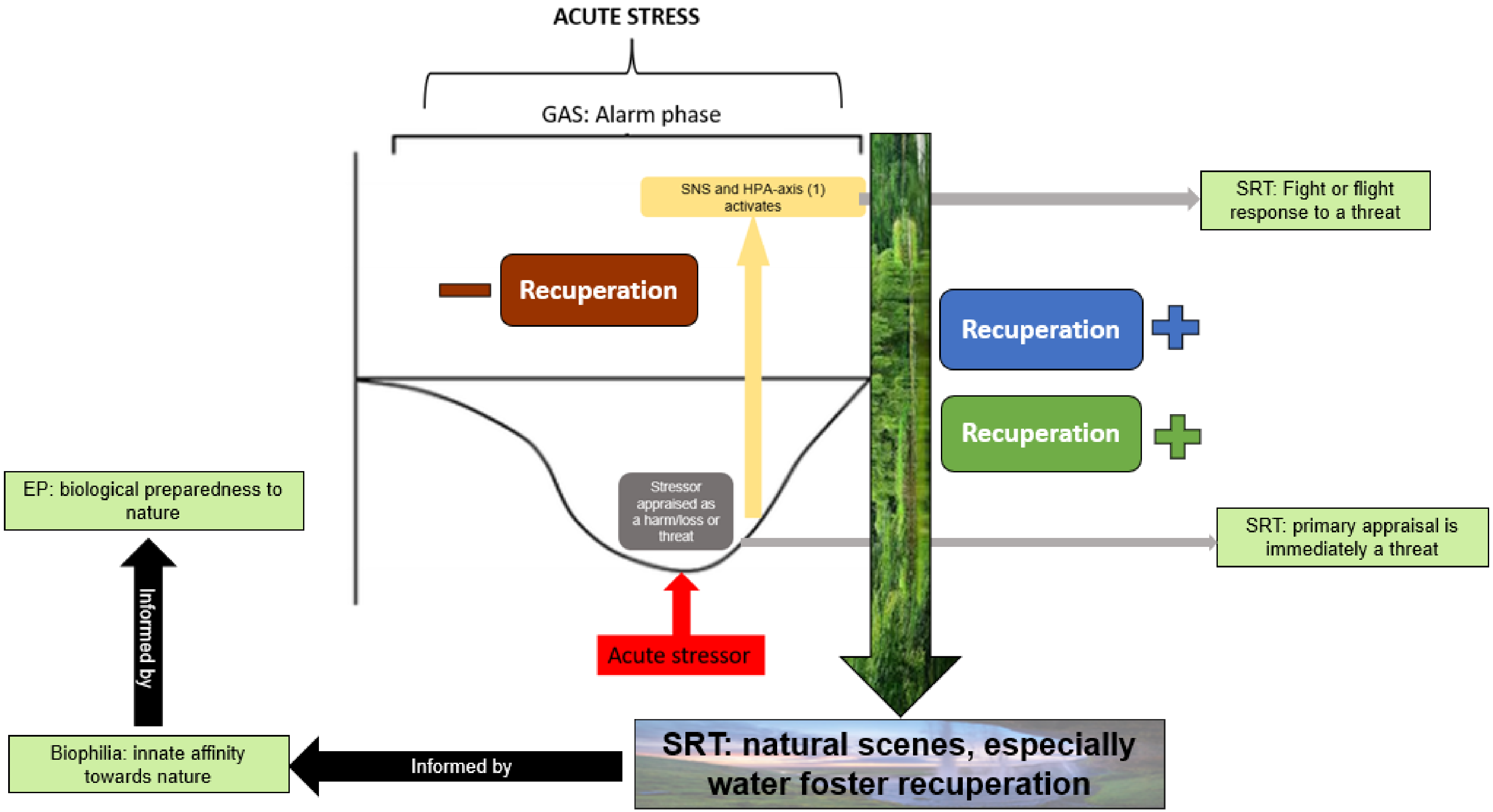
A further consideration of the present results is related to the senses involved in experiencing a natural scene. This study's findings have largely aligned with the minimal existing literature on the stress relieving benefits of nature, and particularly those studies that have demonstrated that virtual exposure to natural areas yield similar restorative benefits to physical presence in a natural area (Annerstedt et al., 2013; Browning et al., 2021; Gao et al., 2019; Nukarinen et al., 2020; Tanja-Dijkstra et al., 2018). However, the physical experience of being in an environment involves more than simply the visual and auditory elements thereof; the senses of touch and smell also play a role. Although the present study did not examine these elements, there are areas of research that are moving in this direction and recognising the importance of touch and smell in the experience of natural areas (Browning et al., 2021). The premise of the biophilia hypothesis and SRT is that being in a natural area conducive to survival would have involved physical immersion. That said, despite the lack of smell and touch in the present study, the results have overwhelmingly supported psychoevolutionary theories of stress relief.

From these results, one can tentatively conclude that green and blue spaces would serve to reduce the impact of acute stress and in doing so, reduce the allostatic load of an individual, and provide a buffer to entering the second phase of the proposed psychoevolutionary psychophysiological model. If one's circumstances are such that moving from the first to the second phase is unavoidable, then at the very least the results of the present study suggest that exposure to natural areas will help provide acute stress relief and minimise the impact of acute stressors.

Furthermore, as has been highlighted in Chapters 1 and 2, existing stress-reducing interventions can be costly, time-consuming, or not practically feasible for everyone. The stress reducing effects of blue and green spaces as discovered in the present study provide support for the suggestion that the impacts of acute stress relief can be mitigated by exposure to these natural areas. Given that the study used virtual exposure yet found results that support studies using real nature immersion, it can be proposed that acute stress relief could be aided simply by viewing images or videos of blue or green spaces.

Figure 35 presents the final version of the proposed psychoevolutionary psychophysiological stress response model, incorporating the results that have been found with theory. The blue and green boxes indicate that blue and green spaces foster acute stress recuperation, while the brown box represents the urban area, which does not foster recuperation. These findings lend support to the psychoevolutionary notion that restoration is effectively attained when being exposed to a blue or green space, but not an urban space. This model serves to add knowledge to existing theories and proposals of acute stress reduction.

Figure 35 Final model presentation, integrating findings with theory



Note: Author's own

6.7 Limitations

While this multidisciplinary, cross-sectional experimental study yielded a number of valuable insights, there are nonetheless limitations that are present. These limitations should be taken into account when interpreting the results of this study.

- The study used non-probability sampling methods and therefore the results cannot be generalised to the larger population. However, provided that the population of interest was all adults between the ages of 18 and 35 that did not meet the exclusion criteria, it was not possible to obtain a list of the entire population and implement probability sampling.
- The four experimental (the three treatment plus one control) groups differed in size. Notwithstanding, the groups only differed by one person per group, where the range was from 28 to 31. While not ideal, these groups did not differ greatly in size. The following were the factors that influenced the unequal group sizes:
    - Participants not arriving for the experiment after selecting a time slot for participation.
    - Incomplete or missing self-reported data, which resulted in the exclusion of two participants.
    - One participant withdrew halfway, as they had a meeting to attend and had not factored in the time needed for the experiment.
- The sample was skewed in favour of participants with an age range between 18 and 23 years. Although the study was widely advertised on the researcher's social media to attract a range of participants up to 35 years, the snowball sampling method meant that the younger participants would often bring a group of friends to participate. This could be why the data are skewed in this regard and means the results should be interpreted with caution.
- The sample was also skewed in favour of females, where females accounted for 62.7% of the sample. Although there are slightly more females than males in South Africa (51% females and 49% males), the unequal distribution limits the ability to generalise these findings (Statistics South Africa, 2022).
- The data were collected during a period that spanned into test and exam periods. Given that some of the participants indicated that they were university students, it is possible that the extra burden of preparing for tests and exams heightened their existing stress levels, potentially impacting their acute stress response. It is not

possible to account for the extent to which this may have influenced the results, but it is nonetheless mentioned as a potential limitation.

- Ideally, the researcher would have wanted to take participants to each of the treatment scenes to allow maximum immersion in each scene. However, given that the researcher lives in a landlocked province, it would have been too costly to arrange transportation for 31 people to a fully natural blue space (that is, not a human-made water feature). Secondly, South Africa has an extremely high crime rate (BusinessTech, 2021) and as such taking individuals to a busy urban district such as the central business district would have risked the safety of both the researcher and participants.

6.8 Recommendations for Future Research and Policy

There are a number of recommendations for future research, that can follow from the present study.

- Although it is not necessarily possible to obtain a population list of all healthy adults, future research could expand the age range of participants and obtain participants from a wider variety of sources. This would help provide a sample that is more representative of the population.
- Relatedly, future research could aim to obtain greater diversity in participants. Participants of the present study had to have internet access to sign up for the study and be within easy travelling range of the experiment site to participate. Future research, especially within the South African context, should advertise such studies across urban and rural areas and make accessibility for participation easier.
- Although the total sample size of the present study was appropriate (n = 118), the division into four groups meant that the differing groups sizes, even by a marginal amount, may have impacted the results. Future research should therefore aim to obtain an even larger total sample, so that issues such as participant attrition have minimal impact.
- The present study assessed acute stress responses, but it is acknowledged that a variety of personal factors that were not accounted for may have played a role in the perception of restoration by participants. Future research should screen for factors such as pre-existing anxiety disorders, and traumatic histories that do not resort under the diagnosis of PTSD, and substance abuse.

- Building on the novel findings of the present study, future research should similarly assess EDA and heart rate responses to blue spaces. The present study has filled a gap in literature, but there remains a significant amount of research to be done to saturate the field.
- Although a purely quantitative methodology aligns with current standards of psychophysiological research, future research could potentially incorporate a qualitative element to further explore perceptions and experiences of stress and stress relief.
- Practically, the findings of the present study can be used as justification and evidence for the protection of local (and international) green and blue spaces. Given the rate of urbanisation it more critical than ever before to ensure that blue and green spaces are not eradicated for the sake of urban development.
- The findings of this study can also be used as justification for the inclusion of green and blue spaces at the workplace. The inclusion of a garden, even if small, and a water feature can be used to reduce staff stress throughout the day.
- While industries as gyms already use first person videos of walking in nature on their treadmills, this principle can be taken further to personal use. If one is unable to access a green or blue space, virtual viewing thereof can still be used to mitigate acute stress.

6.9 Conclusion

Chapter 6 has consolidated and integrated the findings of the present study into existing literature and the proposed theoretical models. Overall, the present study has demonstrated that exposure to blue and green areas are conducive to acute stress relief and that urban areas are not. The study has employed a unique battery of measurement tools and at least two novel findings have been introduced: that blue spaces effectively reduce acute stress levels as measured by EDA, and that there are no significant differences in heart rate before and after viewing blue spaces. Nonetheless, this study has provided new insights for the field of green and blue space research and has provided confirmatory evidence, supporting the psychoevolutionary notion that natural areas that would have fostered the survival of our ancestors are still considered restorative today.

Given the every-increasing stress levels locally and internationally, cost-effective, simple acute stress relieving solutions are required. This study has demonstrated that viewing a green or blue space can help minimise the negative impacts of acute stress and help promote recovery. The existing study has served as platform for future research endeavours, given the range of possibilities for future research suggested. It is hoped that the results of the study will serve to promote the protection of blue and green spaces, given their acute stress relieving benefits.

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APPENDIX A
INFORMATION SHEET

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Humanities
Department of Psychology

INFORMED CONSENT FORM

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

There are two parts to this informed consent form:

- An information sheet (to provide information about the study)
- A consent form (to sign if you choose to participate)

You will receive a copy of the information sheet.

PART 1: INFORMATION SHEET

Introduction

You are invited to participate in the research study mentioned above. This information sheet will explain all procedures involved in the study to allow you to decide whether you wish to participate. If some of the words or concepts contained within this document are not familiar to you, or if you do not understand some or any of the information provided, please inform the researcher of this so that she may provide a clearer explanation.

The purpose of the study

The researcher is affiliated with the University of Pretoria and is conducting research aimed at understanding the way in which various natural and urban areas influence stress levels in a healthy early adult population (age 18 -39). Natural areas include green spaces (vegetation such as trees, grass, and flowers) and blue spaces (areas containing water such as the ocean, waterfalls and rivers). Urban areas refer to city areas. Since

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stress is such a prominent aspect of daily adult life, the study aims to investigate the extent to which exposure to each of these areas influences stress relief. The results of this study will potentially be used to influence stress relieving techniques and methods employed and recommended by individuals and health professionals.

Participation

The research will involve your participation in both physiological assessments and psychological questionnaires at various stages while watching video clips. You will first be required to watch a short clip from a movie that is designed to elicit a stress response. Following this, you will watch a first-person video of an individual walking through either green, blue, or urban areas. If you are assigned to the control group, you will not watch any further videos and will simply sit comfortably in the room where the research is being conducted. The physiological assessments will assess electrodermal activity and cardio stress index non-invasively. The psychological questionnaires will require you to answer questions regarding basic demographic information, preferences about nature types, and emotional states at a given time. The entire activity will take approximately half an hour of your time.

The data gathered will remain confidential and will only be accessed by the researcher and her supervisors. Should any of your physiological assessments indicate compromised health, you will be alerted to this by the researcher, but this information will remain confidential and details of a local clinic will be provided if you do not have a general practitioner to consult.

If you wish to remain informed on the results of the study, you may contact the principal researcher for further information (contact details provided below).

The information gathered during the course of the research process will be used for the purpose of the research study and will thereafter be stored in a safe location in the Department of Psychology at the University of Pretoria for 15 years for archiving purposes. The results of this study may be used for research at a later stage.

Furthermore, your participation in this study is voluntary, which means that you are not obliged to participate, and you may withdraw at any time without having to offer an explanation and without any consequence to you.

Potential risks or discomfort

In order to generate increased stress levels, you will be required to view a short video clip designed to heighten physiological arousal. The clip will not, however, include graphic violence, sex, blood, or religious connotations. An additional, external measure will be employed to create a stress response, but you will in no way be physically harmed. Please note that if you have been a victim of interpersonal violence in the last six months you may experience emotional distress as a result of the stressor. Debriefing will be provided after the experiment should you require it, and a referral to free counselling services can be made if needed.

Benefits of participation

The study will not provide any direct benefit, however your participation will contribute to a better understanding of the effectiveness of natural areas in combatting stress.

Any further questions regarding the research study may be directed to the principal investigator:

Dr. Nicoleen Coetzee
Email: nicoleen.coetzee@up.ac.za

APPENDIX B: INFORMED CONSENT

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

PART 2: CONSENT TO PARTICIPATE

I hereby confirm that I have been informed about the nature, procedures, and risks of this study. I am aware that the information will only be used for research purposes, and that my confidentiality will be protected. I voluntarily participate in the study and I am aware that I can withdraw at any time without offering any explanation or suffering any consequences.

Participant name (please print) ______________________

Participant signature ______________________

Date ______________________

Researcher name Ruth Coetzer

Researcher signature ______________________

Date ______________________

Thank you for your participation!

APPENDIX C
SCREENING QUESTIONNAIRE

PERSONAL AND BIOGRAPHICAL INFORMATION

1. Sex:* ☐ Male ☐ Female ☐ Other ☐ Prefer not to say

2. Ethnicity:* ☐ Asian ☐ Black ☐ Coloured ☐ Indian ☐ White

3. Age:* ☐ 18-20 ☐ 21-23 ☐ 24-26 ☐ 27-29 ☐ 30-32 ☐ 33-35

*For statistical purposes only

4. Have you smoked in the last 12 hours? (Including e-cigarettes)

Yes ☐ No ☐

5. Do you have epilepsy (or any other condition that could be triggered by the sound/visuals of videos)?

Yes ☐ No ☐

6. Are you currently taking any blood pressure medication, or other medication that affects blood pressure?

Yes ☐ No ☐

7. Have you been diagnosed with PTSD (post-traumatic stress disorder) within the last year (or suspect you may be suffering from PTSD)?

Yes ☐ No ☐

APPENDIX D
PSYCHOLOGICAL QUESTIONNAIRE (PRE-TEST)

Psychological Questionnaires (pre)

1. Perceived Stress Scale

The questions in this scale ask you about your feelings and thoughts during the last month. In each case, you will be asked to indicate by circling how often you felt or thought a certain way.

To indicate your answer, circle the number that best represents your feelings using the following scale:

1	2	3	4	5
Never	Almost never	Sometimes	Fairly often	Very often

In the last month...

1	How often have you been upset because of something that happened unexpectedly?	1	2	3	4	5
2	How often have you felt that you were unable to control the important things in your life?	1	2	3	4	5
3	How often have you felt nervous and "stressed"?	1	2	3	4	5
4	How often have you felt confident about your ability to handle your personal problems?	1	2	3	4	5
5	How often have you felt that things were going your way?	1	2	3	4	5
6	How often have you found that you could not cope with all the things that you had to do?	1	2	3	4	5
7	How often have you been able to control irritations in your life?	1	2	3	4	5
8	How often have you felt that you were on top of things?	1	2	3	4	5
9	How often have you been angered because of things that were outside of your control?	1	2	3	4	5
10	How often have you felt difficulties were piling up so high that you could not overcome them?	1	2	3	4	5

Overall, how stressed do you feel *at this moment*?

1	2	3	4	5
Not at all	Slightly	Somewhat	Considerably	Extremely

2. Nature Relatedness Scale

For each of the following, please rate the extent to which you agree with each statement, using the scale from 1 to 5 as shown below. Please respond as you really feel, rather than how you think "most people" feel.

1	2	3	4	5
Disagree strongly	Disagree a little	Neither agree or disagree	Agree a little	Agree strongly

1	My ideal vacation spot would be a remote, wilderness area.	1	2	3	4	5
2	I always think about how my actions affect the environment.	1	2	3	4	5
3	My connection to nature and the environment is a part of my spirituality.	1	2	3	4	5
4	I take notice of wildlife wherever I am.	1	2	3	4	5
5	My relationship to nature is an important part of who I am.	1	2	3	4	5
6	I feel very connected to all living things and the earth	1	2	3	4	5

APPENDIX E
PSYCHOLOGICAL QUESTIONNAIRES (POST TEST – TREATMENT GROUPS)

Psychological Questionnaires (post)

1. Restoration Scale

This scale is a self-rating measure of the restorative quality of natural environments. Please note, therefore, that these questions refer to the **second** clip you watched, not the stressor clip.

a. Emotional dimension

Imagine you were in the projected scene. How would you describe the effect the landscape has on you in terms of the following emotions? (Please circle the appropriate number below the emotion)

Depressed (very much)								Elated (very much)
1	2	3	4	5	6	7	8	9
Unsure (very much)								Confident (very much)
1	2	3	4	5	6	7	8	9
Grouchy (very much)								Good natured (very much)
1	2	3	4	5	6	7	8	9
Anxious (very much)								Relaxed (very much
1	2	3	4	5	6	7	8	9
Fatigued (very much)								Energetic (very much)
1	2	3	4	5	6	7	8	9

b. Physiological dimension

Imagine you were in the projected scene. How would you describe the physiological response that the landscape elicits in you? (Please circle the appropriate number below the statement)

My breathing is becoming faster								
Not at all								Very much so
1	2	3	4	5	6	7	8	9
My muscles are becoming tenser								
Not at all								Very much so
1	2	3	4	5	6	7	8	9
My hands are sweating								
Not at all								Very much so
1	2	3	4	5	6	7	8	9
My heart is beating faster								
Not at all								Very much so
1	2	3	4	5	6	7	8	9

c. Cognitive dimension

Imagine you were in the projected scene. How would you describe the landscape's influence on your cognition? (Please circle the appropriate number below the statement)

I am interested in the presented scene								
Not at all								Very much so
1	2	3	4	5	6	7	8	9
I feel attentive to the presented scene								
Not at all								Very much so
1	2	3	4	5	6	7	8	9
My mental fatigue is decreasing								
Not at all								Very much so
1	2	3	4	5	6	7	8	9
I feel concentrated in my mind								
Not at all								Very much so
1	2	3	4	5	6	7	8	9
I feel reflective of myself								
Not at all								Very much so
1	2	3	4	5	6	7	8	9

d. Behavioural dimension

Imagine you were in the projected scene. How would you agree with the following statements? (Please circle the appropriate number below the statement)

I would like to explore this place further								
Not at all								Very much so
1	2	3	4	5	6	7	8	9
I would like to visit here more often								
Not at all								Very much so
1	2	3	4	5	6	7	8	9
I would like to stay here longer								
Not at all								Very much so
1	2	3	4	5	6	7	8	9

2. Perceived Stress Scale

The questions in this scale ask you about your feelings and thoughts during the last month. In each case, you will be asked to indicate by circling how often you felt or thought a certain way.

To indicate your answer, circle the number that best represents your feelings using the following scale:

1	2	3	4	5
Never	Almost never	Sometimes	Fairly often	Very often

In the last month...

1	How often have you been upset because of something that happened unexpectedly?	1	2	3	4	5
2	How often have you felt that you were unable to control the important things in your life?	1	2	3	4	5
3	How often have you felt nervous and "stressed"?	1	2	3	4	5
4	How often have you felt confident about your ability to handle your personal problems?	1	2	3	4	5

5	How often have you felt that things were going your way?	1	2	3	4	5
6	How often have you found that you could not cope with all the things that you had to do?	1	2	3	4	5
7	How often have you been able to control irritations in your life?	1	2	3	4	5
8	How often have you felt that you were on top of things?	1	2	3	4	5
9	How often have you been angered because of things that were outside of your control?	1	2	3	4	5
10	How often have you felt difficulties were piling up so high that you could not overcome them?	1	2	3	4	5

3. Follow up questionnaire

1. Overall, how stressed do you feel *at this moment*?

1	2	3	4	5
Not at all	Slightly	Somewhat	Considerably	Extremely

2. How frightening did you perceive the stressor to be?

1	2	3	4	5
Not at all	Slightly	Somewhat	Considerably	Extremely

3. If you watched a video after the stressor, how restorative did you perceive the scene to be? (If you did not watch anything after the stressor, please leave this question blank)

1	2	3	4	5
Not at all	Slightly	Somewhat	Considerably	Extremely

4. Considering how stressed you felt before the experiment, how would you rate your *current* stress levels?

1	2	3
Less stressed than before	About the same	More stressed than before

APPENDIX F
PSYCHOLOGICAL QUESTIONNAIRES (POST TEST – CONTROL GROUP)

Psychological Questionnaires (post)

1. Perceived Stress Scale

The questions in this scale ask you about your feelings and thoughts during the last month. In each case, you will be asked to indicate by circling how often you felt or thought a certain way.

To indicate your answer, circle the number that best represents your feelings using the following scale:

1	2	3	4	5
Never	Almost never	Sometimes	Fairly often	Very often

In the last month...

1	How often have you been upset because of something that happened unexpectedly?	1	2	3	4	5
2	How often have you felt that you were unable to control the important things in your life?	1	2	3	4	5
3	How often have you felt nervous and "stressed"?	1	2	3	4	5
4	How often have you felt confident about your ability to handle your personal problems?	1	2	3	4	5
5	How often have you felt that things were going your way?	1	2	3	4	5
6	How often have you found that you could not cope with all the things that you had to do?	1	2	3	4	5
7	How often have you been able to control irritations in your life?	1	2	3	4	5
8	How often have you felt that you were on top of things?	1	2	3	4	5
9	How often have you been angered because of things that were outside of your control?	1	2	3	4	5
10	How often have you felt difficulties were piling up so high that you could not overcome them?	1	2	3	4	5

2. Follow up questionnaire

1. Overall, how stressed do you feel *at this moment*?

1	2	3	4	5
Not at all	Slightly	Somewhat	Considerably	Extremely

2. How frightening did you perceive the stressor to be?

1	2	3	4	5
Not at all	Slightly	Somewhat	Considerably	Extremely

3. Considering how stressed you felt before the experiment, how would you rate your *current* stress levels?

1	2	3
Less stressed than before	About the same	More stressed than before

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APPENDIX G
ETHICAL APPROVAL

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
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Faculty of Humanities
Research Ethics Committee

13 November 2017

Dear Ms Liprini

Project:	**Psychophysiological stress responses to urban, green and blue spaces in a healthy adult sample**
Researcher:	**R Liprini**
Supervisor:	**Dr N Coetzee**
Department:	**Psychology**
Reference Number:	**28033788 (GW20171034HS)**

Thank you for the application that was submitted for ethics consideration. As the study involves students, the Dean of the Faculty of Humanities has to also approve the study.

I am pleased to inform you that the above application was **approved** by the **Research Ethics Committee** on 26 October 2017 and by the Dean of Humanities on 7 November 2017. Data collection may therefore commence.

Please note that this approval is based on the assumption that the research will be carried out along the lines laid out in the proposal. Should the actual research depart significantly from the proposed research, it will be necessary to apply for a new research approval and ethical clearance.

We wish you success with the project.

Sincerely

Prof Maxi Schoeman
Deputy Dean: Postgraduate Studies and Ethics
Faculty of Humanities
UNIVERSITY OF PRETORIA
e-mail: tracey.andrew@up.ac.za

cc: Dr N Coetzee (Supervisor)
Prof C Wagner (HoD)

APPENDIX H
MANOVA RESIDUAL PLOTS FOR LINEARITY