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Assessing the effects of external environmental factors in public squares on mental health and well being

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Abstract

Many environmental issues arise due to urbanization, such as increased pollution and city densification. World health organizations and sustainable development have recently focused on mental health as a rising concern. As builders and architects, it is our responsibility to identify the impact of the environment on the user and to adjust our surroundings in a healthy and restorative manner. This research looked at restorative environments and how they affect people's emotions and well-being. The relationship between individual and environmental characteristics is investigated in this study. A restorative environment may reduce stress and mental fatigue while also improving attention. The environment can influence a person's views, attitude, and performance. This impact might be either negative or positive. Fear, anger, anxiety, and sadness are frequent emotions that the environment may induce and increase. This study evaluated respondents' restorativeness using virtual reality and online videos. This research was a collaborative effort to piece together new methodologies and procedures and explain the relationship between built environment characteristics and restorativeness to comprehensively understand new methods for analyzing and assessing environmental interactions and how they interact. The study concentrated on attention restoration and stress recovery theory. Five physical and perceptual restorative components were separated and simulated based on these two theories. These architectural spaces stressed restorative factors of complexity and coherence. This study used online videos and VR headsets to test respondents' perceived restorativeness of the virtual environment using eight models of varying coherence and complexity based on built environment attributes. Three restorative variables were extracted from the expected five restorative components: fascination, coherence, and complexity. Statistical analysis was used to investigate restorativeness and emotions; as a result, increasing each restorative component and overall restorativeness were associated with positive emotions. According to a fixed effect model regression, three attributes of building placement, crowdedness, and surface material significantly impacted perceived restorativeness. The height of the building and the style of architecture had minimal influence. Most restorative environment research has concentrated on natural settings, stress, and mental health. This research looked at restorativeness in built environments, particularly in metropolitan regions. Urban planners and legislators might use the study's findings to make communities and public spaces more pleasant and restorative.

Keywords: mental health, well-being, sustainable cities and communities, restorative environments, environmental psychology

Summary

Mental health is one of the concerns that the World Health Organization and Sustainable Development have tackled in recent years (Volkov, 2020). Our responsibility as contemporary society's builders and architects is to understand the impact of the environment on the user and work to transform our surroundings in a good and healing way. Kaplan and Kaplan investigated the natural environment and its potential to restore mental fatigue (Kaplan & Kaplan, 1989).

This study investigated how restorative environments affect people's emotions and well-being. The relevance of the relationship between individual and environmental factors is discussed in this study. Because of the traits and characteristics of a restorative environment, they can relieve tension and mental weariness and help focus. Furthermore, the environment may be improved by utilizing natural and practical components in the region, such as natural materials and water availability.

This research discusses the necessity to repair and improve an individual's mental health in their surroundings and to make it the primary emphasis of their employment. Identifying the properties and characteristics of restorative environments and features that contribute to their positive effects, selecting appropriate public urban settings for research purposes, and determining the most influential inventory factors will be among the researcher's challenges.

Many countries' populations are now concentrated in urban areas, which provide inhabitants with more diverse cultural opportunities than rural areas. These include more access to educational and medical services, as well as more significant opportunities to engage with people from all walks of life in dynamic public areas. On the other hand, city people are subjected to unfavorable conditions such as air pollution, visual blight, traffic congestion, and noise. Growing up in a city has been linked to a higher risk of chronic stress, leading to illnesses such as anxiety disorders, depression, and coronary heart disease (Fleury-Bahi et al., 2016, p. 127).

People's thoughts, attitudes, and performance may all be influenced by their surroundings. This impact might be either destructive or beneficial. A person's everyday emotions include anxiety, anger, worry, and sadness, and the environment has the power to provoke and intensify these sensations easily, as well as to enhance these emotions and mental conditions (Berto, 2014).

Virtual reality is a cutting-edge technology that enables individuals to interact with a computer-generated world. Using VR technology and online movies, this study analyzed and contrasted the findings of respondents' perceived restorativeness. The current study was a collaborative effort to piece together fragments of these new methodologies and procedures and explain the relationship between built environment characteristics and restorativeness to provide a comprehensive understanding of new methods for analyzing and assessing environmental interactions and how they impact one another. This study looked at various strategies and instruments that may be used to aid with this.

This study was built on the concepts of attention restoration and stress recovery. Five physical and perceptual restorative elements were extracted and integrated into simulated designed settings based on these two theories. These architectural settings stressed the complexity and coherence of beneficial aspects.

This research effort used eight models with varying degrees of coherence and complexity based on diverse built environment aspects to assess respondents' perceived restorativeness of locations using two different methods: online videos and VR headsets.

Five environmental factors were constructed in two stages to yield eight models. The attributes include the average number of people, the location of the building in the environment, the building height, the building type, and the surface building material/color. The intricacy and coherence of the eight produced models varied, as did the perceived restorativeness.

The final stage in constructing a stated preference experiment is the design and production of the survey instrument. The questionnaire is broken into four sections. Age, gender, mother language, and country of

origin (western versus non-western) were collected as sociodemographic data. This data is required to research the relationships between sociodemographic factors, emotional reactions, and preferred restorative contexts in local public areas. After that, the analyzed the collected data was essential in reaching the research's conclusion. The data were analyzed using statistical tools such as SPSS and Nlogit. Using principal component analysis, three variables were generated from the projected five restorative components: fascination, coherence, and complexity. Questions regarding fascination and being away were merged and scored as one component, while questions on the scope factor were removed, and complexity and coherence remained distinct components. The findings revealed a substantial and distinct relationship between these three factors and emotions.

Measuring the environment's healing value was one of the study's research issues. This was accomplished by calculating the mean response of the 14 questions aimed at assessing the situation's restorativeness. Cronbach's alpha was employed to test the hypothesis's reliability, and it passed with an excellent outcome.

The final research issue was how people are affected by this trait and restorativeness. Pearson correlation analysis was used to investigate the relationship between restorativeness and emotions. According to the findings, boosting each restorative component and overall restorativeness was closely associated with emotion, with restorativeness responders feeling more cheerful.

According to a fixed effect model regression, only three factors, building placement, crowdedness, and surface material, had a significant impact on perceived restorativeness, while the other two, building height and architecture style, had little impact. Furthermore, multiple regression analysis of gender and experiment type was insignificant, indicating that these gender and experiment type variables have no relationship to restorativeness.

Although there has been some study on restorative surroundings, most of it has focused on natural settings and their influence on stress and mental health. However, the focus of this study was on restorativeness in constructed settings and their magnitude, particularly in metropolitan situations. Urban planners and legislators might leverage the study's findings to create more pleasant and restorative neighborhoods and public spaces for individuals.

Chapter I

1. Introduction

The environment may have an effect on our body, soul, mind, and spirit. In today's fast-paced world, this influence of the environment, as well as the pressures of everyday life, is more felt, and when the pressure reaches a critical point, individuals feel the urge to flee and escape from the situation with a high level of mental tension. This urge to leave, to go away, and a sense of exhaustion, which is not always physical, is referred to as mental fatigue (Kaplan & Kaplan, 1989).

Mental fatigue may be caused by a variety of factors; environmental pressures and attempting to concentrate on a certain issue in busy situations are two of the most common reasons (Kaplan & Kaplan, 1989, p. 178). Stress might worsen this mental fatigue. With the increasing expansion of urbanization, one of the primary sources of stress and discomfort may be attributed to crowded environments and urban noise (Hartig, 2017). These are precisely the situations that every individual encounters on a regular basis. Noise or visual pollution, or a focus on issues of little interest to the audience, make it so difficult to tolerate and react to environmental demands that it results in mental breakdown and, in the long term, endangers society's mental health.

One of the issues that the World Health Organization and Sustainable Development has addressed in recent years is mental health (Volkov, 2020). Our task as builders and architects of modern society is to recognize the effects that the environment has on the user and try to change our surroundings in a positive and restorative way. Kaplan & Kaplan studied the natural environment, and its restorative ability to reduce mental fatigue (Kaplan & Kaplan, 1989).

The relationship between humans and their surrounding environment is bidirectional and is being formed and transformed by different factors including users' perception and sensation or the environments' structures. As Rapoport (1990) stated, the environment contains messages, meanings, and codes that are deciphered and judged by its users based on their roles, expectations, motivations, and other personal, social, and environmental factors. In a society that is moving toward sustainable development, our design approach should be oriented toward restoration, as well as the creation and management of spatial settings that may promote mental health and emotional well-being for all people.

As a consequence, all buildings are firmly rooted in their surroundings and strongly linked with the societies in which they formerly resided, and as a result, each building has an untold narrative: each building has its own story. Even when a structure already exists, it maintains a link to the past while still clinging to the future and finding a means to get there (Plevoets & Van Cleempoel, 2019). A beneficial influence on people's mental health may be achieved via the continuity and history that is entwined with the body and existence of current and historic structures. It can also contribute to the identity of the person or society through this continuity and history (Mayes, 2018).

Everyone has had a moment of anxiety and exhaustion when they thought to themselves, "I want to run away" or "I have to get out of here." It happens to everyone at some point in their lives. Such sensations are continually overlooked in industrial societies where the wheel of the economy is more essential than anything else, and where the mental condition of its citizens is pushed to the fringes of attention and is

only brought to the forefront when mental problems or crises present themselves. To extend that, "a new index of 301 diseases reveals that mental illness is one of the most common causes of overall illness stress globally, accounting for 21.2 per cent of years of disability throughout the globe" (Mental Health Foundation, 2016). There are a variety of things that might contribute to this sense of fatigue and restlessness. In addition to concentrating on subjects that are not inherently pleasant to the person or on tasks that need intense mental concentration, stress and job pressure can be mentioned. It is also possible for external variables to work together to awaken this sensation in individuals and lead them to get irritated. One of the first concerns that should be noted is noise or visual pollution. Other aspects to consider include distance from nature as well as excessive interaction with the cold and depressing urban environment.

In moments of anxiety and exhaustion, according to Kaplan and Kaplan (1989), a person's mental fatigue is recognized, and it is considered that the individual has to recover and restore from the environment and circumstances in which one finds himself or herself. Upon researching this emotion, they develop an environment that has the power to aid in the maintenance and improvement of people's inner states by improving the attractiveness and tranquility of their surroundings. Creating restorative atmosphere in the areas with which a person comes into daily contact is one of the essentials that may greatly contribute to an individual's mental health and have a beneficial influence on the health of society in the long term.

While it is vital to plan and develop places with restorative characteristic from the start for new projects, this will not resolve the underlying issue, which is the disregard of architecture's psychological components. The environments in which each person of society lives, works, and travels are constructed without regard for the psychological feedback they provide; the only approach to cope with disregarded circumstances is to enhance them. In metropolitan contexts, we are often confronted with structures that have suffered to time's harshness and will soon be demolished.

However, the design of spaces should consider the psychological load and establish a restorative effect in them, following basic fundamental criteria and serving as a role model for future construction. However, in many parts of the world we are confronted with environments that not only lack these features but also have negative effects on mental health, particularly in cases where the building is old and forgotten, can turn into crime zones and harm the health of the community.

This study addresses the need to restore and enhance an individual's mental health in their environment and make it the primary focus of their employment. The researcher's challenges will include identifying the properties and characteristics of restorative environments and features that contribute to their positive effects, selecting appropriate public urban settings for research purposes, and determining the most influential inventory factors.

Public space has always been a top priority in every city's urban planning strategy, and in today's world, these urban spaces have emerged as critical components of both cities and communities' urban planning strategies. Plazas, squares, and parks, all essential components of the urban fabric, are today more significant than they have been in recent history. Apart from having a substantial impact on health, these places also offer recreational space for people to exercise, play, connect and engage with one another in a more social environment. Good public and open spaces are also necessary for building personal ties inside city areas, which is why they should be maintained. It has been shown that having an open place to enjoy increases a feeling of connection to one's local surroundings, as well as good psychological impacts, through encouraging interactions among community members.

1.2 Research goals

The fundamental purpose of this research is to determine which public space elements contribute to restorativeness, ultimately leading to the formation of a healthier society. The study ties attention restoration theory to biophilic design, which involves combining greenery with physical settings to create a more pleasant atmosphere. To date, natural and environmental psychologists have undertaken empirical study on the favorable impacts of green areas on human mental and physical health, and their findings have been published. People who perceive restorative aspects in an environment with restorative properties, comparable to natural settings, have favorable attitudes and actions toward the desired area.

Cities have engaged the assistance of architects in order to offer people with environments that are accessible, human-centered, and of high quality. As a result, high-quality design and architecture were required for these sorts of institutions due to the strong demand for these types of facilities.

The present research proposal aims to examine the restorative effects of selected environments to elucidate how efficiently a designed or built environment can provide appropriate emotional/perceptual qualities for promoting mental health and well-being of their users. For this purpose, the restorative process can be studied from different approaches:

- Identify relevant built environment attributes and apply environmental restorative features in VR simulations
- Relationships between characteristics of public space on the one hand and restorativeness on the other hand
- Providing guidelines for designing restorative environments

1.3 Research questions

To achieve the goals, it is necessary to answer the following questions:

- What are restorative environments and how do they affect people?
- What is perceived restorativeness and how can it be measured?
- Which BE characteristics affect perceived restorativeness?
- How can these features be implemented in a virtual public square?
- Which of the environmental features have a higher restorative effect on the users of the environment?
- What are the users' Areas of Interest (AOI) impacts on the restorative/destructive effects of the respective environment?

1.4 Methodological justification

Humans are familiar with objects, living creatures, and everyone who is conscious of their surroundings may be analyzed and characterized by their surroundings. The person's environment is all around him or her and continually interacts with him or her.

The environment may be analyzed from a variety of perspectives. A few examples include dividing the environment depending on human interaction, the age of the environment, or the mutual effect of the environment and humans.

This is an issue that has drawn the attention of many academics today in a variety of domains, particularly in the study of human behavior, and has increased their focus on the impact that the environment may play in a person's ability to perform at their best (Bechtel & Churchman, 2003). This influence may be either bad and destructive or beneficial and restorative depending on the circumstances. Individuals may feel a range of emotions during the day, including nervousness, anxiety and sadness. The environment may easily induce and increase these emotions, or it might operate to enhance these emotions and the mental condition of those who are exposed to them. It is always conceivable that the tension of everyday life causes a person to become mentally exhausted as a result of the amount of stress he or she is under. Because of the way it interacts with the physical environment surrounding it, this posture may either raise or decrease stress levels (Berto, 2014).

According to the definition of stress, it is defined as an imbalance between a person's environmental demands and his or her capacity to satisfy or comprehend these expectations. Individuals who live in metropolitan areas are more susceptible to urban overload, a sort of stress that happens when the number and intensity of environmental stimuli exceeds a person's capacity to comprehend and adjust to them (Bechtel & Churchman, 2003). Moreover, studies have identified a variety of demands or neurological stimuli from the physical or social environment, like "congestion or urban noise," as a possible cause of chronic stress that develops under settings of ongoing stress (Hartig, 2017).

While the subject of restorative environments is a major topic of debate in the fields of environmental psychology and nerve-based architecture today, there are flaws and gaps in many of its contents, and indeed, over the last few years, these stress recovery and attention restoration theories have continued to support this view and have been expressed and studied in limited contexts. The significance of historic structures on an individual's identity and mental health has been explored in works such as Mayes' book (2018) *Why Old Places Matter*. Additionally, although the problem of altering the current environment toward restorativeness has been considered, research on modifying public squares and plazas with an eye toward restorative settings is quite sparse. Thus, the primary distinction between this reading and the remainder of the study is the integration of these restorative theories and the creation of a suitable atmosphere, both physically and psychologically, in terms of beneficial influence on the audience.

Humans and their environment have a complicated two-way connection, which is influenced by a variety of circumstances. Numerous studies have been undertaken to build a list of these criteria throughout the years. However, due to the complexity of these components, most research has concentrated on only a few of the entangled chain-factors. Additionally, the majority of these studies are centered on psychology, with a particular emphasis on counseling sessions and surveys. While they are incredibly important tools, they seem to ignore the diverse approaches and tools created in recent decades in environmental and neurological research. This is because of a lack of convenient access to the tools and their high cost. Stress's detrimental effects may be quantified using a variety of laboratory and non-experimental approaches.

- 1) Changes and tracking of attentions by VR eye trackers,
- 2) Through questionnaires and personal reports (Berto, 2014).

Due to technology improvements and the availability of measuring instruments, new and hybrid methodologies may now to collect data on human-environment interaction variables. These approaches are concentrated on examining the emotional impacts of the environment, as well as users' emotional

and behavioral reactions, through the use of a number of instruments that have previously been utilized in other domains.

Current research is an integrated attempt to piece together fragments of these new methodologies, procedures, and explain relation between built environment characteristics and restorativeness in order to provide a comprehensive knowledge of new ways for analyzing and assessing environmental interactions and how they impact one another. This study discusses several strategies and instruments that may be used to assist with this.

Chapter II

2. Literature review

2.1 Introduction

Natural or built, old or new, virtual or real, the environment can be divided and analyzed based on how it was developed. It can be investigated from the audience's perspective and classified, for example, as restorative or not. Because a comprehensive analysis of the environment is not suited for this study, we will focus on the restorativeness of built environments due to their efficacy. The environment is defined as the base for all human and non-human events and activities. These categories cover a wide range of environmental concerns, such as the history and significance of human activities, as well as the mutual interaction of man and the environment. The impact of the environment is then thoroughly studied, and a range of settings that benefit humans are investigated for their positive and restorative aspects. The features and characteristics of restorative environments, as well as their effect on individuals, are described in detail, and a consensus on the physical and psychological characteristics of the restorative environment is reached in order to use them in designing and redesigning environments with restorative properties and a positive impact on humans is reached. Depending on the level of human intervention and whether the environment is man-made or not, the environment can be divided into two major categories: natural environment and built environment.

2.2. Built environment

The term "built environment" refers to all buildings built by man to support human activity. Everything physically related with a city, town, or village is referred to by this expression, including buildings, roads, squares, parks, pathways, business signs, street furniture, and so on (Board & Medicine, 2005, p. 14; Portella, 2014; Schuldenrein, 2017) . Broadly defined to encompass land use patterns, transportation systems, and design elements that, when combined, give possibilities for mobility and physical exercise (Board & Medicine, 2005, p. 14).

The built environment refers to landscapes that are primarily created by humans in order to support human activities. Buildings, parks, and infrastructural facilities are examples of these contexts. They are observed at many sizes, from neighborhoods to cities and neighboring municipalities that comprise "larger metropolitan regions"(Schuldenrein, 2017).

The average North American currently spends around 90% of his or her time indoors, 5% in automobiles, and 5% outdoors. In the industrialized world, four out of every five people live in cities, whereas globally, more than half of the population was urbanized around the turn of the century. As a result, the built environment (rather than the natural environment) has become the most important habitat for people, particularly in the industrialized world. The built environment encompasses both the buildings where people spend their time (home, school, office, recreational facilities, stores and malls, and so on) and the larger built environment of human settlements (villages, towns, suburbs, and cities). It is not just a physical environment, but also a social environment in which people congregate and interact with one another. Human health is greatly impacted by the design, development, and operation of built environments (Encyclopedia of PublicHealth).

Many countries' populations are now concentrated in metropolitan regions, which provide citizens with more diversified cultural facilities than rural locations. These include a wider range of entertainment alternatives, quicker access to educational and medical facilities, and more opportunity to interact with individuals from all backgrounds in vibrant public spaces. However, city dwellers are subjected to

undesirable conditions such as air pollution, visual blight, congestion, and noise. Growing up in a city has been related to an increased risk of chronic stress, which can result in diseases including anxiety disorders, depression, and coronary heart disease (Fleury-Bahi et al., 2016, p. 127) .

Researchers and policymakers have emphasized the need of creating citizen-friendly urban settings that enhance well-being, health, and quality of life. One method is to provide access to nature at various scales (Collado et al., 2017).

human's interaction with the environment is bidirectional; just as people alters the environment to maximize its potential, the environment reacts to these changes by impacting the audience's body and mind. These impacts will be maximized when we have a firm grasp on this link and use cognition to modify our living environment.

2.3 The mutual impact of man and the environment

Structures, whether built or natural, have an impact on individuals. At one point in time, it was assumed that the built environment influenced the character of life. When that viewpoint crumbled, the natural reaction was to claim that the environment had no effect. However, each viewpoint is based on the falsehood of the other. The organism and its surroundings interact; the environment is both social and physical. One cannot foresee a man's nature based on the landscape in which he or she lives, nor can one predict what the person would do or feel based on the landscape. As people increase and their technology begins to dominate the globe, land organization becomes increasingly vital to the quality of human lives (Lynch et al., 1984).

In the 1950s and 1960s, social scientists in the United States began to investigate the built environment and its relevance to human behavior and experience (Bechtel & Churchman, 2003, p. 3). In response to inquiries from psychiatrists and architects about how to improve the design of mental wards, Canadian psychologists Osmond and Sommer and New York psychologists Proshansky and his colleagues Ittelson and Rivlin began to investigate how the design of these settings influences' patient behavior.

Because social scientists have typically focused on individuals and their experiences, most of the study focused on the built environment as an independent variable, or context. An architect was one early researcher who considered the environment as a dependent variable, that is, as the result of human actions. Rapoport investigated variations in home shapes caused by cultural and climatic variables using an anthropological approach. Architects, planners, and urban designers became aware during the 1960s and 1970s that many modernist tenets of city and building design were causing serious problems for daily life; this encouraged building professionals to gain a better understanding of human responses to the designed environment, for which they turned to social scientists and their research methods. Environmental psychology, ecological psychology, environmental sociology, environmental anthropology, human ecology, social ecology, man-environment (and then person-environment) studies, environment behavior studies, and environmental design research are some of the descriptive names that have emerged to delineate the field.

Researchers understand that the built environment and human behavior and experience interact—that the environment does not drive human behavior and experience, and that any effect it does have is most likely influenced by a variety of other variables. The constructed environment is acknowledged to be adaptive, to vary through time, and to contain both permanent, semifixed, and moveable elements (Franck, 2005).

The built environment is continually affecting the human mind and mental health, either directly or indirectly. For instance, high-rise residential structures are incompatible with the psychological health of

mothers with young children or Alzheimer's patients; surroundings with smaller dimensions and lower levels of environmental stimulation are more compatible (Evans, 2003).

In terms of the influence of physical and environmental factors on stress reduction, the restorative theory may be investigated via two basic theories that address both mental fatigue and stress: (1) the restorative theory and (2) the restorative model. Researchers Ulrich et al. (1991) investigated the improvement of stress in interactions with the natural environment, resulting in the Stress Recovery Theory (SRT). Researchers also investigated the effects of the environment on conscious and directional focus and mental fatigue, resulting in the Attention Restorative Theory (ART). Natural surroundings, according to both ideas, protect individuals from the stressful impacts of the environment and provide more physiological, emotional, and concentration restoration than urban ones (Berto, 2014). To build restorative environments, it may be necessary to make changes to the current environment. In general, past study has focused on the addition of greenery to the built environment; nevertheless, it seems that one of the most effective methods to transform existing environments, whether worn out or historic, is to re-use the facilities that are already there. In the context of building renovation, adaptive re-use is described as a procedure that may greatly enhance an existing structure in terms of its economic, social, and environmental performance. A building's constant reuse in this context goes beyond fulfilling new user requirements and adapting its body to the surrounding social, economic, and environmental demands; it also goes farther by taking use of restorative characteristics and settings, which are not always possible in older buildings. Restorative strives to address the psychological requirements of users, and adaptation with the goal of having a good influence on the audience, which will be referred to as a restorative adaptable environment in the future.

The study of restorative environments started with Kaplan and Kaplan (1989), and continued with Ulrich's (1991) studies of stress, following that many researchers in recent years, have focused on those theories. Hartig and his colleagues started researching restorative environments in 1991 and have since undertaken research in a variety of sectors, including restorative environments for people's favorite places. Their research has mostly focused on urban and natural settings; some of the findings from these studies may be seen in Berto's (2014) review paper on the relevance and function of the natural environment in stress management. Additionally, in 2018, Weber and Trojan conducted a study of current studies to explore the characteristics and significance of urban restorative value.

Preferred and environmental preferences, as well as the restorative effects of natural environments for mental fatigue and stress, develop traits such that when an environment has these features, it is referred to be a restorative environment. Numerous studies have claimed that they did not necessarily focus on this idea, but the word content of the restorative environment matches Kaplan's attention restorative theory. As indicated before, this dissertation will concentrate on these two perspectives.

2.4 Restorative environments

The environment has the potential to influence a person's thoughts, attitude, and performance. This influence might be harmful or restorative. A person experiences a variety of emotions during their everyday lives, including nervousness, anger, anxiety, and sadness, and the environment has the ability to readily elicit and exacerbate these feelings, as well as to enhance these emotions and mental condition (Berto, 2014).

The environment may readily induce the word "stress" in a person, since it indicates an imbalance between the environment's demands on the individual and his capacity to meet or understand them (Bechtel & Churchman, 2003, p. 670). Stress is the psychological, physiological, and often behavioral response of an individual to a circumstance that challenges or threatens their well-being (Ulrich et al., 1991). One of the types of stress that has become especially important in our lives today is chronic stress. With chronic stress, the arousal in a person never disappears completely (Buckle, 2015).

By expanding research on topics such as landscape beauty and the psychological benefits of experiencing a pristine natural environment, environmental psychologists suggest the characteristics and quality of environments that, when removed from demands, promote recovery for a longer period than the initial period (Hartig, 2017). Spending time in a park, garden, plant-filled room, or even viewing street trees from a window may help a person psychologically disengage from the responsibilities of daily life and focus on something pleasant and intriguing (Collado et al., 2017).

Another theory that was paired with stress and emphasized the environment's restorative influence on it is mental exhaustion. At the conclusion of a period of hard work and long work days, man desires time off and rest. This sense of fatigue may strike you after just a few hours, when you are under the strain of a project or a time of concern and anxiety, or when you are managing many difficulties concurrently. Typically, this exhaustion is not physical, and one may even suffer from a deficiency of physical exercise. This is actually mental fatigue. The concept of stress can sometimes be confused with mental fatigue, but these are two separate categories. Stress occurs when the risk of harming or threatening a situation is predicted; While mental fatigue may occur in situations even where the person enjoys performing a particular task (Kaplan & Kaplan, 1989, p. 178).

To alleviate this sense of fatigue, you must rest to allow the body to repair and restore. All restoration experiences take place throughout the activity, and all activities take place in the natural setting. Restorative processes are not always environment-specific, although they may occur more readily or peacefully in certain activities and locations. Restorative environments are ones that relieve mental fatigue and stress. We are referring to the recovery or restoration of resources or adaptive capacities that have been exhausted as a result of fulfilling the demands of daily living.

As humans constantly rely on their physical, mental, and social resources and pay the price for adjusting to stressful situations, there is a perpetual need for repair. Since a result, repair is critical, as new demands develop and resources must be replenished to satisfy them (Collado et al., 2017).

In the long run, the inability to replenish depleted resources can have serious consequences for effective functioning, emotional well-being and health in the broader sense, mental and physical. Rehabilitation environment applications can provide psychotherapy or rehabilitation goals as defined by a health professional. However, psychotherapy is often involved with capacities that a person has never had. Therefore, it can be retrieved only according to the normative criteria of certain people. Alternatively, psychotherapy and rehabilitation may focus on capacities lost due to an accident or certain pathological stages, rather than on the normal process of adapting to an environment. This means that the theory and applications of restorative environments have a wider range of psychotherapy and rehabilitation in general. "They do not necessarily exclude relatively unusual events, but their scope extends to situations that reflect natural comfort" (Hartig, 2017).

The effect that physical and environmental conditions can have on reducing stress and helping to restore and improve the resources needed can be discussed through two main theories that focus on both mental fatigue and stress. Studies by Ulrich et al. (1991) focus on improving stress in interaction with the natural environment. His research is known as Stress Recovery Theory (SRT). Kaplan's (1995) study, which revolves around the effect of restorative environment on concentration and directional attention and mental fatigue, is also known as ART theory. "It protects against the effects of environmental stressors and offers more physiological, emotional and attention restorations than urban environments."

2.4.1. Attention Restoration Theory (ART)

When the pressure of life on people reaches a critical point, they feel the need to "get away from all situations" and "escape" from that situation. This interpretation implies the need of altering one's condition and location, which is sometimes overlooked, and it is critical to pay close attention to this alteration of space, and particularly to the goal of this escape. One may seek shelter in a variety of locations to avoid this sensation, but many of them are incapable of resolving the fatigue. While being away is a required requirement for repair, it is not sufficient, since several characteristics impact this characteristic (1989, Kaplan & Kaplan, p. 177). By Kaplan and Kaplan (1989), which were subsequently expanded to artificial settings. In fact, the characteristics that make a natural environment restorative, if present in any other environment, may be restorative of this fatigue.

The notion of attention restoration is a well-known concept in the area of restorative environments. Indeed, Rachel and Stephen Kaplan initiated a 12-year study endeavor in the early 1970s that resulted in the concept of attention restoration (ART). They initially articulated this thesis in 1989 in the book of the experience of nature (1989). The authors of this book take a wide look at their long-term study on the link between human and environment, which includes discussions of perception and visual preferences in addition to restorative experiences.

The main hypothesis in attention restoration theory is that humans have a limited capacity to pay attention to less attractive things. Believers in this theory believe that the cognitive mechanism needed to control or inhibit certain stimuli is called the central executor (Kaplan and Berman, 2010). Exhaustion of the central executor results in fatigue of the directional nerves. According to attention restoration theory, the environment may influence this tiredness, particularly when specific features of the link between people and the environment exist. These features are some of the topics that attention restoration theory researchers have addressed in their numerous studies, including the Kaplan and Talbot (1995) classifications for indicators of restorative environments, which are described later in this section.

2.4.2 Theory of psychological evolution, Stress Recovery Theory (SRT)

Ulrich was the first researcher to develop the Stress Recovery Theory. According to Zajonc (1983), early responses of individuals to their surroundings, including emotional and general impacts (such as interest or hatred), occur without conscious cognition or processing of information about the environment's perception. When specific environmental preferences or traits are reacted to, favorable emotional responses emerge. These include the presence of natural elements such as vegetation, as well as structural and aesthetic elements such as geometry, depth indicators, spatiality, curving landscapes, and security.

This idea presumes that specific settings may help humans cope with stress, which is one of the expressions of an evolved emotional system. It is believed that the process of reducing stress begins with the good emotional effect of seeing mild, engaging, pleasant, and peaceful situations. According to this

idea, common landscape characteristics such as shape, tree distribution, monolithic grassland, or the presence of water are likely to invoke restorative characteristics of the environment, since these landscapes are comparable to the early conditions of human evolution. As a result, this hypothesis is characterized as an evolutionary psychology theory. Ulrich (1991) and others have done various tests to test the hypothesis of stress recovery theory (Parsons, Tassinary, Ulrich, Helb & Alexander 1998; Harting, Davis & Garling 2003).

One of them is the positive effect theory, which asserts that some environmental stimuli have an effect on negative ideas by activating more positive and complete ones. Experiments have been conducted to demonstrate the beneficial benefits of nature on lowering emotions of anger, stress, fatigue, and depression (Sagy, Bauer, Lindstrom, and Espnes 2017).

Indeed, although each of these two theories highlights a distinct restorative structure, they both point to the environment's restorative impact on users through stimulation of an emotional receptor. While stress recovery theory stresses the relevance of fast and emotion-driven cognitive processes, attention restoration theory highlights the necessity of slow cognitive mechanisms. In fact, "the greater the environment's capacity to alleviate anxiety and stress, the more secure and relaxed it is, as stress recovery theory suggests." Additionally, the higher the environment's capacity to refocus attention, as the theory of attention restoration implies, the more stimuli impacting perception have a stronger influence on cognitive resources and free up more space for their function (Ashtak et al., 2017).

Ulrich introduces individuals who have experienced this emotion as a result of a stressful film to both the natural and urban environments, comparing the difference and restorative impact of the built and natural environments. He makes the point that unconscious attention and fascination alone cannot indicate that an environment has been restorative, because a person's exposure to heights or, for example, a snake, even if it is in a natural bed and accompanied by involuntary attention, cannot indicate that an environment has been repaired. Is more a source of tension than a source of rest (1991, Ulrich et al.).

A positive initial affective response, comprised of liking and moderate to high interest, should motivate and sustain prolonged attention/intake, produce higher levels of positive feelings, reduce negatively-toned or stress-related feelings such as fear and anger, and suppress stressful or extraneous thoughts (Ulrich, 1981, 1983).

Identifying the restorative effects of various environments and the characteristics of a restorative environment can be critical in determining which features an environment should include to be classified as a restorative environment and the restorative effects the environment has on its various users. According to Kaplan and Talbot (1995), a restorative setting has four indicators:

2.5 Characteristics of restorative environments

Kaplan and Kaplan (1989), in addition to the characteristics that the environment necessarily has for restorative properties and are included in the characteristics of preferred environments, list four main characteristics for restorative environments, each of which is defined.

2.5.1 *Being Away*

When people are looking for a recovery experience, they talk about the need to "get away" or "run away," and that can mean a change and a break. Escaping usually means not having the parts of life that normally exist and probably not always being preferred. Examples include escaping the hustle and bustle, everyday

life or noise. Another type of escape can be skipping daily chores. "And the third state, which is more similar to the principle, is when a person is tired of advancing and pursuing a specific goal that requires a lot of mental work and needs to rest" (Kaplan & Kaplan, 1989, p. 183).

"Being away requires more conceptual than physical transformation. A new or different environment, while potentially useful, is not necessary. Change the direction of a person's gaze, or even a different look at the previous environment can make the necessary conceptual change" (Kaplan, 1995).

2.5.2 Other environments and Extent

"It is unlikely that seeking sanctuary in a telephone booth or a prison cell would be beneficial. While these settings satisfy the need for change, they are extremely constrained. While the term "a totally different environment" is often used to refer to a restorative situation, the two most critical features are its correlation and extent, which combined provide significance to the idea of extent (Kaplan & Kaplan, 1989). "A restorative environment should be sufficiently complex and cohesive to give an audience with something to observe and experience, as well as enough thinking to cleanse the mind of other ideas."

2.5.3 Fascination

"In addition to the need for extent, another element that has been forgotten in many related topics is the source of attention and attractiveness. In fact, the attractiveness of a category attracts involuntary attention. "The importance of this issue is not only because it makes the environment attractive and interesting, but also because it allows the individual to function properly without the need for directional focus." (Kaplan & Kaplan, 1989, pp. 184,185)

Fascination can likewise be derived from extremes along a 'soft-hard' dimension. Thus, there is the 'hard' appeal of watching motor racing and the 'soft' fascination of wandering in a natural setting. Soft fascination, which is characteristic of some natural environments, has a specific advantage in terms of offering a chance for reflection, which can further boost the advantages of recovering from directed attention fatigue (Kaplan, 1993).

2.5.4 Complexity

As seen in the section on preferred environments, Ulrich emphasizes the significance of complexity in environmental preferences. The amount of independently seen aspects in a situation is referred to as its complexity. High complexity is connected with a large number of elements and element dissimilarity. Complexity has long been a prominent variable in experimental aesthetics, with findings from multiple laboratory investigations utilizing randomly generated, unstructured arrays indicating that aesthetic preference or pleasantness is related to complexity in an Inverted-U-shaped manner (Ulrich, 1983).

2.6 BE characteristics affecting perceived restorativeness

2.6.1 Structural properties

Natural stimuli can be structured in a variety of ways, including the existence of homogenous textures, redundant elements, element groups, and qualities that give continuity among separated or different pieces. Patterning that provides a focal point in the scene might be very important.

Meetings with highly organized scenes should elicit both like and intense interest. Because the perspective contains a considerable lot of information about the surrounding environment relevant to adaptive functioning, a vast vista of organized high complexity should inspire relatively substantial attention and liking. Initial sentiments of intense liking/pleasantness would create approach impulses and physiological arousal, which would maintain the observer's following activities. The idea that structural or

organizational features impact aesthetic choice is also prevalent in Gestalt theory and intuitive design and art literature, where ideas like "harmony" and "composition" have long been stressed (Ulrich, 1983).

2.6.2 Focality

Focality is a variable that appears to tap an essential gross structural attribute and is far less broad than the previous concepts. The degree to which a scene has a focal point, or an area that draws the observer's attention, is referred to as focality. It appears when textures, landform curves, and other patterns draw the observer's attention to a certain section of the scene.

A conspicuous feature, or combination of characteristics, can also generate a point or subarea of dominance that draws the viewer's attention. A significant benefit of focality over other structural factors is that it may be used to scenarios ranging from very simple to highly complex (Ulrich, 1977).

2.6.3 Depth/spaciousness

Influences both the immediate emotive reaction to a situation and the subsequent process of cognitive judgment. This varies from the commonly held belief that depth is solely an assumed feature requiring significant intellect. It is theorized that a lack of depth (e.g., an optically impenetrable foreground directly ahead of the spectator) might be a terrible ambience that swiftly generates hate and uneasiness with minimum thought. Settings with multiple depth signals and clear spatial definition enable cognitive evaluation, generate more environmental information, and should thus be preferred (Ulrich, 1983).

2.6.4 Ground surface texture

Textures that characterize ground surfaces in the natural world are critical in identifying depth, and they may have a major impact on cognitive assessment after the first emotional reaction. Textural gradients in the ground can play a significant role in depth perception, and the type of a textural surface has a significant impact on the accuracy of depth estimates. Ground surface textures influence the complexity and organization of the two-dimensional visual array, in addition to affects on depth perception and assessments of mobility opportunities. Scruffy, uneven textures in scenes offer the spectator with an unorganized high complexity that works against preference (Ulrich, 1983).

2.6.5 Threat/Tension

Natural circumstances defined by threat or risk should provoke dislike and frequently terror, resulting in adaptive avoidance, according to an evident implication of the viewpoint that impacts drive adaptive conduct. If harmful or threatening aspects are close to the viewer and visible, they should prompt rapid action. In this setting, the conventional concept that emotions are only the outcome of cognitive judgment makes little sense (Ulrich, 1983).

2.6.6 Deflected vistas

Authors from several areas have noted that when the line of sight in a natural or urban context is bent or curved, it signals that fresh landscape information is just beyond the visual limitations imposed by the observer's location. Because this trait is primarily cognitive, it is unlikely to have a significant role in the first emotional reaction. S. and R. Kaplan describe "mystery" as a "promise of knowledge" connected with an anticipated shift in vantage point, which is essentially the same quality. Only when the observer believes that additional information may be obtained at a minimal risk will diverted sight lines or mystery be positively associated to preference (Ulrich, 1983).

2.6.7 Water

Water has been defined as a landscape feature that inspires attention, aesthetic pleasantness, and good sentiments such as tranquillity in a huge corpus of intuitive literature (e.g., Hubbard & Kimball, 1967). Although some water phenomena can elicit negative affective reactions (for example, a stormy sea or a lake dotted with chemical foam pollution), a consistent finding in the experimental literature is that scenes with water features are usually accorded especially high levels of preference or pleasantness. Water is a type or dimension of environmental material that creates ambiances that are good at triggering emotive reactions rapidly.

In short, all cases can be stated as follows:

- The environment is of medium or high complexity.
- This complexity has a structural feature that creates a focal point and has other patterns and structural systems.
- Have a medium to large depth, which can be understood without ambiguity.
- The surface texture of the ground should be homogeneous, inclined to uniform and be evaluated as suitable for movement.
- Have a diverse eye-catching view.
- There is no known or insignificant threat or danger.
- The presence of a water will increase the interest and preference of the audience.

If any of these characteristics are absent, for example, if the flooring is hard and uneven and mobility is restricted, the atmosphere will be unpleasant. (1983, Ulrich)

To determine their efficacy, the majority of research on restorative settings have examined the restorative effects of built and natural surroundings or have merged their ideas with others such as biophilia or salutogenic. Few investigations have resulted in the development of suggestions, additional points, and novel features for remedial situations. However, a review of other papers revealed numerous other characteristics.

2.6.8 Beauty

Beauty blends the ART process-oriented characteristics of Fascination and Extent with the aesthetics-oriented dimension. Previous empirical work on restorative settings has either portrayed content as a nature vs. non-nature comparison or taken nature as the sole context depicted. We observe not just natural beauty, but also various other types of beauty exhibited here. "Community membership," for example, reflects a higher conceptual beauty. The combination of attraction, scope, and aesthetic characteristics well captures the ART notion of "soft fascination" and its importance in the context of contemplation. This shows the potential significance of soft fascination research, as well as the importance of incorporating this notion more prominently into the ART framework. Ouellette et al. (2005) and Ryan et al. (1998) also mentioned the effect of materials such as stone in their study of restoration environments.

2.6.9 Existence of natural elements

Psychological and physical studies on the psycho-physical impacts of wood inside have shown that these places are related with a larger decrease in stress than non-wood indoor environments. Thus, by expanding the use of wood in architecture and incorporating good aspects of nature into the artificial environment, such as restorative environmental design, building designers may increase the inhabitants' well-being.

Wood is an excellent material for a restorative environment because it satisfies both the broad criteria of a sustainable design pattern and a connection to nature. Psycho-physiological research on wood in the built environment supports the notion that wood utilization benefits the audience's health. Although few research have explored the healing capabilities of wood directly, there are several examples of how the usage of wood helps inhabitants' health and well-being (Burnard & Kutnar,2015).

2.6.10 Nearby nature

"The wilderness evokes sentiments of awe and amazement, and direct interaction with it prompts thoughts about spiritual meanings and everlasting processes. Individuals feel more familiar with their own thoughts and feelings, and they feel 'different' in some manner - calmer, at peace with themselves, 'more beautiful on the inside and unstified.'" (Kaplan & Kaplan, 1989, p. 141) The term "nature" is frequently reserved for regions that have not been influenced by humans, feature trees and other plants, and cover a large area. People are often aware of how significant nature is to them. Even if there is just a small quantity of "nature" around, they value having regular touch with it.

Frey's research gave more evidence that the impacts of local nature extend beyond people's reactions to the physical context. Several questions about life happiness were included in her study. Each of the six neighborhood satisfaction categories was found to be strongly connected to an individual's reported level of life satisfaction. In other words, persons who engaged in gardening and other nature-related activities near their houses reported higher levels of neighborhood and life happiness.

"Stress management" has become an accepted need in the workplace, and firms have spent large sums on employee stress programs. An examination of such techniques, however, reveals a complete disregard for the significance of the natural environment. The findings of the different research give compelling evidence that being close to nature provides a wide variety of psychological and physical advantages. People are more content with their houses, careers, and lives when they have enough access to nature in the urban environment.

People love natural surroundings because they give a variety of possibilities to wander, view, and ponder. They are not always conscious of the various types of interactions they have with nature or the diversity of advantages that arise. The Job Pressures Project outcomes have been very consistent with our predictions. Access to nature at work is associated with lower levels of reported job stress and better levels of job satisfaction.

Workers with a view of natural elements, such as trees and flowers, were less stressed and were happier with their occupations, according to the findings, than those with no outside view or who could only see constructed features from their window. Furthermore, employees who had a positive attitude toward nature reported fewer illnesses and headaches. As we have seen, nearby nature does not have to be a large region. Indeed, even a few trees, or a view from a window at home or at work, may give happiness (Kaplan & Kaplan, 1989, pp. 157-163).

2.7 Environmental preference

The environment in terms of positive impact can be studied and evaluated with different names, approaches and theories, including preferential and restorative environments. What is said about environments, both in the theory that Kaplan and Kaplan (1989) and in the view of Ulrich et al. (1991), is that the restorative foundation of an environment and its positive effect on reducing stress or increase attention, whether in the natural or built environment, is to prefer these environments. Preference in

environment is a prerequisite for being in the category of restorative environments, but it is certainly not enough.

Preference is strongly intertwined to fundamental issues. Preference, we believe, is a manifestation of fundamental human wants. Preference is predicted to be stronger in environments where an organism is likely to thrive and decrease in environments where it may be injured or made useless. Thus, humans, like other animals, choose environments in which they can operate efficiently.

Various environmental theories have argued that environmental choice is reflective of perceptual systems that allow the individual to determine whether a specific environment should be addressed or avoided, often in a very quick and automated manner. According to this theory, environmental preferences are determined by environmental features that may have a functional meaning for the perceiver. Perceiving walkable grounds, for example, may evoke a favorable evaluative response since the presence of an accessible escape path may reduce the likelihood that predators would injure the individual. The preceding logic can explain why environmental choice and restoration may be connected. Particularly for individuals who are feeling weak or low, environmental affordances for restoration should have great adaptive value (van den Berg et al., 2003) .

Although people rely primarily on vision to perceive their surroundings, new research indicates that ambient noises can play an important role in healing experiences in both indoor and outdoor settings. The findings were consistent with prior research on visual stimuli, and nature sounds were assessed to have greater healing power than urban sounds (Shu & Ma, 2018).

According to the study, simulated natural landscapes are more beautiful than simulated built environments. Furthermore, natural habitats have been shown to have greater restorative effects than built environments. The current study indicated that exposure to nature was related with more favorably toned changes in mood states and slightly higher performance on a concentration test than exposure to the built environment (van den Berg et al., 2003). Based on the experiments and findings in the field of environmental preferences, Kaplan has obtained a matrix that can be used to assess the extent of environmental preferences.

- **Informational factors in preference**

The Preference Matrix has been concerned with the two main informational demands - understanding and exploration - as well as a dimension that takes into account how easily accessible the information is. Combining these two domains results in four unique combinations, or patterns (Table 1).

Understanding refers to people's need to make sense of their surroundings, to grasp what is going on around them. Understanding gives you a sense of security. People might get concerned when they can not grasp a scenario. Understanding, on the other hand, is insufficient. People desire to travel, broaden their horizons, and discover what is ahead. They want further information and new challenges (Ryan et al., 1998, p. 10).

The sensation that there is something more than what the eye sees or hears while entering space; And it will be understandable. A new perspective is awaiting discovery (Lynch & Studies, 1960, p. 2). Additionally, as an assumption from data that will occur with some time and acquaintance with space. Each has a forecast about the surroundings and what awaits them, which will take the shape of immediate and inferred predictions. The combination of exploration and comprehension, as well as their dimensions, which represent the amount of immediate and inferred access to knowledge, results in four patterns that constitute the following preference matrix.

Table 1 Preference matrix (Kaplan & Kaplan, 1989, p. 52)

	Understanding	Exploration
Immediate	Coherence	Complexity
Inferred, predicted	Legibility	Mystery

These combinations, or informative factors, are given names in the landscape evaluation literature. However, it is crucial to note that these criteria have been defined in a variety of ways. The context of the matrix has a significant impact on our utilization. In other words, we consider these aspects in terms of how they aid understanding or exploration, as well as a two- or three-dimensional examination of the picture. To investigate the environmental features or aspects of how the environmental scene is arranged that assist determine each of these four combinations.

Coherence and complexity are the two-dimensional plane-based informational characteristics. They both entail direct awareness of the scene's aspects in terms of quantity, grouping, and location. Legibility and mystery, on the other hand, necessitate the use of the third dimension. When individuals see situations, they not only infer a third dimension, but they also envision themselves in the scenario. These two aspects require inferring what it would be like to be in the represented place.

As the table shows, coherence and legibility have one thing in common: they both convey information that might aid in making sense of the environment. A well-organized and differentiated setting is easy to comprehend. Complexity and mystery, on the other hand, are concerned with information that offers the possibility of investigation, either because of the diversity of the elements or because of indications that suggest there may be more to observe. Although the four informational variables work together in the context of a scene or setting, it is helpful to study them one at a time for clarification (Ryan et al., 1998). So accordingly, we can conclude the characteristics of preferred environments as:

2.7.1 Complexity

This informative aspect has been emphasized by two very distinct disciplinary traditions. For many years, psychologists interested in aesthetics focused on the importance of complexity. The primary conclusion of this "experimental aesthetics" investigation, which used intentionally produced stimulus patterns, was that individuals prefer patterns that are neither at the high nor low end of the complexity continuum.

The other complexity-focused tradition varies in two crucial ways. The emphasis has been on the environment rather than artificial stimuli, and the approach is not research-based. Many of the visual resource management methods employed by federal land agencies presume that variety is an essential component of scenic beauty; settings with more diversity obtain better scores in these scoring systems.

Complexity is described in the research under examination here in terms of the number of various visual features in a picture; how detailed the scene is; and its richness. Thus, it indicates how much is going on in a given scene, how much there is to look at - concerns that rely on the image plane rather than depth signals. Clearly, when there is more diversity in the scene, when there is the sense that there are more distinct things accessible, exploration is improved. Complexity, it may be said, gives substance or something to ponder about (Kaplan & Kaplan, 1989, p. 54).

2.7.2 Coherence

This informative element has gotten little attention. Coherence, in our opinion, aids in maintaining order and directing attention. A cohesive scene is well-organized and holds together. Anything that helps arrange the scene's patterns of brightness, size, and texture into a few primary units improves coherence. Repeated components and textural consistency, both instances of redundancy, aid in delineating a region or area of the image plane.

Coherence, like Complexity, requires little inference and relies on the two-dimensional nature of the situation. A consistent atmosphere aids one's capacity to make sense of one's surroundings. An ordered setting is easy to comprehend; it could not be more enticing to explore. It's worth thinking about the trade-offs between coherence and complexity. A cluttered environment may appear to be unnecessarily complicated. Given this framework, it is more likely that it lacks coherence. It is crucial to note, however, that a scene might have both a high Complexity and a high Coherence (Kaplan & Kaplan, 1989, p. 55).

Table 2 Matrix of Complexity and Coherence

	Complexity	
	Low	High
Coherence		
Low	Not much there	Visually messy
High	Clear and simple (boring)	Rich and organized

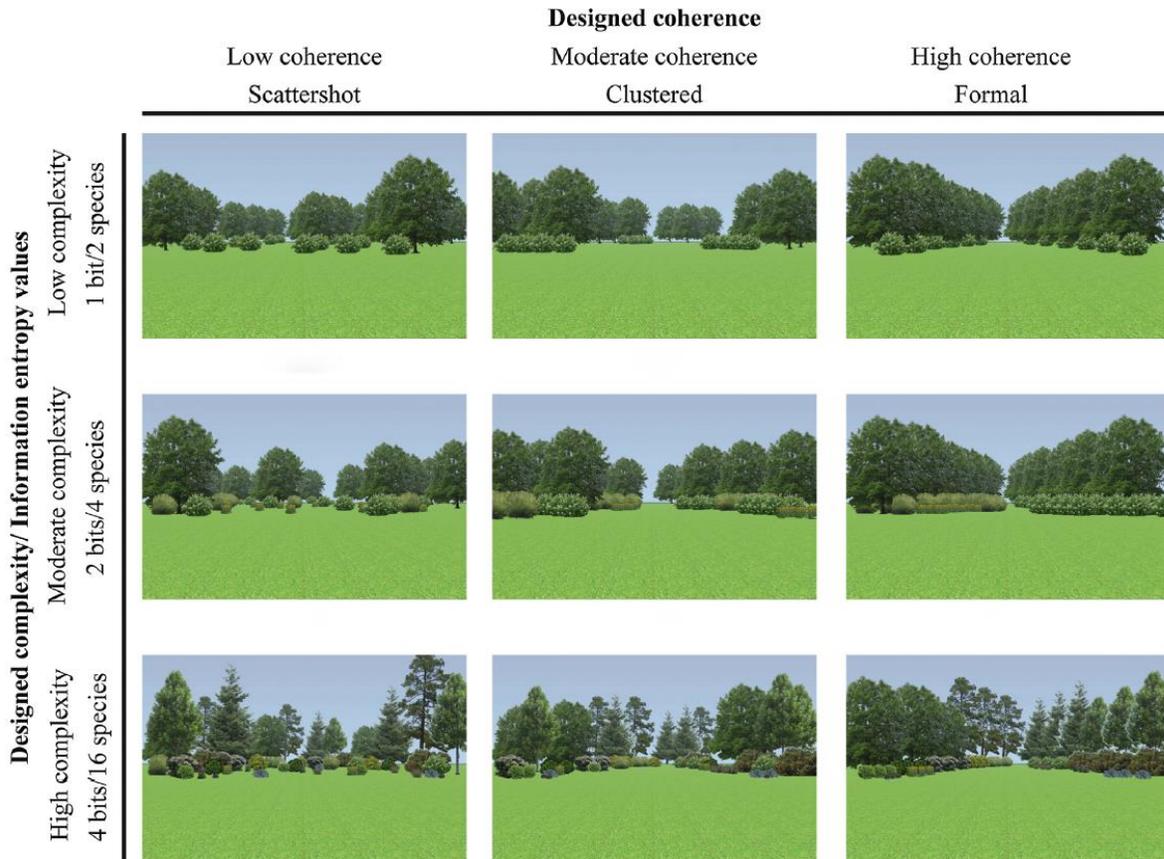


Figure 1 Digital model of coherence/complexity designed by Rob Kuper (2016)

2.7.3 Legibility

Lynch studied the mental picture of the American metropolis held by its residents to determine the visual quality of that city. He focused in particular on one aesthetic quality: the perceived clarity or "Legibility" of the cityscape. He implies the ease with which its pieces may be identified and grouped into a cohesive pattern/Just as a readable printed page can be visually understood as a linked pattern of identifiable symbols, so a legible. The environmental image is the generalized mental picture of the outer physical world that an individual holds in the process of way-finding.

A clear picture, obviously, allows one to move about effortlessly and swiftly. Indeed, an unique and visible environment not only provides protection, but it also increases the potential depth and intensity of human experience (Lynch, 1960).

Lynch's concept of legibility encompasses all of what we call comprehension, because he emphasizes the need of both coherence and organization. However, in his study of legibility, he demonstrated the importance of orientation and way-finding to the ability to create a mental map of the environment.

Lynch's word for this more structural (and inferential) part of comprehension is used here. A readable place is one that is simple to comprehend and recall. It is a well-structured area with identifiable features, making it simple to navigate both within the scene and back to the starting place. Legibility thus implies a promise or prognosis of the ability to comprehend as well as operate successfully.

Landmarks and areas that are distinct and significant (concepts for which Lynch gave perceptual analysis) are key help in obtaining readability. These aid in the formation of a cognitive map and the "memorability"

of a scene (or city, for Lynch). Such distinguishing aspects or locations are especially important in conveying the impression that one can perceive and maneuver efficiently within the environment (Kaplan & Kaplan, 1989, p. 56).

2.7.4 Mystery

This informative aspect likewise incorporates promise, but this time it is the promise of learning more. Something about the location draws one in, pushes one to enter and explore forth, offering an opportunity to learn something not immediately obvious from the initial vantage point. There are various ways in which sceneries or settings might imply that additional information is accessible. The curve in the front path and a brightly lighted location partially concealed by foreground greenery are two famous examples. Even minor land-form changes, such as partial occlusion from plant, can heighten the sensation of mystery.

Thus, in order for Mystery (as described above) to exist, there must be a promise of further knowledge as one walks farther into the picture. This suggests that there would be a way to enter the scene, that there would be somewhere to go. It is critical to distinguish between mystery and surprise. A road that leads to a visible locked door implies surprise but not Mystery. For the latter, the shift in perspective must deliver knowledge that is consistent with what is previously known, rather than being unexpected. Given the continuity, one may generally come up with various different hypotheses for what one would uncover - in other words, there is both inference and exploration.

The prominent role Mystery has played in preference supports their claim that "it is a pleasant challenge to the imagination that sets the observer to trying to determine for himself by closer investigation what is concealed from his first glance, or, if this be impossible, to filling in and completing the unseen landscape according to the play of his own fancy." (Hubbard & Kimball, 1917, p. 82).

Such data show that choice necessitates at least a modicum of the attributes that allow for quick processing. A lack of Coherence makes it harder to grasp what is in front of you; a lack of Complexity reduces your chances of being involved in seeing. It is not always the case, however, that possessing more of these informative variables increases desire. However, there is a hint that "the more the merrier" for the two components that rely on stronger inference. More legibility increases confidence that the setting will remain comprehensible. More mystery entices deeper investigation.

2.8 Perceived restorativeness scale (PRS)

In 1996, PRS was first used. One of the primary goals of this scale is to provide designers with a measurement tool that can be used to examine the influence of current and potential settings on people (Ivarsson & Hagerhall 2008). Hartig et al. (1996) first established the Perceived Restorativeness Scale (PRS) based on ART to evaluate the visual environment that can enable attention recovery, which contains four subscales: being away, fascination, coherence, and compatibility. Over the previous 30 years, the PRS has been regularly enlarged and refined (Laumann, 2001 & Pasini et al., 2014) and has been frequently utilized in the restoration assessment of visual landscape contexts. According to the Italian version, restoration is carried out in a location where everything is in the right dimension (Coherence), without any time and/or space constraints (Scope), away from ordinary life (Being away), and with relaxed (Fascination) and pleasurable (Coherence) activities. Each attribute is graded on an 11-point scale, with 0 indicating "not at all," 6 indicating "quite a lot," and 10 indicating "completely" (Pasini et al. 2009). It should be noted that PRS has been modified multiple times.

Previous research has used photographic slides (Pasini, 2014), two-dimensional movies (Wang, 2016), and real-life settings (Garg et al., 2010 & Peschardt, 2013) to offer visual landscape-based environmental stimuli. Furthermore, visual scene preference has been the focus of attention recovery research. These investigations indicated the significance of structural aspects in the physical environment in assessing attention recovery, such as specific qualities, scene scale, plant percentage, and scene openness (Tabrizian, 2018). Previous study has also shown that the degree to which a scene is viewed as "natural" is the most important predictor of landscape preference, implying that the most essential component is the distinction between preferences for natural and man-made environments (Li 2022).

Hartig et al. (1997) developed the best-clarified and most simply accessible scale, with 26 items to describe human-environment connections and four subscales. These four features have been treated independently in order to provide a more comprehensive overview. Natural landscapes, according to respondents, are more favorable to attention recovery than artificial landscapes (van den Berg, 2003). Mikel et al. (2021) discovered, on the other hand, that urban squares with greenness reduced several negative emotional markers and contributed to attention restoration.

2.9 An overview of the characteristics of built environment and restorative settings

Some of the features mentioned so far, in appearance but different in concept, can be equated or perceived together and with almost similar meanings. Like the concept of Fascination that Kaplan expresses and the structure and focal point that Ulrich proposed. Therefore, in relation to summarizing and categorizing the items mentioned, it may be possible to divide the features into 3 categories: 1 (items that refer to the physical features of the space 2) items that affect the spatial features of the environment, 3 (items that They lie within the perceptual and perceptual concepts of the environment. Table below shows a summary of the items previously discussed.

Table 3 Restorative Environmental Characteristics

	Physical	Perceptual
Restorative Environments Characteristics	Focality	Extent
	Water	Being away
	Wood	Mystery
	Ground surface texture	Fascination
	Nearby nature	Coherence
	Deflected vistas	Complexity
	Depth	Legibility

Environment is composed of strong environmental qualities and characteristics - those environmental qualities and characteristics have an emotional effect on users. In academic studies on environmental psychology, these environmental characteristics are referred to as "environmental affective characteristics." These environmental characteristics trigger a variety of emotions and experiences in the users' emotional network (which is often compound but may be independent in certain situations), which is referred to as the "environmental influence on the user." According to studies and findings, the effective

quality of the environment has the largest influence on environmental attractiveness, both for experts and non-specialists, as well as for healthy and ill persons. As a result, "the physical quality of the environment should take efforts to develop an emotional quality comparable with the function of space in order to be successful in the direction of space's vitality and efficiency" (Daneshmand 2014).

Recent study has shown that beneficial environmental features not only influence and define users' emotional networks, but also may result in the short- or even long-term restoration of feelings such as anxiety, distress, or depression that impact a psychologically damaged individual. These effective environmental properties that can have a psychological restorative effect are called "environmental restorative qualities"; to such environments, "restorative environments" or "healing environments," and to this type of emotional effect is called restoration effects.

2.10 Exterior aspect of the restorative effect of the environment

The emphasis, in this perspective, is on the external environment components and aspects that have an influence on an individual's emotional network due to their effective emotional or restorative environmental properties. The emphasis of this approach is that by situating the individual within the environment, the landscape, together with its components and characteristics, presents an audience with a viewpoint that contains qualities that may have a restorative emotional impact on the individual. Researchers of this hypothesis, by separating the elements of the environment, try to investigate the emotional or restorative effect of each component of an environment as external stimuli on the users of the environment.

Generally, landscape components may be classified as soft or hard. Additionally, research has been conducted in this viewpoint on the function of each of these landscape types or their combination. Typically, hard landscape components such as pavement, stone, asphalt, ambient lighting elements, signs, benches, and chairs are physically integrated into the surroundings. Generally, audiences dislike hard elements. On the other hand, soft landscape materials are more desirable and include covering plants and trees, shrubs, flowers, grass, water and land. Regarding the emotional effect of soft landscapes, numerous results have been obtained from studies, including the following:

- The interaction between trees and space users is intricate (Braines, 2000). The juxtaposition of trees and the natural environment, on the other hand, may significantly relieve stress. (Adedeji, 2011)
- Soft landscape components such as the sound of birds, the seasonal display of fruit blossoms and the change of leaf color, offer the glory of nature and have a great impact on the feeling of the audience of the space (Azwar and Ghain, 2009)

How the restorative effect from the external aspect and finding the restorative structure of this emotional effect is a case that has been discussed a lot in recent studies and several theories have been presented in this regard. For example, one of the reasons for the restorative effect of an environment mentioned in research is to rest on directed attention. The gap between the "important" and the "interesting" has become wider in the contemporary world, to the point that today's individual, in order to keep personal peace of mind, must attempt to focus on the "essential" and avoid the "interesting" distractions. Slow and lacks direct attention (Kaplan, 1995).

2.11 The internal aspect of the restorative effect of the environment

Rather than concentrating on the influence of exterior components and elements, this perspective emphasizes the function of the audience's internal systems in relation to the surroundings and how they are affected. Much of the study in this field has been on the function of sensory neurotransmitters in response to environmental stimulation. In this respect, fatigue and adaptability are two critical aspects in the study of the neurological system of the body, and the internal component of the restorative impact of sensory nerve receptors has been addressed in view of these two factors.

Sensory neurotransmitters are divided into two categories based on adaptability:

- 1- Slow compromise receptors or tonic receptors
- 2- Rapid compromise receivers or fuzzy receivers or motion receivers or speed receivers (Gaiton and Hall 2016)

Meanwhile, several studies have shown that natural surroundings are more restorative than other types of environments. Experiments demonstrate that once subjects are exposed to simulations of natural and urban surroundings, their performance improves significantly in natural settings. (2012) (Clayton). These studies place more value on nature's restorative properties and regard nature as a potential facilitator of restoration (Hartig,2017).

Van den Berg's study shown that observing natural environments enhanced participants' moods and had a greater restorative impact on them in this respect (van den Berg, Koole, & van der Wulp, 2003). Ulrich also asserted in his psychoanalytic theory that natural surroundings might induce psychological and physiological changes that promote well-being, particularly in anxious individuals. This suggests that these places have a greater capacity for restorative activity. Additionally, experimental studies demonstrate that patients with a view of nature recover more quickly and easily than those with a view of a brick wall. In comparison to urban areas, seeing nature sights had a greater favorable effect on students' stress levels. Finally, it should be recognized that natural impacts may occur in a variety of professions, and the beneficial restorative effect of nature posters in workplaces, roadside greenery for motorists, or green space in a hospital waiting room is only partial. These are the outcomes (Clayton, 2012).

In this section, the two points previously briefly related to the effect of restorative environments on attention as well as stress will be addressed comprehensively.

2.12 How the restorative environment affects Kaplan's perspective

To describe the role of the restorative environment, Kaplan measures its effect on mental fatigue. For a person with mental fatigue, focusing on an issue that is low-attractive or high-responsibility may seem overwhelming, while focusing on a high-attractive topic may not be a chore. These two types of attention were given by Kaplan in 1989. "He considers them involuntary and involuntary concentration," William James was quoted as saying. In the first case, focus does not require a lot of energy and is created in situations where significant events have occurred or a particular topic has seemed interesting to the person. And in the case of voluntary focus, it counts for situations where an attempt is made to focus on a subject that is not interesting in itself. Kaplan calls this type of voluntary attention as directed attention (Kaplan & Kaplan, 1989, p. 179).

2.13 How the restorative environment affects from Ulrich's point of view

Ulrich's theory of stress recovery was originally known as Psycho-Evolutionary Theory, which states, "Because some natural environments have the characteristics and contents of visual stimuli that individuals are biologically and evolutionarily prepared to be aware that spending time in a natural environment or watching a natural scene more than urban environments can help people reduce stress. In addition to being non-threatening, these features include survival-related features, such as water and specific vegetation configurations, focal points, moderate depth of field, and average visual richness compared to other environments. Natural environments are not the only ones that enhance recovery, and not all natural environments are necessarily restorative. "However, most studies to date have examined the impact of contact with nature on performance, health and well-being of people compared to other environments." (Collado et al., 2017)

Also, the negative effects of stress can be measured in various laboratory and non-experimental methods. These methods can generally be divided into three main categories: 1) Neuropsychological methods or through physical changes in people who are affected by stress, such as Heart rate or transpiration rate, 2) changes in function or behavior, 3) through questionnaires and individual reports "(Berto, 2014). that using these methods can be compared with a predetermined environment, its effect Measure stress and even directional focus.

2.14 Conclusion

This chapter addressed the following research questions: What is a restorative environment, what are the restorative properties of the environment and how can they be achieved, and how do they work.

Additionally, this chapter discussed the significance of the interaction between effects of individual and the environment. As previously stated, the restorative environment, by virtue of its traits and characteristics, have the capacity to alleviate stress and mental fatigue and aid in focus. Additionally, it is possible to enhance the environment by using its natural and effective features, such as natural materials, and the presence of water in the area.

Here we will turn to integrating the two perspectives of stress and focus on restorative experiences. Because the Stress Theory of Ulrich et al. (1991) does not allow a significant role for attention, the integration challenge can be defined as the "development of stress theory" that allows such a role. Ulrich et al. Emphasize the reduction of concentration (and performance loss in general) as a result of stress. The proposed integration here, which focuses on the various factors that lead to stress, offers a completely different perspective on the role of reducing focus.

Most researchers distinguish between physiological and psychological theories of stress. The first concerns the response of the autonomic nervous system to injury or threat of injury. The second case focuses on cognitive assessment of whether the individual has the resources to deal with one. However, Kaplan (1995), quoting Fisher et al. (1984), makes the point that physiological and psychological stress reactions are interrelated and do not occur alone. In addition, they are used between negatives stimuli to create a stress response and those that require more information to be processed before the stress response occurs. According to both points, there is a difference in emphasizing the factors leading to the stress response. "We can accept that the stress response is a consistent stimulation of the organism to deal with a potentially negative situation" (Kaplan, 1995).

The graphic below illustrates the relationship between variables relevant to the restorative environment and the techniques for measuring these characteristics:

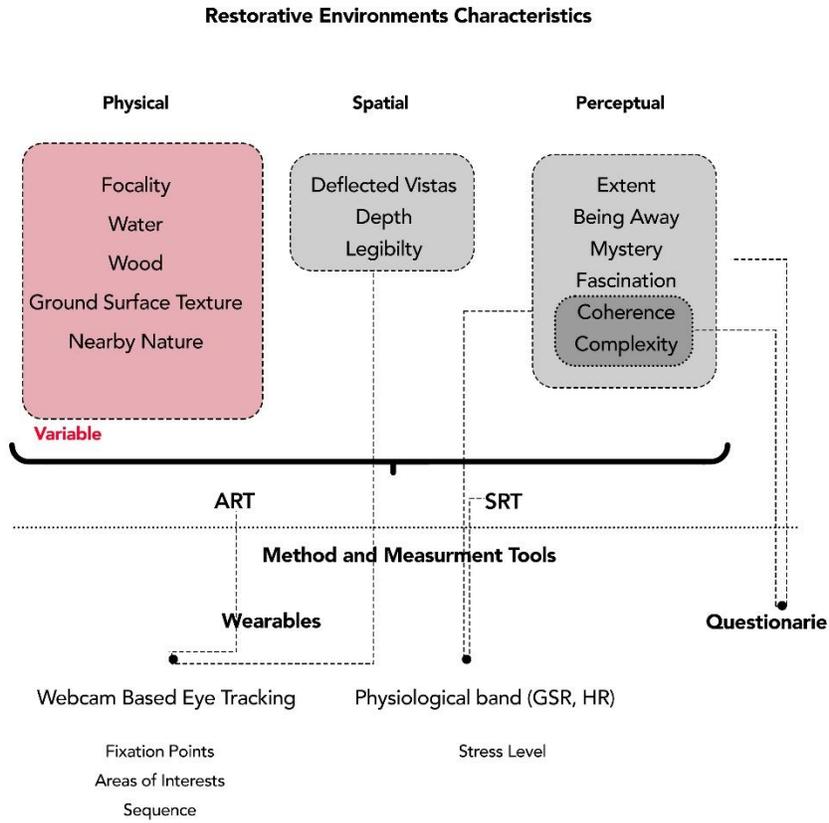


Figure 2 Proposed technique for evaluating restorativeness

Chapter III

3. Methodology

Due to the complexity and time commitment connected with the attendance of all participants in a research, various ways were used to get as close to the test as possible while saving time. The following are some of the methods and instruments used to collect data for this study. The experimental procedure is given in this section of the study. The design, participants, materials, method, measurements, and data analysis are all part of this. A stated preference experiment was planned and implemented both online and in lab utilizing VR headsets to collect data on how people experience public places as a function of spatial elements and how they rated the restorativeness of the environment.

To perform meaningful research, it is critical to first grasp the research problem. According to Hensher et al. (2015), the researcher must begin by asking, "Why is this research being conducted?" Irrelevant research questions can be avoided by answering this question first.

The primary goal of this research is to test which public space characteristics contribute to restorativeness contributing to the creation of a healthier society in the long term. The study ties attention restoration theory and stress recovery theory, which involves combining greenery with physical settings to create a more pleasant atmosphere. The research questions are: What are restorative environments and how do they affect people? What is perceived restorativeness and how can it be measured? Which built environment characteristics affect perceived restorativeness? How can these features be implemented in a virtual public square? Which of the environmental features have a higher restorative effect on the users of the environment? The research questions relevant to this study are stated in Chapter I. The first three research questions were addressed in the chapter II literature review. The answers to these questions give the context and theoretical basis for this study.

This study was conducted using two separate approaches: virtual reality and online questionnaires. In the digital twin laboratory, one group of volunteers used virtual reality headsets and went through the designed environments to conduct the experiments. The second group viewed recorded films of simulated environments while completing online surveys.

3.1 Virtual Reality (VR)

Virtual reality is a relatively new technology that enables users to interact with a computer-generated world. While the majority of virtual reality environments are built for human-computer interaction, a select few additionally include voice or touch sensors for user engagement. With virtual reality technology, individuals may get a decent picture of a computer-simulated environment, whether it is based on a real-world environment, an imagined environment, or a mix of the two. Virtual reality, sometimes referred to as immersive multimedia environments, may replicate a physical presence in one location and in either the actual or virtual worlds. As a result, simulated environments may be fairly comparable to real-world situations or quite unlike to what is observed in game worlds that are entirely fictional and controlled by the rules specified by the virtual environment's creators.



Figure 3 An example of a virtual reality headset application and placement in a simulated virtual environment.

The majority of virtual reality environments are largely visual and may be seen through a computer screen or a headset tool. Certain simulators include additional sensory data, such as sound creation. In more complex applications like the medical, gaming, and military sectors, touch technology devices include tactile information referred to as feedback forces. Virtual reality is a technique in which a virtual world is projected in front of the user's eyes and the user interacts with it via head and body movement. Indeed, a person feels as if he is in the world, and by shifting the position of its body, someone may move and observe in a more realistic setting.

Virtual reality's application domains are almost limitless, and everything that connects with reality may be connected to virtual reality. However, the deployment of this technology has been more striking in several sectors so far. Architecture, education, tourism, museums, entertainment, healthcare, aerospace, automotive, commerce, military and medical industries, and mental health are just few of the sectors covered.

Another sort of virtual reality is made using 360-degree panoramic photos and presents the entire realism of a genuine location to others. By photographing the desired environment in 360 degrees and synchronizing the images in related specialized software, or by using photogrammetric methods with images taken or filmed with the help of drones, the experimental environment will become a three-dimensional environment with textures that are close to reality. Another advantage of this form of presentation is the ability to combine it with virtual reality by observing them with VR headsets which can be used to place the intended 3D components in real-world situations that have been captured 360 degrees or photogrammetrically.

Thus, an environment in virtual reality may be classified according to its fundamental characteristics as follows:

1. Simulated real environment: A virtual environment that is simulated with 3D rendering software based on an existing real environment (see Figure 7).
2. Simulated imaginary environment: A virtual environment that has been simulated with 3D-making and rendering software based on an imaginary environment of a builder or designer, and such an environment does not exist in reality (see Figure 7).
3. A realistic 360-degree shooting environment is one that has been created using 360-degree photography, video recording, or photogrammetry, as well as the required equipment from a genuine environment, and whose texture is identical to that of the actual world (see Figure 7).

4. Hybrid environments: A virtual environment in which one of the preceding three kinds of settings serves as the foundation and, via the use of specialized software, at least one of the other three environments' attributes are added (See Figure 7).



Figure 4 An example of a variety of environments in virtual reality. The above category environments are presented in order from right to left.

The second category was utilized in this research and design case study. In a hypothetical city block, five attributes were designed and executed based on a review of relevant literature. Twin Motion, a 3D-modeling and rendering program, was used to create this simulated virtual environment based on the environmental restorativeness factors.

Alternatives that differ concurrently on a certain set of criteria were produced on the basis of an experimental design. Each respondent was presented with four alternatives. Each alternative was presented in the form of a video (included in the survey) that replicated a predetermined path through a virtual public space, and participants in the lab were free to explore the environment. After watching the video, respondents were asked to describe their thoughts and opinions on each alternative. In the laboratory, it was possible to confirm that all participants performed the research using the same computer and computer screen in equivalent conditions. In contrast, it is possible that online survey respondents answered the question using a variety of devices and in a number of contexts. This enabled the examination of potential differences between the two cases.

The online survey was implemented using the Limesurvey platform, an open-source web survey tool. Limesurvey enables users to create, publish, and collect responses to surveys via a web-based interface, without the need for programming.

3.2 Design

This research utilizes a stated preference experiment to collect data on perceived restorativeness, user emotions, and preferences of relevant public-space features. The street block is considered the spatial unit for potential alternatives. The primary public space in the experimental street block is rectangular and surrounded by residential buildings. There is a pedestrian walkway on both sides of the path. It is also worth noting that the architecture of the street block incorporates the foundations of restorative components, such as trees, water pools, and restorative materials based on literature study.

Stated preference experiments are a tool for gathering information about people's hypothetical preferences. There are various alternatives for hypothetical or actual circumstances (Louviere et al., 2000). There is more control over the available research attributes. Stated choice data can also be used to determine attribute preferences (Hensher et al., 2015). Next, for each option, determine which attributes will be included in the experiment. These features are the means by which alternatives can be characterized. Because of the use of an unlabeled experiment, the attributes of each alternative are identical. According to the literature, the attributes are the construction characteristics that this study will analyze. When choosing attributes, Hensher et al. (2015) warn against ambiguity and inter-attribute correlations. For reliable results, this should be avoided. To eliminate significant correlations, the entire

list of probable traits obtained from the literature is condensed by combining or deleting equivalent attributes.

The four street block designs in this study differ in five attributes, each having two levels (Table 4). Eight unlabeled alternatives were constructed using an orthogonal fractional factorial design to evaluate the principal effects of the qualities. Each model was imported into Twin Motion 2022.2 with environmental characteristics like as vegetation, water animation, and animated building and human models. Models for virtual reality trials and video modes for online surveys were also developed in Twin Motion 2022.2.

Table 4 Attribute and level of simulated virtual public spaces

Attribute	Level 1	Level 0
A, Average number of people in the public area	crowded	not crowded
B, Building placement inline in the environment	aligned	not aligned
C, Building height	same height	varying in height
D, Architectural building type	two types	five types
E, Surface building materials/Colors	two types	six types

This survey is based on the two most important characteristics of restorative environments, namely coherence and complexity of the built environment. The built environment's crowdedness is included first. This quality is relevant for both the complexity and coherence factors. The average number of people in a public place is classified as either crowded or not crowded, which influences respondents' perceptions of the restorativeness elements complexity and coherence. Next is the settlement of building units; the level of coherence can be altered by adjusting building placement in the environment. There is a direct relationship between building placement in the environment, whether aligned or randomly dispersed, and coherence factor, according to a review of the relevant literature. Also retrieved from coherence features is the height of a building. In the literature section, deflected vistas are explored as a result of building heights described in two categories: same height or different height.

Following this, two features of architectural building type and building materials/colors are designed to account for complexity characteristics. The architectural building type, or variety in the architecture of the structures, was included. There are several styles of architecture, but the choice was made to select clearly recognizable building types and to include a mixture of two types on the first level and five types on the second level. Accordingly, for building surface materials and colors, two types representing low complexity and six types representing high complexity are identified.

After determining the attributes, attribute levels must be assigned to each variable. The number of levels for each attribute must be carefully evaluated. When two levels are employed, the relationship between attribute levels in terms of utility can only be determined to be linear. The variety of levels is also an important factor to consider. It is preferable to maximize the endpoints of the levels; however, it is important to keep in mind the realism of the levels for the respondents and their capacity to distinguish the variations between attribute levels. Table 4 displays the attributes selected for the experiment and their corresponding levels.

3.2.1 Experimental Design Consideration and Generation

When constructing an experimental design, there are a variety of design categories from which to choose. The most generic design category is the complete factorial design. This is defined by Hensher et al. (2015, p. 202) as "a design in which all feasible treatment combinations are listed." For a design with five attributes and two levels each attribute, this would result in a total of ($2^5=$) 32 treatment possibilities (or alternatives). This number of choices is so vast that it would be impossible to include them all in the

investigation. In each experiment question, respondents will evaluate one alternative. This would require them to answer as many questions as there are options, which would be incredibly time and energy consuming and place a tremendous load on the respondents. When selecting the treatment combinations for the fractional factorial design, caution must be taken. The experiment will likely be statistically inefficient or suboptimal if its design is determined at random. Therefore, a scientific method must be used to determine the ideal treatment combinations (Hensher et al., 2015). Orthogonality is defined by Hensher et al. (2015, p.208) as "a mathematical constraint demanding that all qualities be statistically independent of one another." This allows the researcher to explore the effects of each attribute independently. However, Hensher et al. (2015) caution that if just main effects are considered and interaction effects are ignored, the interaction effects will be confused with one another and it will be presumed that all interaction effects are small. In actuality, this may not be the case. However, introducing interaction effects will increase the size of the design, which is undesirable when considering the depiction of the experiment in simulated environments.

There are software applications that can build fractional factorial designs efficiently. In this research scenario, options were generated using Minitab software. Existing efficient designs are also available for use in research. Table 3 presents the plan that will be utilized for this study. This design contains 8 treatment combinations. A unique number has been allocated to each attribute level in a coding scheme used to describe attribute levels.

A	B	C	D	E	
0	0	0	0	0	Alternative 1 = {0 0 0 0 0}
0	0	0	1	1	Alternative 2 = {0 0 0 1 1}
0	1	1	0	0	Alternative 3 = {0 1 1 0 0}
0	1	1	1	1	Alternative 4 = {0 1 1 1 1}
1	0	1	0	1	Alternative 5 = {1 0 1 0 1}
1	0	1	1	0	Alternative 6 = {1 0 1 1 0}
1	1	0	0	1	Alternative 7 = {1 1 0 0 1}
1	1	0	1	0	Alternative 8 = {1 1 0 1 0}

Design Summary

Taguchi L8(2⁵)
 Array
 Factors: 5
 Runs: 8
 Columns of L8(2⁷) array: 1 2 3 4 5

A total of eight alternatives were created, and the resulting videos were separated into two groups of four. Each respondent received a total of four video alternatives. The four options displayed to each respondent were chosen at random and mixed in choice sets in a random manner. The final virtual settings were launched and incorporated into online surveys with MP4 format for video mode on

YouTube as an online platform. Also, the digital twin lab with VR headsets for self-navigation and immersive mode in Twin motion software was used.

The starting point is identical in both scenarios. In the video mode, respondents clicked the play button to see sequentially the videos comprising the various possibilities. Respondents were able to investigate each possibility by seeing a video that approximated a predetermined route walk. Each movie was 1 minute and 10 seconds in duration. In the VR mode, respondents also sequentially explored four alternatives. The distinction is that they could independently control the path using the controllers and the viewpoint rotation by adjusting their head position without a time limit.

3.3 Purpose

The goals of this project are to create and test a method for measuring people's experiences in public areas, as well as to determine the relative impact of environment variables on perceived restorativeness (emotions and choices) over person-state variables (mood, value, and personality). This purpose necessitates the collection of five kinds of data: socio-demographic factors, personality traits, mood, values, and emotional reaction data from virtual public spaces. These data are required to meet the research objectives

Data on socio-demographics such as age, gender, mother tongue, and country background (western vs non-western countries) will be collected. This data is required to examine the links between sociodemographic factors, emotional responses, and preferred restorative contexts in neighborhood public areas. The information gathered is basic and non-sensitive. The GDPR-mandated measures to protect respondents' privacy include pseudonymization, restricted/regulated access to data, encryption activation on computer, and separate storage of the encryption key file.

Undergraduate and graduate students from the Department of the Built Environment, TU/Eindhoven will be invited as participants. It begins with sociodemographic factors (Section I), then moves on to personality traits (Section II). The final segment focuses on the respondents' current mood. In the fourth portion, participants use VR headsets to experience virtual environments for around 1 minute per environment. Respondents are asked to select their preferred spaces and identify their affective response to each public space. In the final portion, participants are questioned about their experience and opinions about public space preferences. It will also consist of another group of participants who watch videos online and will answer the questioner on Lime-survey.

3.4 Visualization of the Attributes

After determining the way of presenting the attributes and the design of the experiment, the following step is to visualize the attributes and their levels. This paragraph will go over how to achieve it. The environmental basis for all simulated environments will be described first, followed by an explanation of the attribute modeling.

3.4.1 Environmental Base

For the creation of the simulated environments one environmental base was used. Base on literature study fundamental restorative characteristics of environments were considered in designing the environment base. Presence of water as water pools, greenery as trees, restorative materials as wood and stone are settled in the designed public area.

3.4.2 Attribute Modeling

This paragraph will look further into the choices that were made regarding visualization of the attributes and levels. Images are provided to support the textual explanation. The enlarged versions of these images can be found in appendix A.

Average number of people

To begin with, the average number of people, which is a dynamic attribute, necessitates the placing of moving pedestrians in the simulated environment. Twinmotion is used to accomplish this (Twinmotion, 2022). Twinmotion is a tool for architectural visualization that includes a material library, asset library, character pathways, and video choices. Continuous pedestrian routes may be drawn using character paths. In these character pathways, users may change the pace of the character, the direction of movement, and the density of characters. This feature aided in defining the attribute in two levels: crowded and uncrowded.

Building placement in the environment

Based on research, this attribute is derived from the coherence characteristics of restorative settings. Building placement in the environment that is aligned shows a high degree of coherence, whereas building placement that is not aligned (randomly allocated) represents a low degree of coherence.

Building height

This feature indicates coherence in a vertical axis, which is also known as deflected vistas in the literature. Building height is classified into two levels: same height with a high degree of coherence and different building height with a low degree of coherence.

Building type

This characteristic is used to account for the complexity of the environments. Building architectural styles are classified into six distinct building types as one degree of high complexity and two types of buildings as the other level of low complexity.

Surface building material/color

The materials and colors of surface buildings are another feature for covering the complexity factor. This attribute's high complexity is comprised of six materials and colors, while the low complexity is comprised of two materials and colors.

3.5 Models for Analysis

Paragraph 3.7.1 explains the models that will be used for the analyses of the preference data collected through the survey. Consequently, paragraph 3.7.2 describes the equations that can be used to determine the model fit of the estimated models.

3.5.1 Model Explanation

There are various models that can be estimated for preference data, of which five will be discussed in this paragraph and will eventually be used for analysis of the data. It concerns the Exploratory factor analysis, Linear regression model and the Latent Class model.

Factor Analysis

Exploratory factor analysis (EFA) is a statistical procedure used in multivariate statistics to reveal the underlying structure of a reasonably large set of variables. EFA is a factor analysis approach whose primary purpose is to find the underlying connections between measured variables (Norris, Megan; Lecavalier, 2009). It is often used by academics to find a set of latent constructs underlying a battery of measurable variables when building a scale (a scale is a collection of questions intended to test a specific study topic) (Fabrigar, 1999). It should be utilized when the researcher has no prior assumptions regarding the components or patterns of measured variables (Finch, J. F.; West, S. G. 1997). Measured variables are any of various human characteristics that may be observed and measured. A human's physical height, weight,

and pulse rate are examples of measurable variables. Researchers often have a high number of measured variables that are supposed to be connected to a smaller number of "unobserved" factors. The number of measurable variables to include in the analysis must be carefully considered by researchers (Fabrigar, 1999). When each component is represented by numerous measured variables in the analysis, EFA processes are more accurate.

The common factor concept underpins EFA (Norris, Megan; Lecavalier, 2009). Manifest variables are expressed as a function of common components, unique factors, and measurement errors in this model. Each distinct component has an effect on only one manifest variable and does not explain relationships between manifest variables. Common factors impact several manifest variables, and "factor loadings" are measurements of a common factor's influence on a manifest variable (Norris, Megan; Lecavalier, 2009). We are primarily interested in discovering common factors and associated manifest variables for the EFA method.

EFA takes the position that any indicator/measured variable may be linked to any factor. EFA should be used initially when constructing a scale before proceeding to confirmatory factor analysis (CFA) (Worthington, 2006). EFA is required to identify underlying factors/constructs for a collection of measured variables, whereas CFA enables the researcher to test the hypothesis that a link exists between the observed variables and their underlying latent factor(s)/construct(s) (Suhr, 2006). Because there is no one approach for EFA, the researcher must make a variety of critical judgments regarding how to conduct the study.

Linear Regression Model

A Linear Regression model predicts the dependent variable y using one or more independent variables x and represents the dependent variable with a straight line - that is, it defines a linear relationship. A simple linear regression is a linear regression with only one independent variable. However, numerous independent variables are included in this study, necessitating multiple linear regression (Field, 2009). A Linear Regression model predicts the dependent variable y based on one or more independent factors x and represents the dependent variable with a straight line - that is, it defines a linear relationship. A simple linear regression is one that has only one independent variable. However, numerous independent variables are included in this study, necessitating a multiple linear regression (Field, 2009). The equation for the Linear Regression model is shown in equation 1:

$$y = \beta_0 + \sum(\beta_n x_n) + \varepsilon$$

In this equation β_0 is the constant generated by the model and β_n is the regression coefficient for independent variable x_n . An error term is added that describes the difference between the predicted and the observed value of the dependent variable y (Field, 2009).

Fixed effect model

Fixed effects models in statistics are statistical models in which the model parameters are fixed or non-random values. In contrast to random effects models and mixed models, in which all or part of the model parameters are random variables, all model parameters in fixed effects models are constant. In econometrics (Greene, 2011).and biostatistics (Diggle, Fitzmaurice2004), a fixed effects model refers to a regression model in which the group means are fixed (non-random), as contrast to a random effects model in which the group means are a random sampling from a population. Typically, data may be categorized based on multiple observable variables. For each classification, the group means might be described as fixed or random effects. In a model with fixed effects, each group's mean is a group-specific constant (Gomes, 2022).

In panel data when longitudinal observations exist for the same subject, subject-specific means are represented by fixed effects. In panel data analysis, the phrase fixed effects estimator (sometimes

referred to as the inside estimate) refers to an estimator for the coefficients in the regression model that incorporates these fixed effects (Ramsey, 2002).

3.6 Skills and tools

An important aspect of simulations is the software that is used to create them. There are many different software packages available for this purpose and Stamps (2016) advises to choose the simplest format that will provide the abilities to address the purposes of the simulations. Commonly with software packages a Computer Aided Design (CAD) package is used, complemented with specialized programs for e.g. people, plants, etc.

For the simulations in this study, several programs were considered. Because the focus of this research is on building aspects in public squares, each building requires unique characteristics. Sketch up is a 3D modeling computer program for a wide range of drawing and design applications, including architectural and landscape architecture, that is useful for building creation. This is a popular design program that allows architects to quickly create 3D models of their designs. Pre-set elements in the program, such as doors, windows, and walls, allow for simple material changes and quick construction of 3D building models. After defining each building unit, the models are loaded into Rhino 7 to create the block street. The application has a rendering engine that can render photos and walkthroughs (videos). However, this rendering engine takes a lengthy time to create the renderings at the quality levels required for this experiment.

One possibility is to use the application Twinmotion in conjunction with Rhino (Twinmotion, 2022). The application includes tools including a material library, vegetation, and character routes for animating humans, bicycles, and cars. It takes substantially less time to render a model than it does for the Rhino rendering engine. The application even allows you to design virtual reality worlds. Which will be used for research purposes by those who complete the survey at the TU/e digital twin lab.

3.7 Survey Construction

The design and creation of the survey instrument is the final stage in establishing a stated preference experiment. It is critical that the survey instrument used is appropriate for the study purpose. An online survey will be developed and distributed for this study. The survey instrument and design should contribute to a good understanding of the research objective, and respondents should be able to comprehend the study objective as intended. Ambiguity in queries should be avoided. LimeSurvey, an online survey platform, was used in this study as the survey instrument (LimeSurvey.org, 2021). This section outlines the survey's format and the questions that are asked. Appendix B contains a printout of the whole survey.

The survey begins with a survey introduction that includes a brief overview of the study topic. This is followed by the statement that all findings will be anonymized and treated privately. In addition, respondents are requested for permission to collect and analyze their data in this study. They are directed to an informed consent form that includes information about what will happen with their data. Respondents are requested to carefully read these statements and to proceed with the survey only if they grant their approval. The opportunity is offered to ask the researcher questions before giving consent. The handling of data collected through the survey, the consent form, and the survey in general have been approved by the Ethical Review Board of the faculty of the Built Environment at the Eindhoven University of Technology. The introduction further states the approximate time it will take to fill out the survey and notes that it is advised to take the survey on a pc or tablet. And for those who completed the survey in the digital twin lab with VR headsets, respondent completed the questioner in researcher's laptop.

The survey is divided into four sections. Data on socio-demographics such as age, gender, mother tongue, and country of origin (western vs non-western) will be gathered. This information is needed to investigate the connections between sociodemographic characteristics, emotional reactions, and preferred restorative environments in local public spaces. The information obtained is simple and unimportant. Pseudonymization, restricted/regulated access to data, encryption activation on computer, and separate storage of the encryption key file are all GDPR-mandated methods to protect respondents' privacy.

Participants will include undergraduate and graduate students from the Department of the Built Environment at TU/Eindhoven. It starts with sociodemographic characteristics (Section I), then moves on to personality traits (Section II) (Section II). The final section focuses on the respondents' present state of mind. Participants utilize VR headsets to experience virtual spaces for approximately 1 minute per environment in the fourth section. Respondents are asked to define their emotional response to each public area. In the last section, individuals are surveyed on their public place preferences and experiences.

After Watching the environments, respondents were asked to report their experience. First question was regarding their primary emotion and then they should choose their overall emotion then Fourteen questions were representing the restorativeness of environment which are defined from 0 to 10.

***When roaming in the street block, my primary emotion was...**

Stressed ▼

***When roaming in this street block, I felt...**

	-3 Strongly	-2 Moderately	-1 Slightly	0 Neutral	1 Slightly	2 Moderately	3 Strongly	
Stressed	<input type="radio"/>	Relaxed						
Sad	<input type="radio"/>	Happy						
Bored	<input type="radio"/>	Excited						
Unsafe	<input type="radio"/>	Safe						
Annoyed	<input type="radio"/>	Comfortable						

Figure 5 Questions regarding emotions

***How much do these statements apply to your experience there?** (where 0 = not at all, 6 = rather much, and 10 = completely)

	0	1	2	3	4	5	6	7	8	9	10
Places like that are fascinating	<input type="radio"/>										
In places like this my attention is drawn to many interesting things	<input type="radio"/>										
In places like this it is hard to be bored	<input type="radio"/>										
Places like that are a refuge from nuisances	<input type="radio"/>										
To get away from things that usually demand my attention I like to go to places like this	<input type="radio"/>										
To stop thinking about the things that I must get done I like to go to places like this	<input type="radio"/>										
There is a clear order in the physical arrangement of places like this	<input type="radio"/>										
In places like this it is easy to see how things are organized	<input type="radio"/>										
In places like this everything seems to have its proper place	<input type="radio"/>										
That place is large enough to allow exploration in many directions	<input type="radio"/>										
In places like that there are few boundaries to limit my possibility for moving about	<input type="radio"/>										
There is a lot going on in this scene	<input type="radio"/>										
There are numerous elements to look at in this environment.	<input type="radio"/>										
The scene contains many elements of different kinds	<input type="radio"/>										

Figure 6 Questions regarding restorative factors

Chapter IV

4. Results

The findings of the performed analyses are presented in this chapter. IBM SPSS Statistics 26 and NLOGIT 6 are the programs used to conduct the analysis. In paragraph 4.1, a descriptive analysis is conducted to establish the representativeness of the responses within the sample.

4.1 Descriptive Analysis

In order to maximize the likelihood of participation, the survey was distributed online across a variety of social media platforms. Graduate and undergraduate students of the built environment department at TU/e were also asked to participate in the experiment using immersive virtual reality headsets at the digital twin laboratory. The data collection began on June 24, 2022, and ended on July 25, 2022. During this period, 112 respondents started the survey. The survey had a completion rate of 75%, as 84 out of the total number of respondents that began completed it. The incomplete survey answers were useless for the analyses because they lacked either the stated preference experiment or the personal information required to put replies in the proper context and identify groups within the experiment outcomes. The incomplete survey answers are omitted from the final dataset.

In the survey, the background characteristics of respondents were collected. These criteria contextualize the survey results. By defining the characteristics of the respondents, it is possible to compare the sample to the overall population and study the data in more depth (for example to investigate if certain characteristics are related to certain results). Descriptive analysis is used to examine and characterize sample data based on their characteristics.

4.1.1 Respondents' Characteristics

The frequency distribution of the sample's socio-demographic traits is shown in Table 5. The sample ranges in age from 20 to 60 years old and is around 60 percent male and 40 percent female. The great majority of respondents were between the ages of 20 and 30, and nearly 40 percent were from western nations, including 28.6 percent of Dutch origin.

Table 5 Respondents' Characteristics

Variable	Levels	Sample
Age	Mean	28.09 (min = 20, max= 60)
	Age 20 to 30	78.6%
	Age 31- and over	14.3%
	Not answered	7.1%
Gender	Male	59.5%
	Female	40.5%
Ethnic group	Western Countries	39.3%
	Nonwestern Countries	60.7%
Language	Dutch	28.6%
	Non-Dutch speakers	71.4%
Total		100%

In Table 6, the present mood of respondents is shown. The majority of the sample had a good disposition, with 40.5% having a very pleasant and 33.3% a pleasant mood and just a mere 10.7 % having a bad mood at the beginning of the survey.

Table 6 Respondents' Mood (N=84)

Variable	Levels	Sample
Mood	Very Unpleasant	2.4%
	Unpleasant	8.3%
	Neutral	14.3%
	Pleasant	33.3%
	Very Pleasant	40.5%
	Not answered	1.2%
Total		100%

4.2 Inferential statistics Analysis

The process of using data analysis to determine characteristics of an underlying probability distribution is known as statistical inference. Inferential statistical analysis infers sample characteristics by testing hypotheses and providing estimates. The observed data set is assumed to be a representative sample of a larger population.

4.2.1 Cronbach's alpha reliability test

To address first the research question regarding perceived restorative scale measurements, Cronbach's alpha of the five restorative factors (fascination, being away, coherence, scope, complexity) is conducted. Fourteen questions with the assumption of representing each of these five restorative factors were asked from the participants (table 3).

Table 7 Restorative factors questions

Factors	0	1	2	3	4	5	6	7	8	9	10
Fascination											
Q1. Places like that are fascinating	0	0	0	0	0	0	0	0	0	0	0
Q2. In places like this my attention is drawn to many interesting things	0	0	0	0	0	0	0	0	0	0	0
Q3. In places like this it is hard to be bored	0	0	0	0	0	0	0	0	0	0	0
Being Away											
Q4. Places like that are a refuge from nuisances	0	0	0	0	0	0	0	0	0	0	0
Q5. To get away from things that usually demand my attention I like to go to places like this	0	0	0	0	0	0	0	0	0	0	0
Q6. To stop thinking about the things that I must get done I like to go to places like this	0	0	0	0	0	0	0	0	0	0	0
Coherence											
Q7. There is a clear order in the physical arrangement of places like this	0	0	0	0	0	0	0	0	0	0	0
Q8. In places like this it is easy to see how things are organized	0	0	0	0	0	0	0	0	0	0	0
Q.9 In places like this everything seems to have its proper place	0	0	0	0	0	0	0	0	0	0	0
Scope											
Q10. That place is large enough to allow exploration in many directions	0	0	0	0	0	0	0	0	0	0	0
Q11. That place is large enough to allow exploration in many directions	0	0	0	0	0	0	0	0	0	0	0
Complexity											
Q12. There is a lot going on in this scene	0	0	0	0	0	0	0	0	0	0	0
Q13. There are numerous elements to look at in this environment.	0	0	0	0	0	0	0	0	0	0	0
Q14. The scene contains many elements of different kinds	0	0	0	0	0	0	0	0	0	0	0

Before proceeding with the analysis of perceived restorativeness and designed attributes, it was assessed if all questions for overall emotions and overall restorativeness were appropriate for measuring their respective topics. This was accomplished by determining if the reliability of the scales (i.e., Cronbach's alpha) increased when items were added or removed. When all items were included, the reliability for overall emotion and perceived restorativeness was highest. The scales were then created by averaging the mean ratings of all corresponding items. The resulting scale reliability for overall emotion (.881) and perceived restorativeness (.927) was excellent (Cronbach's alpha greater than 0.8). Table 3 displays the sample data for the two scale scores.

Table 8 Overall Emotions and perceived restorativeness Cronbach's alpha

	Cronbach's Alpha	N of Items
Emotions Items	.881	5
Restorativeness Items	.927	14

4.2.2 Principal Components Analysis.

Principal Component Analysis, or PCA, is a dimensionality-reduction approach that is frequently used to decrease the dimensionality of big data sets by reducing a large collection of variables into a smaller set that retains the majority of the information in the large set.

Searches for the fewest factors that may explain the shared variance (correlation) of a group of variables. PCA was conducted to extract the possible restorative factors from the five assumed factors (Fascination, coherence, complexity, scope, being away).

A factor extraction method used to generate linear combinations of observable variables that are uncorrelated. The first factor has the most variance. Each successive component explains a decreasing proportion of the variance and is uncorrelated with the others. The eigenvalue is a measure of how much of the common variance of the observed variables a factor explains. Any factor with an eigenvalue ≥ 1 explains more variance than a single observed variable. So, the first three-components have an eigenvalue of more than one and three components were extracted from the initial assumption factors.

Table 9 Total variance explained

Component	Total	Initial Eigenvalues	
		% of Variance	Cumulative %
1	6.141	55.829	55.829
2	1.851	16.825	72.654
3	1.160	10.547	83.201
4	.705	6.408	89.610
5	.398	3.620	93.229
6	.229	2.077	95.307
7	.163	1.485	96.791
8	.136	1.238	98.029
9	.102	.930	98.959
10	.085	.776	99.735
11	.029	.265	100.000

Extraction Method: Principal Component Analysis.

The minimum factor loading criteria was set to 0.50. The communality of the scale, which indicates the amount of variance in each dimension, was also assessed to ensure acceptable levels of explanation. The results show that all communalities were over 0.50.

An important step involved weighing the overall significance of the correlation matrix through Bartlett's Test of Sphericity, which provides a measure of the statistical probability that the correlation matrix has significant correlations among some of its components. The results were significant, $\chi^2(n = 44) = 604.999$ ($p < 0.001$), which indicates its suitability for factor analysis. The Kaiser–Meyer–Olkin measure of sampling adequacy (MSA), which indicates the appropriateness of the data for factor analysis, was 0.779. In this regard, data with MSA values above 0.600 are considered appropriate for factor analysis.

Finally, the factor solution derived from this analysis yielded three factors for the scale, which accounted for 83.201 percent of the variation in the data. As a result, Questions regarding the Scope factors were removed, and the being away factor was merged into Fascination group questions. Accordingly, the two questions regarding the scope factor (Q10: That place is large enough to allow exploration in many directions, Q11: That place is large enough to allow exploration in many directions) it has been identified to be theoretically unrelated to this research purposes.

Bartlett's Test of sphericity proved significant, and all commonalities were over the required value of 0.500. The three factors identified as part of this factor analysis aligned with the theoretical proposition in this research. However, the initial proposal stated the five restorative factors the results are reduced to three factors: Fascination, Complexity, and Coherence.

Table 10 KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.779
Bartlett's Test of Sphericity	Approx. Chi-Square	471.604
	df	55
	Sig.	.000

Varimax rotation (also known as Kaiser-Varimax rotation) maximizes the total of the squared variance of the loadings, where 'loadings' refers to the correlations between variables and factors. This often results in high factor loadings for a limited number of variables and low factor loadings for the remaining variables. All remaining components have eigenvalues greater than 1. (Stevens, 1996). The outcome is that a limited number of significant factors are emphasized, making it simpler to evaluate the data.

Table 11 Rotated Component Matrix¹

variable	Component		
	1	2	3
Q1. Places like that are fascinating	.682		
Q2. in places like this my attention is drawn to many interesting things	.615		
Q4. Places like that are a refuge from nuisances	.889		
Q5. To get away from things that usually demand my attention I like to go to places like this	.903		
Q6. To stop thinking about the things that I must get done I like to go to places like this	.818		
Q7. There is a clear order in the physical arrangement of places like this			.943
Q8. In places like this it is easy to see how things are organized			.957
Q9. In places like this everything seems to have its proper place			.822
Q12. There is a lot going on in this scene		.868	
Q13. There are numerous elements to look at in this environment		.873	
Q14. The scene contains many elements of different kinds		.822	

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

According to Table 9, three factors are extracted. Questions expressing fascination and being away (Q1, Q2, Q4, Q5, Q6) are combined into component 1 reflecting the fascination factor, whereas questions (7, 8, 9) and (12, 13, 14) indicate coherence and complexity, representing component 3 and 2 respectively.

To assess respondents' emotional responses to each alternative, questions about emotions were separated into five categories: (stressed/relaxed), (sad, happy), (bored, excited), (unsafe/safe), and (annoyed, comfortable). The scale for each question ranged from -3 to 3, signifying negative to positive emotions. Table 8 calculates the mean value for each sub-emotion on a scale of -3 to +3 to have a better understanding of the respondents' feelings for each model.

¹ Rotation converged in 5 iterations.

Table 12 Emotional statistics

Model		Stressed/Relaxed	Sad/Happy	Bored/Excited	Unsafe/Safe	Annoyed/Comfortable
1	Mean	-.35	.05	.13	-.05	-.58
	Std. Deviation	1.406	1.011	1.471	1.694	1.662
	Minimum	-3	-2	-3	-3	-3
	Maximum	2	2	2	3	2

As indicated in table 7, the question was divided into three components that represented fascination, coherence, and complexity. On a scale of 0 to 10, respondents indicate their choice for each question. So, to provide a more accurate assessment of the restorative factors, the mean value of each restorative component is determined (table 11). According to the literature, each restorative factor (fascination, coherence, and complexity) is linked with the overall restorativeness of environments. The greater each factor, the better the restorativeness of the environment.

4.2.3 Correlation

A Pearson product-moment correlation was conducted to examine the relationships between fascination, coherence, and complexity in the designed built environment settings. The Pearson correlation coefficient assesses the strength of a two-variable linear relationship. It has a value ranging from -1 to 1, with -1 indicating total negative linear correlation, 0 indicating no correlation, and + 1 indicating total positive correlation. Results show that restorativeness is strongly directly related to the emotion status (.465).

Table 13 Pearson product-moment correlation of restorative factors and emotions

Factors		Emotion	Fascination	Complexity	Coherence	restorativeness
Emotion	Pearson Correlation	1	.466**	.072	.261**	.465**
	Sig. (2-tailed)		.000	.185	.000	.000
Fascination	Pearson Correlation	.466**	1	.000	.000	.633**
	Sig. (2-tailed)	.000		1.000	1.000	.000
Complexity	Pearson Correlation	.072	.000	1	.000	.585**
	Sig. (2-tailed)	.185	1.000		1.000	.000
Coherence	Pearson Correlation	.261**	.000	.000	1	.507**
	Sig. (2-tailed)	.000	1.000	1.000		.000
restorativeness	Pearson Correlation	.465**	.633**	.585**	.507**	1
	Sig. (2-tailed)	.000	.000	.000	.000	

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

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

4.2.4 Fixed effect model analysis

Fixed-effects (FE) is a statistical regression model in which the intercept of the regression model is allowed to vary freely across individuals or groups. It is often applied to panel data in order to control for any individual-specific attributes that do not vary across experiment. FE explore the relationship between predictor (built environment characteristics) and outcome variables (restorativeness) within the respondents group. It can be used to analyze the relationship between a single dependent variable and several independent variables. The objective of regression analysis is to use the five attributes as independent variables whose values are known to predict the value of the restorativeness as dependent value.

As table 16 shows three attributes of building placement, Crowdedness and surface materials have significant value and can impact the people's perception of an environment while the other two built environment characteristics of architecture style and building heights were insignificant (Sig. value is more than .05).

Table 14 Fix-effect model analysis for restorativeness

Variable	Coefficient	Sig.
Intercept	5.155971	.000**
Gender	-.002121	.995
Experiment type	-.273453	.495
Crowdedness	-.293275	.026**
Building Placement	-.312145	.016**
Building Height	-.026793	.838
Architectural Type	-.024993	.848
Surface Material	.335857	.029**

Dependent variable: Restorativeness

Significance at 1% 5% level.

Same method was used to examine the effects of 7 predictors on emotions. Result showed that this time crowdedness, building placement, building height had significant value and respondents emotions were highly affected by these three environmental attributes (Table 15).

Table 15 Fix-effect model analysis

Variable	Coefficient	Sig.
Intercept	1.073179	.000**
Gender	.189563	.340
Experiment type	-.374488	.104
Crowdedness	-.424080	.000**
Building Placement	-.245688	.021**
Building Height	-.229856	.033**
Architectural Type	-.374488	.104
Surface Material	-.003771	.976

Dependent variable: Emotion

Significance at 1% 5% level.

For better understanding the influence of attributes on restorativeness, fixed effect analysis was performed separately for three restorative factors of fascination, coherence and complexity.

Crowdedness was the only significant value for fascination factor (table 16). In matter of coherence, three attributes of crowdedness, building placement and building height had the most effect on perceived coherence of respondents (table 17). Turning to complexity factor, again three factors of crowdedness, building height and surface material was most important for the respondent (table 18).

Table 16 Fix-effect model analysis

Variable	Coefficient	Sig.
Intercept	.178711	.356
Gender	-.091451	.581
Experiment type	.155418	.416
Crowdedness	-.302136	.001**
Building Placement	-.074514	.391
Building Height	-.070233	.425
Architectural Type	-.091141	.300
Surface Material	.023556	.818

Dependent variable: Fascination
Significance at 1% 5% level.

Table 17 Table 18 Fix-effect model analysis

Variable	Coefficient	Sig.
Intercept	.660404	.001**
Gender	.081664	.614
Experiment type	-.258135	.169
Crowdedness	-.355383	.000**
Building Placement	-.363644	.000**
Building Height	-.224751	.008**
Architectural Type	.025433	.762
Surface Material	-.099507	.309

Dependent variable: Coherence
Significance at 1% 5% level.

Table 18 Table 18 Fix-effect model analysis

Variable	Coefficient	Sig.
Intercept	-.389721	.038**
Gender	.038828	.807
Experiment type	-.198969	.280
Crowdedness	.354091	.000**
Building Placement	.110260	.194
Building Height	.248220	.004**
Architectural Type	.055253	.520
Surface Material	.374861	.000**

Dependent variable: Complexity
Significance at 1% 5% level.

4.3 conclusion

This study project used eight simulated alternatives based on diverse built environment attributes with varying degrees of coherence and complexity to investigate the perceived restorativeness of environments by respondents using two different methods: online videos and VR headsets.

Principle component analysis found that three variables, including fascination, coherence, and complexity, were extracted from the hypothesized five restorative components. In particular, questions about fascination and being away were merged and evaluated as one component, while questions about the scope factor were deleted, and both complexity and coherence remained distinct factors.

One of the study's research questions was how to quantify the restorativeness of the environment. This was accomplished by calculating the mean response of the 14 questions aimed to assess the setting's restorativeness. Cronbach's alpha was used to assess the reliability of this hypothesis, and with an excellent result of .927, it was approved.

The other research question was how people are affected by restorativeness characteristics. Pearson correlation analysis was used to assess the relationship between restorativeness and emotions. The results indicated that increasing each restorative element and overall restorativeness was closely connected with the emotion, and restorativeness respondents had a higher positive emotion.

A fixed effect regression model revealed that only three attributes of building placement, crowdedness, and surface material had significant value on restorativeness, whereas the other two attributes of building height and architecture style had little impact on perceived restorativeness.

Also, the effective size of restorativeness on emotions was slightly higher in the female category and among those who performed the experiment with a VR headset, but multiple regression analysis of gender and experiment type was insignificant, indicating that there is no relationship between these gender and experiment type variables on restorativeness.

Chapter V

5. Conclusion, discussion & recommendations

The study's findings are discussed in this final chapter. Furthermore, this chapter discusses the current study's limitations and concludes with recommendations for practice and future research.

5.1 Conclusion

This study looked at what restorative surroundings are and how they improve people's emotions and well-being. This research discusses the significance of the interaction between individual and environmental variables. They have the capacity to reduce tension and mental fatigue, as well as aid in attention, due to the features and characteristics of a restorative environment. Furthermore, the environment may be enhanced by employing natural and practical components in the area, such as natural materials and water availability.

This research also examined the relevance of the relationship between individual and environmental factors. As previously said, the restorative environment has the ability to ease tension and mental fatigue, as well as help in focus, due to its attributes and characteristics. Furthermore, the environment may be improved by utilizing its natural and effective elements, such as natural materials and the availability of water in the region.

Virtual reality is a novel technology that allows people to interact with a computer-generated environment. This study examined and compared the results of respondents' perceived restorativeness using VR technology and online videos. The current study was an integrated effort to piece together fragments of these new methodologies, procedures, and explain the relationship between built environment characteristics and restorativeness in order to provide a comprehensive understanding of new methods for analyzing and assessing environmental interactions and how they impact one another. This research addressed numerous tactics and tools that may be utilized to help with this.

The ideas of attention restoration and stress recovery served as the foundation for this work. Based on these two hypotheses, five physical and perceptual restorative features were extracted and merged into simulated designed situations. The complexity and coherence of restorative features were emphasized in these architectural spaces.

This study project employed eight models with differing degrees of coherence and complexity based on distinct built environment features to evaluate the perceived restorativeness of places by respondents utilizing two different methods: internet videos and VR headsets.

Three variables, including fascination, coherence, and complexity, were derived from the predicted five restorative components using principal component analysis. Questions concerning fascination and being away, in particular, were combined and assessed as one component, while questions about the scope factor were eliminated, and complexity and coherence remained separate components. The results demonstrated a significant and clear link between these three variables and emotions.

One of the study's research topics was how to assess the environment's restorative value. This was performed by calculating the mean response of the 14 questions designed to measure the restorativeness

of the situation. Cronbach's alpha was used to examine the reliability of this hypothesis, and it was approved with an excellent result.

The third research topic was how this attribute and restorativeness effect people. The association between restorativeness and emotions was examined using Pearson correlation analysis. According to the findings, increasing each restorative component and overall restorativeness was strongly related to emotion, with restorativeness responders having a higher positive emotion.

A fixed effect model regression found that just three variables, building placement, crowdedness, and surface material, had a substantial impact on perceived restorativeness, while the other two, building height and architecture style, had minimal impact.

Although various research on restorative environments have been conducted, the majority of them have concentrated on natural settings and their impact on stress and mental health. The focus of this research, however, was on restorativeness in built environments and its amount of effect, particularly in urban contexts. The findings of the study might be used by urban planners and policymakers to build and develop more pleasant and restorative communities and public squares for people.

5.2 Limitations and recommendations for further research

This section covers the limits discovered throughout the research. To begin, the sample size for this study was relatively small, with only 84 persons, the majority of whom were students of the built environment. Because the number of samples was limited and the age group was not evenly distributed, the results should be interpreted with caution; also, results in other countries may change owing to cultural variations.

Only a subset of built environment factors was evaluated in the current study. For the purposes of this study, five attributes in two levels were created; however, for future research, these BE characteristics can be more elaborated with a greater number of levels.

The results demonstrated that architectural style had no effect on restorativeness; nevertheless, this study only employed modern buildings; perhaps historical buildings with different architecture styles had different effects on responders. In this study, there were two levels of the same height and two levels of different height in a three-story structure and a six-story building, respectively. While other levels should be tested for further investigation.

Questioners were employed in this study to assess respondents' emotions and perceived restorativeness. While it has its own advantages, such as ease of access and cheap cost, there are alternative approaches, such as electrocardiogram (ECG) heart beat sensors, eye trackers, and electroencephalogram (EEG) headsets, that allow researchers to properly assess the quantitative measurements of their individual worth. As restorativeness has a direct influence on stress, we may have a better and more accurate evaluation of psychological and physiological factors with the use of these modern technologies.

It is also worth noting that the models employed for this research were computer-based with completely simulated environments; hence, the results may change in the actual world with genuine components and environmental features. However, this study employed both VR and online videos to compare the differences between the two approaches, but no difference was found. This might be due to a small number of individuals using virtual reality headsets or a lack of high-quality graphics in simulated surroundings.

Even though more research is needed to explain the relationship of restorativeness on emotions and mental health, as well as the effects of built environment characteristics, this study found that emotion is highly related to an environment's restorativeness, and built environment characteristics can affect the level of perceived restorativeness.

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Appendix

Appendix A: Images of all video alternatives



Figure 7 Alternative 1 = {0 0 0 0 0}

Not Crowded, Buildings not aligned, Different height of buildings, Five types building, Six types material/color . CONSIDERED AS HIGH COMPLEXITY, LOW COHERENCE



Figure 8 Alternative 2 = {0 0 0 1 1}

Not Crowded, Buildings not aligned, Different height of buildings, two types building, two types material/color . CONSIDERED AS LOW COMPLEXITY, LOW COHERENCE



Figure 9 Alternative 3 = {0 1 1 0 0}

Not Crowded, Buildings aligned, same height of buildings, Five types building, Six types material/color
CONSIDERED AS HIGH COMPLEXITY, MEDIUM COHERENCE



Figure 10 Alternative 4 = {0 1 1 1 1}

Not Crowded, Buildings aligned, same height of buildings, two types building, two types material/color
CONSIDERED AS LOW COMPLEXITY, MEDIUM COHERENCE



Figure 11 Alternative 5 = {1 0 1 0 1}

Crowded, Buildings not aligned, same height of buildings, Five types building, two types material/color
CONSIDERED AS LOW COMPLEXITY, MEDIUM COHERENCE



Figure 12 Alternative 6 = {1 0 1 1 0}

Crowded, Buildings not aligned, same height of buildings, two types building, six types material/color
CONSIDERED AS LOW COMPLEXITY, MEDIUM COHERENCE



Figure 13 Alternative 7 = {1 1 0 0 1}

Crowded, Buildings aligned, Different height of buildings, five types building, two types material/color
CONSIDERED AS LOW COMPLEXITY, MEDIUM COHERENCE



Figure 14 Alternative 8 = {1 1 0 1 0}

Crowded, Buildings aligned, Different height of buildings, two types building, six types material/color
CONSIDERED AS LOW COMPLEXITY, MEDIUM COHERENCE

Appendix B: Complete overview of the survey questions

What is your age?

What is your gender?

● Choose one of the following answers

- Male
- Female
- Others

What is your mother language?

● Check all that apply

- Dutch
- English
- Other:

Which group do you belong to?

● Choose one of the following answers

- Native Dutch background
- Western foreign background
- Non-western foreign background

Figure 15 Demographical questions

What is your present mood?

	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
Very Unpleasant	<input type="radio"/>	Very Pleasant																				

***To what extent do you agree with the statements below?**

	Strongly disagree			Neutral			Strongly agree
In most ways my life is close to my ideal.	<input type="radio"/>						
The conditions of my life are excellent.	<input type="radio"/>						
I am satisfied with my life.	<input type="radio"/>						
So far I have gotten the important things I want in life.	<input type="radio"/>						
If I could live my life over, I would change almost nothing.	<input type="radio"/>						

Figure 16 Mood and personality questions

***When roaming in the street block, my primary emotion was...**

Please choose...

***When roaming in this street block, I felt...**

	-3 Strongly	-2 Moderately	-1 Slightly	0 Neutral	1 Slightly	2 Moderately	3 Strongly	
Stressed	<input type="radio"/>	Relaxed						
Sad	<input type="radio"/>	Happy						
Bored	<input type="radio"/>	Excited						
Unsafe	<input type="radio"/>	Safe						
Annoyed	<input type="radio"/>	Comfortable						

Figure 17 Emotion questions

***How much do these statements apply to your experience there?** (where 0 = not at all, 6 = rather much, and 10 = completely)

	0	1	2	3	4	5	6	7	8	9	10
Places like that are fascinating	<input type="radio"/>										
In places like this my attention is drawn to many interesting things	<input type="radio"/>										
In places like this it is hard to be bored	<input type="radio"/>										
Places like that are a refuge from nuisances	<input type="radio"/>										
To get away from things that usually demand my attention I like to go to places like this	<input type="radio"/>										
To stop thinking about the things that I must get done I like to go to places like this	<input type="radio"/>										
There is a clear order in the physical arrangement of places like this	<input type="radio"/>										
In places like this it is easy to see how things are organized	<input type="radio"/>										
In places like this everything seems to have its proper place	<input type="radio"/>										
That place is large enough to allow exploration in many directions	<input type="radio"/>										
In places like that there are few boundaries to limit my possibility for moving about	<input type="radio"/>										
There is a lot going on in this scene	<input type="radio"/>										
There are numerous elements to look at in this environment.	<input type="radio"/>										
The scene contains many elements of different kinds	<input type="radio"/>										

Figure 18 Perceived restorativeness questions

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