Biophilic Urban Spaces

Design Healing Spaces with Nature

PROFESSIONAL PROJECT REPORT

VIRGINIA PAIVA - 2020-2021

OUUDS

The University of Oklahoma Urban Design Studio

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THE UNIVERSITY OF OKLAHOMA
GRADUATE COLLEGE

BIOPHILIC URBAN SPACES. DESIGNING HEALING SPACES BY NATURE.

A PROFESSIONAL PROJECT

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

Degree of

MASTER OF URBAN DESIGN

By

VIRGINIA PAIVA

Norman, Oklahoma
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BIOPHILIC URBAN SPACES. DESIGNING HEALING SPACES BY NATURE.
A PROFESSIONAL PROJECT APPROVED FOR THE

URBAN DESIGN STUDIO

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CONTENTS

Biophilic Urban Spaces, Designing Healing Spaces with Nature.

KEYWORDS LIST

Stress: Stress is the feeling of being overwhelmed or unable to cope with mental or emotional pressure.

Well-being: Well-being the state of being comfortable, healthy, or happy.

Emotional Arousal: Emotional arousal is the state of being activated, either physiologically or psychologically, and is one dimension of affective response to emotional stimuli.

Galvanic Skin Response (GSR): The galvanic skin response (GSR, which falls under the umbrella term of electrodermal activity, or EDA) refers to changes in sweat gland activity that is reflective of the intensity of an emotional state, otherwise known as emotional arousal.

Experimenter: An experimenter is a person who performs a scientific procedure, especially in a laboratory, to determine something.

Participants: A participant is a person who takes part in something. In this case, a person who took part in the research experiment.

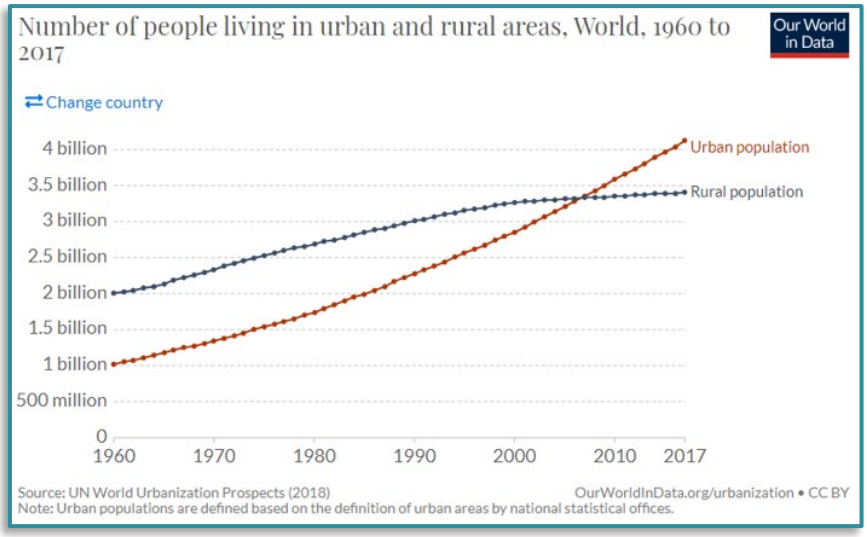
Render: Render is the process of generating a photorealistic or non-photorealistic image from a 2D or 3D model utilizing a computer program.

Biophilia: Biophilia is an innate tendency to focus on life and lifelike processes.

Biophilic Design: Biophilic design is the practice of inserting elements into the built environment that offers an experience with nature.

INTRODUCTION

Biophilia is a term created by Edward Osborne Wilson through his book named *Biophilia* (Wilson, E.O. 1984). In his book, Wilson describes biophilia as a natural tendency to turn attention to living things. In my study, biophilic is applied to urban spaces by exploring their relationship with living things, specifically with nature. The author of the book *Biophilic Cities: Integrating Nature into Urban Design and Planning*, Timothy Beatley, stated, "Biophilic Cities recognize that contact with nature is essential to living a healthy, productive, meaningful life" (Beatley, T. 2011). The modern and busy life people live today obliges us to live more and more in urban areas, which are associated with high levels of stress due to the combination of several factors such as a busy life, air pollution, noise pollution, traffic, and violence. Research has shown that stress is the trigger for several diseases (de Brouwer, 2010).Fig. 1 shows that more than 50% of the world population lives in urban areas. Based on the fact that more than 50% of the world population lives in urban areas, it is logical to conclude they live stressful lives and are at risk of experiencing the negative outcomes associated with stress.



(fig.1 – World population living in urban and rural locations over the period 1960-2017)

What if we could build urban spaces that help to decrease stress levels and provide a sense of well-being?

There are several studies that associate contact with nature with well-being (Heerwagen, 2006), (Tham & Willem, 2005), (Wigö, 2005), (Alvarsson, 2010), (Pheasant et al., 2010), (Biederman & Vessel, 2006). Therefore, the idea of this study is to determine the human relationship between nature, stress levels, and well-being through an experiment that uses a questionnaire and the use of a Galvanic Skin Response (GSR) sensor as means of measurement. The research method, in

brief is to show images of biophilic and non-biophilic urban spaces to the participants and collect feedback through a subjective questionnaire and an objective GSR measurement.

Problem Statement

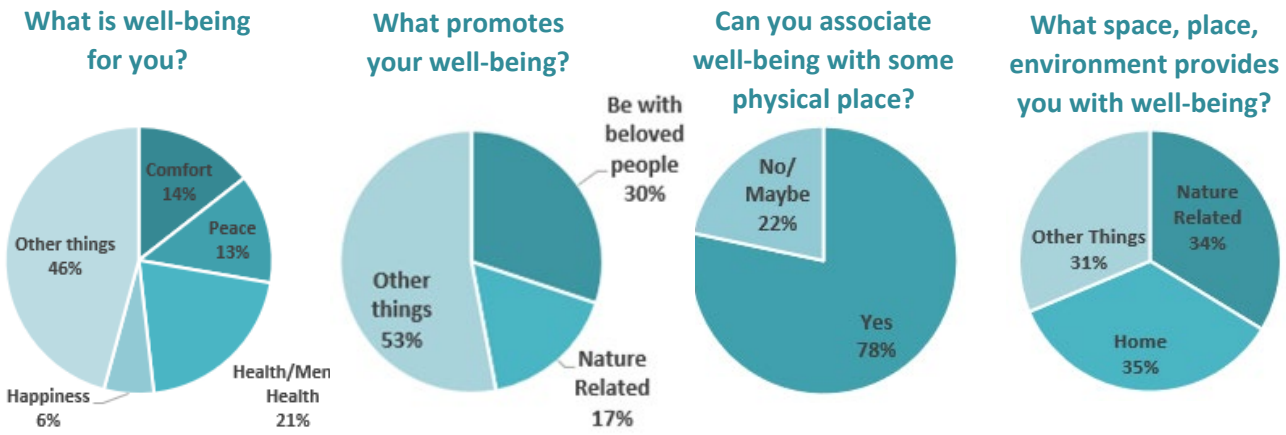
Urban design is part of our lives and is present in practically everything that surrounds us, but it often goes unnoticed by most people. We live inside a built environment, walking through urban and public spaces, working in offices, and residing inside apartments or houses with little awareness about how these spaces affect us. Existing research shows that some spaces whether natural or man-made can influence people's feelings or sensations. Based on those findings, urban designers question whether city spaces actually make us feel well or contribute to mental and physical illness. It also makes urban designers see the need to consider well-being and health when constructing and developing cities. This study looks at the link between urban design, stress, and well-being.

Exploratory Survey

Before beginning my study, I decided to take a brief opinion poll to help me justify and narrow my professional project theme. The survey took place online through social media in order to receive a rapid response. I posted four questions related to well-being. The idea was to capture how people related well-being with a physical and built environment. The questions were:

- What is well-being for you?
- What promotes your well-being?
- Can you associate well-being with some physical space?
- What space, place, environment promotes your well-being?

The survey lasted 24 hours, had 242 views, and 83 responses. Below I show the collected information.



(Fig.2: Summary of the responses collected on a opinion survey)

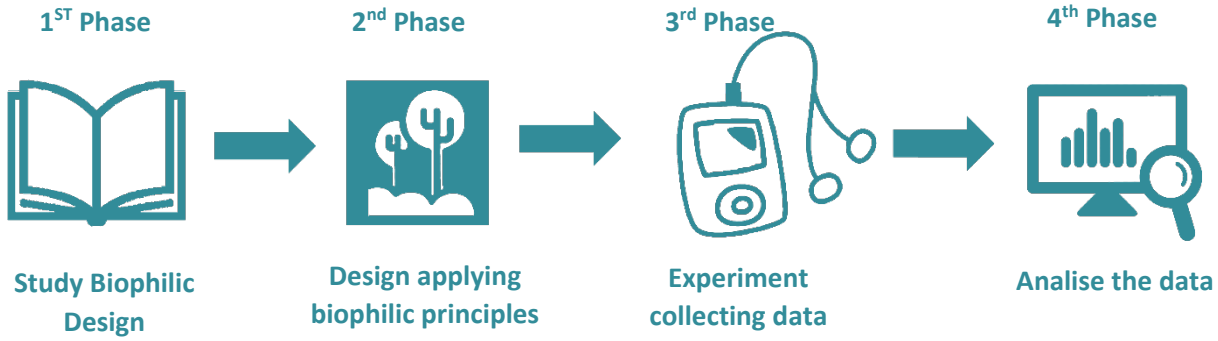
To analyze the answers, I used as a criterion to search for patterns of answers, searching for words or subjects that came up the most. With the information obtained, I was able to establish a relationship that would base my decision on the chosen theme. As we can see, by responses to the first question, the highest percentage of the established standard was that well-being is *good health and/or mental health*. For the second answer, there was the prevalence response of *Nature*. But the pattern was *be with beloved people*. On the third question, is easy to read that is not everyone was capable of relating the sense of well-being with physical space, and the fourth and last question brings again the importance of *Nature*, but the biggest percentage responded *home* which I related to the feeling of ownership. Putting together all the collected results, I concluded that well-being could be established by places where people can be together with loved ones, surrounded by nature that provides a sense of well-being. That made me focus on the importance of the insertion of nature into urban spaces.

PROJECT SUMMARY

This study's purpose is to learn how urban and public spaces can affect people's well-being and stress levels. Learning how the built environment affects human behavior is also a tool to help create buildings and public spaces that promote mental and physical health and focus on creating a sense of well-being.

The Nature Conservancy (TNC) in partnership with the University of Virginia and the Stockholm Resilience Center analyzed the relationship between contact with nature and the quality of mental health. The study, published in the scientific journal Sustainable Earth (McDonald et al., 2018), highlighted that 46% of people living in large cities already suffer from problems related to mental health, however, only 13% of the world's urban population lives close to nature. This study made me realize the importance of creating urban spaces that provide contact with nature thereby promoting health and well-being for society. That's why I decided to focus my study on biophilic urban spaces.

This project was divided into four phases: study phase, design phase; experiment phase, and analysis phase.



(Fig.3: Summary of the research methodology)

The starting point of my research was the literature review that focuses on attributes and principles of biophilic design. A review of precedent studies and exploration of biophilic projects helped me to understand the applicability of biophilic design. Based on this learning process, I was able to implement the biophilic principles into existing urban spaces. For the second phase of the project, I decided to look into existing public spaces where the concepts of biophilic design could

be applied. I choose four public places: A parking lot, a pedestrian bridge, a blank wall, and an urban street. In phase three, the images created using the biophilic principles are presented as exhibits to investigate the relationship between biophilic design, stress, and well-being. This investigation was done through an experiment that used two forms of measuring levels of stress and well-being, a Galvanic Skin Response sensor and a questionnaire. 23 people have participated. Their responses were analyzed to determine their relationship with biophilic design, stress, and well-being. During the fourth and last phase, I analyzed the response data collected from the experiment.

Objectives

General Objectives

My objective in this research is to go deeper into the concepts of biophilic design and verify the benefits of its application to society. I also seek to add to the existing body of knowledge in this area and promote the use of biophilic principles of nature in urban spaces as a way to promote health and well-being.

Specific Objectives

The specific objectives of this study are to investigate the relationship between biophilic design, stress, and well-being by observing subjects' reactions to views of biophilic and non-biophilic images as well as collecting questionnaires and GSR data. In sum, I sought to achieve the following objectives:

- Learn the principles of the Biophilic Design and their applicability.
- Demonstrate the ability to design urban spaces using biophilic design principles.
- Create awareness that there is a direct relationship between human health and nature.
- Encourage the development of biophilic designs.

Research Question

Some studies have shown the benefits of contact with nature (Barton & Pretty, 2010), (Brown et al., 2013), (Van den Berg et al., 2007), (Tsunetsugu & Miyazaki, 2005), but there is little research that has focused directly on the effects of the biophilic design of urban spaces have on users of those spaces. Therefore, I decided to investigate how the insertion of nature into urban spaces can affect people's stress levels and well-being. The main question of my research is: Do biophilic urban designs decrease stress levels and provide users of those spaces a sense of well-being? Through this question, I propose two possible hypotheses:

Null hypothesis: There will be no difference in stress and well-being perception in subjects viewing biophilic urban spaces as stimuli and subjects viewing non-biophilic urban spaces as stimuli.

Alternative hypothesis: There will be a significant difference in stress and well-being perception in subjects viewing biophilic urban spaces as stimuli and subjects viewing non-biophilic urban spaces as stimuli.

Biophilia

The term biophilia (from bio-, meaning "life," and -philia, meaning "love") was popularized by the Author Edward O. Wilson in his book named Biophilia (Wilson, 1984). He saw biophilia being an innate tendency to focus on life and lifelike processes. After him, other authors like Stephen Kellert and Timothy Beatley explored the term through studies and publications focused on the subject. Like all living beings, humans are dependent on nature for survival. But after the industrial revolution and the beginning of large-scale food production, human beings began to distance themselves from direct contact with nature, making them start seeing nature as no longer an essential aspect of human life. But the benefits of nature go beyond providing food and other resources. Nature plays a very important role in the health and maintenance of human life, such as:

- Improves the overall air quality;
- Promotes the life and existence of living beings;
- Moderates the microclimate;
- Protects from harsh winds;
- Decreases noise pollution;
- Provides us with resources;

The lack of contact with nature can cause physical and psychological damage to humans. Therefore, I emphasize the importance of spread the term biophilia as a way to create knowledge of the benefits of contact with nature. Today, the main impediment to this contact with nature is the increasing form of urban life and the form of development and construction of cities. Less and less, nature has been considered in the development of public spaces and urban construction. For reasons of cost and maintenance or just for convenience, cities have become grayer. As a result, there is a need to rethink our cities and urban spaces. Instead of creating arid spaces, full of concrete, walls, and artificial lighting, we must think of an architecture that integrates internal and external spaces. Think of space solutions that provide light and natural ventilation. Finally,

designers must think about developing cities and urban spaces that prioritize the health and well-being of their residents.

Biophilic Design

Biophilic design is the practice of inserting elements into the built environment that offers an experience with nature. A long time before this term became known, the technique of bringing nature into built environments was already applied by our ancestors, as shown in fig. 4 on the side, a painting that illustrates the Hanging Gardens of Babylon, dated 669–631 BC. The term *biophilic design* gained prominence in the 1990s when researchers decided to investigate the relationship between the insertion of nature in palliative care for hospital patients. Because patients experienced more positive responses to the treatment than before, the researchers realized the importance of contact with nature for health. Another research of great relevance that also marks the beginning of the development of biophilic design is the research of Roger Ulrich which compared the evolution of two groups of patients, one group that was kept in a room with a window facing an ordinary tree grove and the other group that was kept in a room with a window facing a brick wall. The result was that patients who had the trees grove view had better responses to the treatment than the other group of patients (Ulrich, 1984). After this, names like Christopher Alexander, Judith Heerwagen, Rachel and Stephen Kaplan, Stephen Kellert, Roger Ulrich, finally consolidated the term with their research and designs. Nowadays, If we take into account that the human population continues to urbanize spontaneously and that some urban centers are miles away from a rural area, the importance of environments and constructions that focus on the experience with nature grows. Biophilic design becomes essential in building healthier cities and environments.

(Fig. 4: Hanging Gardens of Babylon - 669–631 BC)

Biophilic design Benefits and principles

Some benefits of direct contact with nature have already been listed in previous chapters, but here we will focus on the benefits attributed directly to the experience of biophilic design. Therefore, we can divide these benefits into two groups: the ecological benefits and the human benefits.

ECOLOGICAL

- Improving the overall air quality.
- Attracting biodiversity.
- Moderates the microclimate.
- Provides shade.
- Protection from harsh winds.
- Decreases noise pollution.
- Avoids floods.

HUMAN

- Makes you more creative and productive.
- Improves well-being.
- Reduces stress levels.
- Makes you happier and healthier.
- Decreases blood pressure and heart rate.
- Improves mental health

The great challenge for achieving the benefits of the biophilic design is its implementation. The insertion of natural elements in a built environment can be very complicated if some pre-established practices are not taken into account. For this, the author Stephen Kellert presents some basic principles for the successful application of biophilic design:

- Requires repeated and sustained engagement with nature.
- Focuses on human adaptations to the natural world.
- Encourages an emotional attachment to particular settings and places.
- Promotes positive interactions between people and nature.
- Encourages mutual reinforcing, interconnected, and integrated architectural solutions.
- Fosters feelings of membership in a community that includes both people and the nonhuman environment.

- Occurs in a multiplicity of settings, including interior, exterior, and transitional spaces and landscape. (Kellert, 2018, p.18-22).

As a result, a biophilic design must achieve a wide spectrum of physical, mental, and behavioral benefits.

Biophilic Design Application

The development of a biophilic design involves specific strategies and techniques, in addition to general design methodology. That is why it is important to learn these strategies and implement them in order to achieve a satisfactory project result. A good starting point for the development of a good biophilic design is to think of the users of the space as biological organisms and, thus, try to provide their physiological needs respecting their physiological systems as indicators of health and well-being in the context of what is locally appropriate and responsive. Other important factors to be considered when implementing biophilic design are health conditions, socio-cultural norms, expectations, climate, and environmental resources of the place where the project will be implemented. In addition, it is important to consider the type of use, frequency, and duration of the user experience. There are different ways to experience nature in a built environment. And within the biophilic literature, these diverse experiences are divided into 14 biophilic patterns into standardized terminology for biophilic design and to maximize accessibility across disciplines by upholding a familiar language. These standards aim to direct the development of the project so that the biophilic experience can be effective. Below are the 14 patterns of biophilic design:

Nature in the space

(Fig.5: Gardens of the Inhotim Museum)

1. Visual Connection with Nature - A view to elements of nature, living systems, and natural processes.

2. Non-Visual Connection with Nature - Auditory, haptic, olfactory, or gustatory stimuli that engender a deliberate and positive reference to nature, living systems, or natural processes.

3. Non-Rhythmic Sensory Stimuli- Stochastic and ephemeral connections with nature that may be analyzed statistically but may not be predicted precisely.

4. Thermal & Airflow Variability - Subtle changes in air temperature, relative humidity, airflow across the skin, and surface temperatures that mimic natural environments.

5. Presence of Water - A condition that enhances the experience of a place through the seeing, hearing, or touching of water.

6. Dynamic & Diffuse Light - Leveraging varying intensities of light and shadow that change over time to create conditions that occur in nature.

7. Connection with Natural Systems - Awareness of natural processes, especially seasonal and temporal changes characteristic of a healthy ecosystem

Natural analogues

(Fig.6: Gardens of the Inhotim Museum)

8. Biomorphic Forms & Patterns - Symbolic references to contoured, patterned, textured, or numerical arrangements that persist in nature.

9. Material Connection with Nature - Material, and elements from nature that, through minimal processing, reflect the local ecology or geology to create a distinct sense of place.

10. Complexity & Order - Rich sensory information that adheres to a spatial hierarchy similar to those encountered in nature.

(Fig.7: Artwork from the Inhotim Museum)

11. Prospect - An unimpeded view over a distance for surveillance and planning.

12. Refuge - A place for withdrawal, from environmental conditions or the main flow of activity, in which the individual is protected from behind and overhead.

13. Mystery - The promise of more information achieved through partially obscured views or other sensory devices that entice the individual to travel deeper into the environment.

14. Risk/Peril - An identifiable threat coupled with a reliable safeguard. (Browning, 2014, p.23)

These standards pre-defined by the literature (Browning, 2014) are far from being rules, but they should be used as a tool in order to guide and assist in the development of a biophilic design.

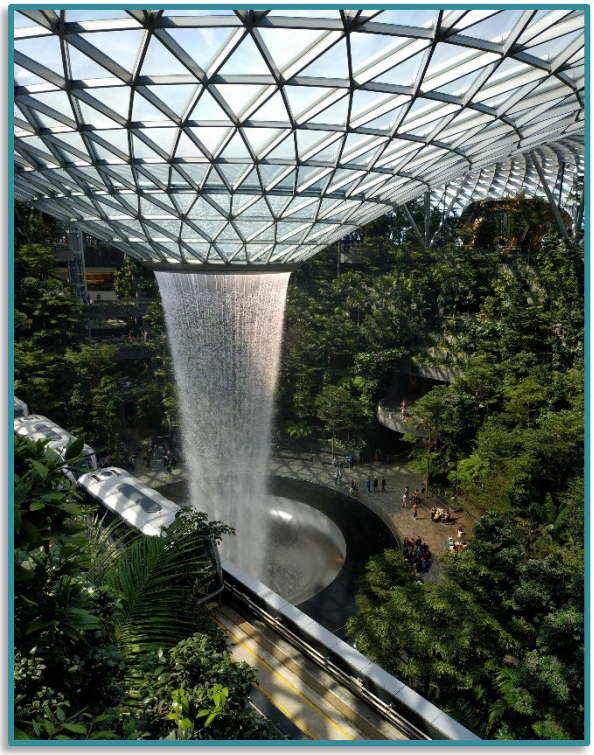
Precedent

It is important to emphasize that for a project to be biophilic, a design doesn't need to contemplate all the biophilic attributes but it must be taken into account the health conditions, socio-cultural norms, expectations of use, climate, and environmental resources of the place where the project will be implemented. And from there, the designer can establish the biophilic experience that it wants to provide for space users. It is known that biophilic design can be applied in different scales of projects: Interior, exterior, commercial, residential, et al. But as the focus of this research is urban spaces, below are images of some precedents of urban biophilic spaces.

High Line

Right in the middle of one of the largest urban centers in the world, a suspended railroad track built in the 1930s has been transformed into an urban park, providing a biophilic experience for New York City residents and visitors.

(Fig.8: High Line)



(Fig.9: Changi Airport)

Changi Airport

Located in the Tanah Merah region of Singapore, Changi Airport was designed to be a large urban center within a large garden. With the main function of joining the existing terminals, it offers all the necessary functions of an airport with the addition of providing market and recreation spaces for the population. With its different and innovative design, Changi Airport is the first in the world to add the function of an Airport with a public gathering place. Promoting a new way of thinking in public/private spaces, this airport showed that large-scale biophilic design is possible, and with that, made the practice of biophilic design known worldwide.

Khoo Teck Puat Hospital

The Khoo Teck Puat Hospital in Singapore (KTPH) is a great reference in the biophilic projects market. Having as it the main requirement of the contest, that the design should be a healing environment, the project is explicitly linked to the objective of human well-being. The existing vegetation of the project occupies up to four times the size of the land attracting dragonflies, birds, and butterflies.

(Fig.10: Khoo Teck Puat Hospital)

(Fig.11: Gardens by the Bay)

Gardens by the Bay

Located in Marina Bay, the park is 101 hectares in size and comprises three distinct gardens - Bay South, Bay East, and Bay Central. The entire plan has an intelligent environmental infrastructure, allowing the endangered plants to flourish. In addition to having become a great space for leisure and environmental education in the country, the place has also become a world tourist destination. The project is an integral part of Singapore's "City in a Garden" vision, which is a project to make Singapore a model country in biodiversity.

As shown, it is possible to find good examples of biophilic urban projects, but they are still few compared to the urban scale. Is necessary that the topic is broadcast and addressed on a large scale. Studies on biophilic design are still very scarce, and the term is still treated as something new, but the need for biophilic design is easy to see when one thinks about the growth of urban centers. Today, more than half of the world's population lives in urban centers and it is projected that this will increase to 70% in the coming years. That is why city planners must start to address biophilic design in their agendas as a way to provide people with contact with nature in their daily lives. Biophilic design mustn't be interpreted as an architectural style, but as a necessity for the health and well-being of the population.

Project Schedule

The project started with a coherent and very comfortable schedule. The project was divided into four phases, where the first phase was the study and literature review phase. Phase two was the implementation of biophilic concepts learned by designing biophilic urban spaces. The third phase focused to do the experiment with the GSR sensor and the questionnaire. And the fourth and last phase was the analysis of the results.

Professional Project Schedule

TASKS			MONTH
PHASE 1	Study	- Biophilic Design Definition	AUGUST
		- Biophilic Design Precedents	
		- Biophilic Design and Health	SEPTEMBER
		- Urban Spaces to place a Biophilic Design	
PHASE 2	Design	- Decide the sites	OCTOBER
		- Draft of the designs	NOVEMBER
		- Render	DECEMBER
		- Finish the designs	JANUARY
PHASE 3	Experiment	- IRB	FEBRUARY
		- Start Learning the Device	
		- Recruit people	MARCH
		- Do the experiment	
PHASE 4	Analysis	- Organize the data	APRIL
		- Analise the data	
		- Write the report	May
		- Review report	

1. October 3rd – Mid-term Jury
2. November 21st – End-of-Term Jury
3. February 27th – Mid-term Jury
4. May 1st – Final Defense

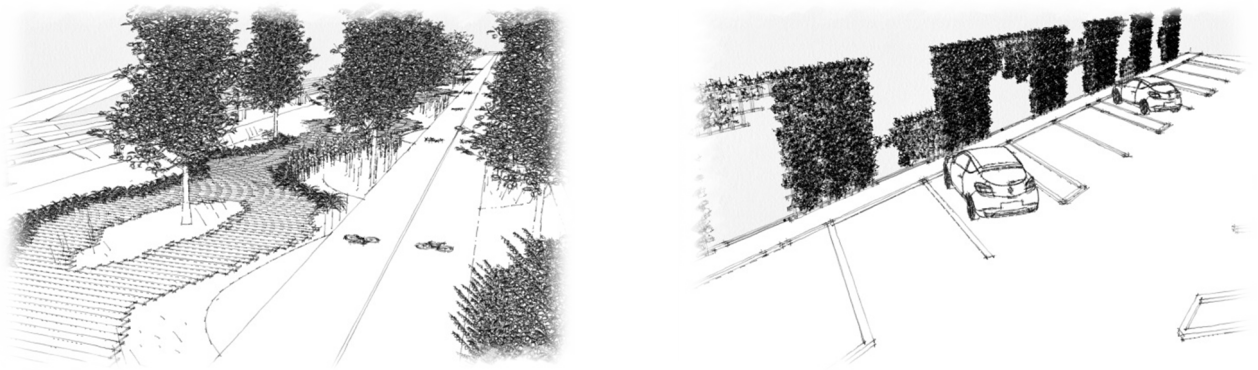
Design Process

At the beginning of the design process, I choose four existing public spaces in the City of Tulsa to apply the concepts of biophilic design. I choose these locations because they are typical spaces in any large city that are part of people's daily lives. These biophilic designs of urban spaces were used as treatment variable in the experiment in the following phases of the study. The criteria I used when choosing the urban spaces are as follows:

- Public places that are part of people's daily lives.
- Places that enable the participants to compare a usual urban space with the Biophilic Urban Space.
- Places that could prove that public spaces can be more pleasant and healthy;
- Places that could make daily contact with nature possible for those who live in big cities.

With these considerations in mind, I choose the four urban spaces: a parking lot, a pedestrian bridge, a corner blank wall, and an urban street. I photographed each space and used the pictures' digital files in the experiment. And then I created my biophilic designs, applying the biophilic elements to the pictures. The designs created and the photos were used to investigate the relationship between biophilic design and stress and well-being. The development of the drawings was done in an orderly manner. The first design to be developed was the blank wall. Followed by the parking lot, pedestrian bridge, and urban street, consecutively.

Below some images of the firsts drafts:



(Fig.12: Sketches of the designs)

Below I describe the development of each design.

Blank Wall

The blank wall is located in the historic neighborhood, Greenwood, in the city of Tulsa. Its location is strategic due to its high visibility by pedestrians and because it is at the head of a historic pathway. The reason for choosing this specific place arose from the importance of rethinking the empty walls of city buildings and also to encourage the development of biophilic walls.

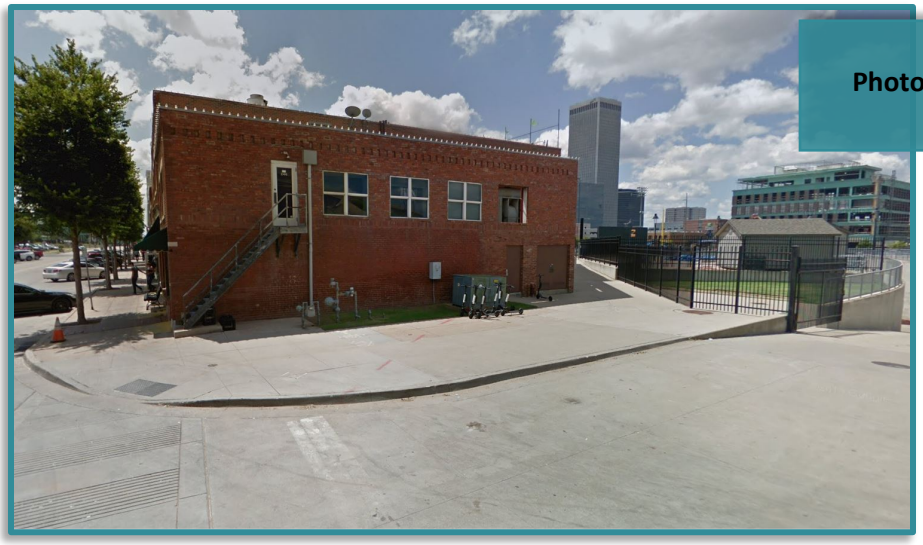


Photo of the existing place.

(Fig.13: Blank wall at Greenwood neighborhood)

Biophilic Blank Wall

Biophilic concepts:

- Vegetations
- Animals
- Natural Materials

(Fig.14: Render of the biphilic blank wall)

Parking Lot

The idea of developing a biophilic parking lot arose from the possibility to create a new use for the parking lots in downtown Tulsa. Like most American cities, Tulsa is a car-dependent city and almost 25% of Tulsa's downtown area is composed of parking lots. Therefore, it would be a great benefit for the city, if all parking lots were transformed into biophilic parking lots. The city would have more green spaces and more beauty.

Photo of the existing place.

(Fig.15: Parking lot at Downtown, Tulsa)

Biophilic Parking Lot

Biophilic Principles:

- Natural Light
- Better Air Quality
- Vegetations
- Animals
- Microclimate
- Natural Materials

(Fig.16: Render of a biophilic Parking lot at Downtown, Tulsa)

Pedestrian Bridge

Jenks is a suburb of Tulsa. One of its mains, physical connections with Tulsa is the Jenks pedestrian bridge. It was a car bridge in the past and became a pedestrian bridge after the construction of a new bigger bridge. Today the bridge is used as a pedestrian pathway to connect to a trail along the bank of the Arkansas River to the Aquarium trail. The idea of turning this pedestrian bridge into a biophilic pedestrian bridge was to continue the focus on nature created by the two river trails, rather than breaking the mood created by trails with iron and cement bridge.

Photo of the existing place.

(Fig.17: Jenks pedestrian bridge, at Tulsa)

Biophilic Pedestrian Bridge

Biophilic Principles:

- Natural Light
- Better air quality (air)
- Vegetations
- Animals
- Microclimate
- Natural Materials/ Naturalistic shapes and forms

(Fig.18: Render of the biophilic Jenks pedestrian bridge, at Tulsa)

Urban Street

Boston Avenue is situated in downtown Tulsa and is the most urban street in town therefore, I thought it was a perfect location to become a biophilic urban street. My idea is to show that even big urban streets can provide a biophilic experience.

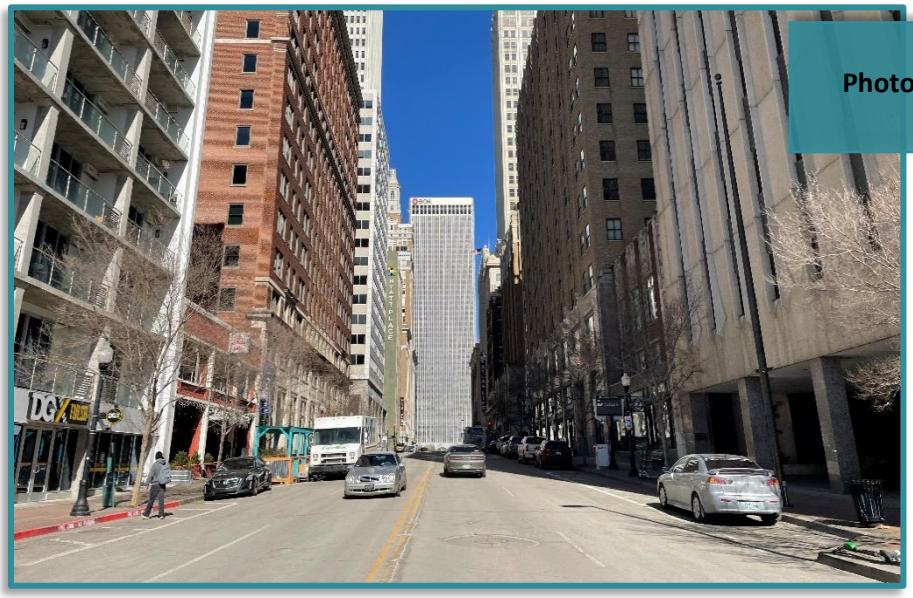


Photo of the existing place.

(Fig.19: Boston Avenue, at Tulsa)

Biophilic Boston Avenue

Biophilic Principles:

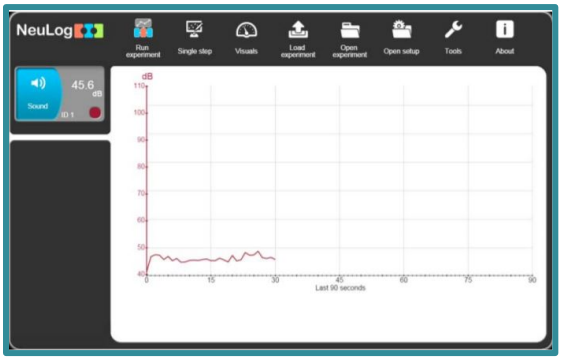
- Natural Light
- Better air quality (air)
- Vegetations
- Animals
- Microclimate
- Natural Materials
- Naturalistic shapes

(Fig.20: Render of the biophilic Boston Avenue, at Tulsa)

The Equipment

People's level of emotional arousal changes in response to their environment. if something is emotionally relevant, e.g., if something is scary, threatening, joyful, then the subsequent change in emotional response increases eccrine sweat gland activity. Therefore, that physical change can be measured using a Galvanic Skin Response Sensor (GSR), a device that can measure the levels of perspiration of the hands. The changes in sweat gland activity are reflective of the intensity of the participant's emotional state, otherwise known as emotional arousal. Therefore, through the levels of perspiration, we can know the intensity of the emotion generated after some stimulus. However, the equipment cannot distinguish the type of emotion generated, only the intensity of the emotion. The technique involves placing two rings on the fingers of the research participants. The equipment collects the results in microsiemens. A microsiemens (µS, uS) is a decimal fraction of the SI unit of electrical conductance and admittance siemens and is equal to 10^{-6} siemens. Conductance and admittance are the reciprocals of resistance and impedance respectively, hence, one siemens is equal to the reciprocal of one ohm (Microsiemens (µS) Electrical Conductance Unit Conversions, 2020). The equipment must be calibrated for each person to be researched because the value varies from subject to subject and also according to the subject's emotional condition. The calibration of the equipment for the participant takes place before the measurement begins. To begin the experiment, the tester asks the subject to sit comfortably and relax for 5 minutes. Next, the tester record the equipment's existing measurement reading. In this way, I was able to find an average emotional arousal value. Emotional arousal can vary significantly from one person to another. Consequently, it is important to establish the base of each participant before the beginning of the measurements.

(Fig. 21: A person using the GSR Sensor)



(Fig.22: Neulog Software)

Participant recruitment

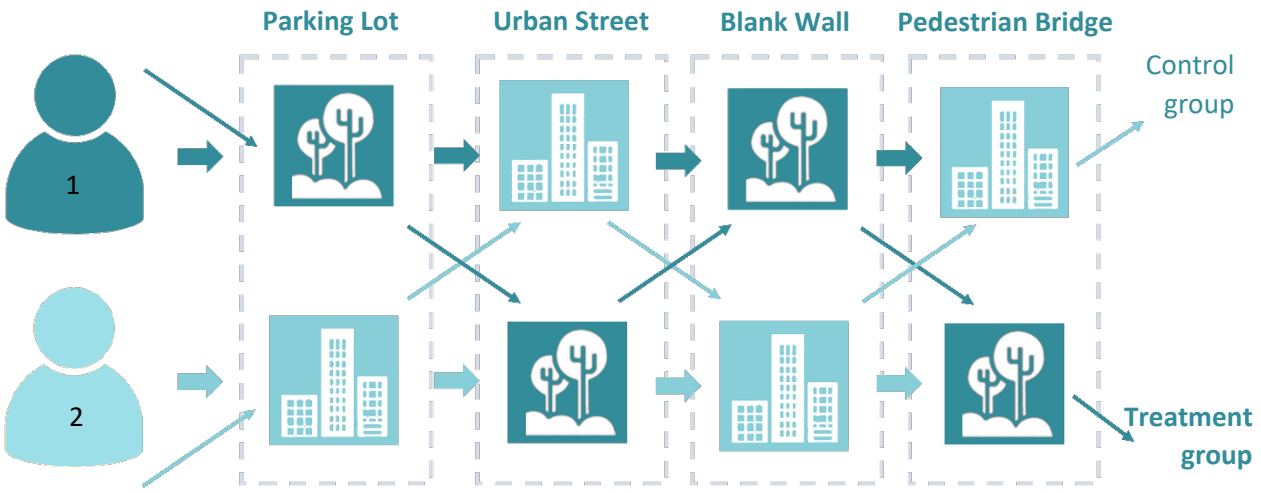
For the development of this research, it was necessary to carry out an Institutional Review Board (IRB) process. In the IRB, I established the process for gaining subject consent to participate in the research and designed the recruitment. For the consent, the participants must sign a printed consent form that contains all the information about the research: description of the procedure, risks, and remuneration, if any. This document (see Appendix 1) must be signed before the testing of a subject starts. I established at the beginning of the research that I would recruit a maximum of 30 random adults who should be students and faculty of OU-Tulsa. They were recruited through OU-Tulsa's internal email distribution and social media. The recruitment document (see Appendix 2) contains brief information about the procedure, information about remuneration, and stated possible risks of the experiment. Through this email, people interested in participating in the research were asked to contact me to make an appointment for the experiment. The appointment was scheduled directly with, and I performed the research on each subject individually, including hooking the subject up to the GSR sensor one at a time. The appointments observed the current COVID-19 interaction safety procedures (United States Department of labor, 2021)

The Experiment

The experiment will use two ways to measure emotional arousal and well-being: a questionnaire and a Galvanic Skin Response (GSR). The experiment starts with the participant sitting in a comfortable chair. The experimenter asked the participant to sign the consent form. After this, the experimenter attached the GSR sensor rings on the participant's fingers as shown in fig. 23. The experimenter encouraged the subject to breathe and try to relax for 5 minutes. After 5 minutes of relaxation, the experimenter starts the measurement with the GSR sensor by displaying the first image on the TV screen that is placed in

(Fig.23: Galvanic Skin Response sensor)

front of the participant. After 30 seconds, the participant answered a questionnaire with 13 questions about the image related to stress and well-being. In the interval between displaying images and completing of each image, the participant will relax for five minutes in order to calibrate the equipment again. Each image was shown for 30 seconds. This procedure is repeated 3 times with different images. The participant will see four images in the total of the experiment (two biophilic and two non-biophilic) as shown below:



(Fig,24: Methodology for displaying images per participant: Control group and Treatment group)

The images shown in the experiments were determined through choices of existing urban spaces of the city of Tulsa. Four urban spaces were chosen. For the non-biophilic images used in the experiment, pictures of these existing urban spaces were taken. And for biophilic images, renders of these urban spaces were produced using the concepts of biophilic design. In order to minimize the bios, I created two groups of four images. One group begins the experiment by viewing an image of a biophilic urban space, and the other group begins the experiment by viewing an image of the non-biophilic space. The images contained in these groups are also different from each other. The questions in the questionnaire were designed to investigate what the participants feel when they see images of non-biophilic urban spaces and biophilic urban spaces (For the questionnaire, see Appendix 3).

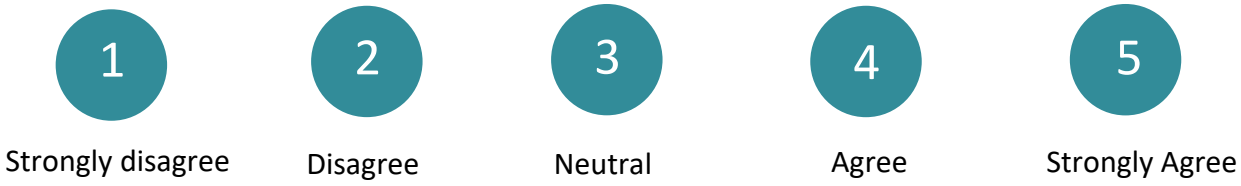
The GSR sensor captured participant's responses instantly and records them in the software that is connected to the equipment and these responses will be compared with the responses of the questionnaire. This comparison of results will help me validate the results and verify if biophilic urban spaces are capable of reducing stress and promote well-being. The experiment should take approximately 30 minutes per participant.

THE ANALYSIS

The analysis of the results obtained was performed by comparing the answers given by the respondents to the questionnaire to the collected measurements from the GSR equipment. A spreadsheet was created with all the individual results of the questionnaire and the GSR results. In this way, the results were compared in three ways:

1. Comparing the results of the questionnaire for the same person to biophilic and non-biophilic images;
2. Comparing the results of all the participants in the questionnaire;
3. Comparing the general result of the questionnaire with the GSR equipment.

The research was designed for a maximum sample of 30 random adults. Participants were recruited via the university's internal email and lasted two weeks, and a sample of 23 participants was reached: 7 men and 16 women. Two forms of data collection were used. A questionnaire and a GSR Sensor. Each participant viewed four images (two biophilic and two non-biophilic). For each image viewed, the participant completed a questionnaire with 13 questions. Two questions collecting qualitative data and 11 collecting quantitative data. A total of 92 responses were obtained, 46 for non-biophilic images and 46 for biophilic images. The GSR Sensor also generates quantitative data. It was used to generate physiological data from the participants while they look at the images. For the quantitative questions in the questionnaire, a Likert scale was used. A Likert Scale is a measurement tool widely used in opinion polls. Participants answer questions based on their level of agreement with a statement. The levels of agreement in this research were scored from 1 to 5, where:



To analyze the quantitative results collected, I applied the statistical technique of factorial analysis using the SPSS software. Factor analysis is used to minimize the number of variables in a small group of factors by grouping the variables that are correlated. Through the SPSS software, I was also able to verify the correlation of different variables by comparing them in different ways in order to confirm the assumption factor. Factor analysis is subjective and depends on the researcher's interpretation of the data to establish a conclusion. But in general, the researcher seeks to confirm or deny his initial hypothesis. It is also possible to see other factors when analyzing and comparing the data. The qualitative data collected from the first two questions of the questionnaire were analyzed manually and grouped by similarity. The questions were generic and aimed to capture the participant's first impression when viewing the images. The questions were:

1 – Describe this picture in one word.

2 – In one world, how does this place make you feel.

The analysis was initiated by comparing the answers to questions Q1 and Q2 of the questionnaire for biophilic and non-biophilic images. In this way, we were able to verify how people felt in both situations. Find below the answers collected for each biophilic and non-biophilic image groups for both questions:

Question 1 – Describe this picture in one word.

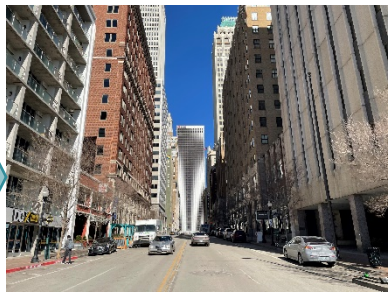
Jenks Pedestrian Bridge

- Lonely
- Peaceful
- Concrete
- Bridge
- Fall
- Urban
- Long
- Summer
- Calm
- Bright

- Awesome
- Organic
- Pretty
- Serene
- Calm
- Bright
- Gorgeous
- Peaceful
- Bridge
- Exercise
- Green

Boston Avenue

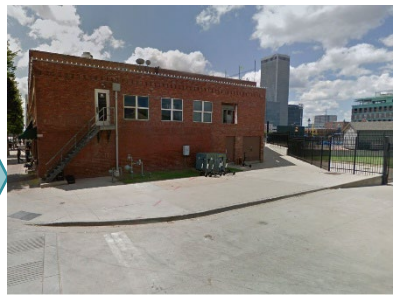
- Boring
- Crowded
- Tall
- Enclosed
- Downtown
- Alive
- Towering
- Overwhelming
- Busy

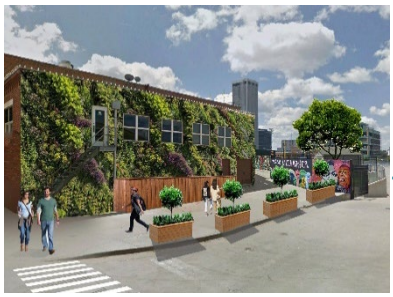


- Modern
- Urban
- Green
- Downtown
- Active
- Street
- Vibrant
- Lively
- Harmony
- Busy

Blank Wall

- Crowded
- Historic
- Secluded
- Greenwood
- Lonely
- Building
- Quiet
- Boring
- Utility
- Industrial
- Bland





- Exciting
- Inclusive
- Nature
- Open
- Green
- Cozy
- Busy
- Casual
- Vines
- Community

Parking Lot

- Dull
- Urban
- City
- Buildings
- Downtown
- Busy
- Asphalt
- Familiar

- Beautiful
- Pretty
- Parking
- Colorful
- Vitality
- Nice
- Business
- Natural
- Inviting
- Open

Question 2 – In one world, how does this place makes you feel.

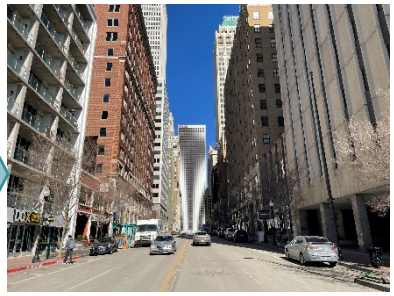
Jenks Pedestrian Bridge

- Empty
- Good
- Safe
- Relaxed
- Neutral
- Surrounded
- Nostalgic
- Peaceful
- Happy

- Happy
- Peaceful
- Calm
- Warm
- Awake
- Relaxed
- Active

Boston Avenue

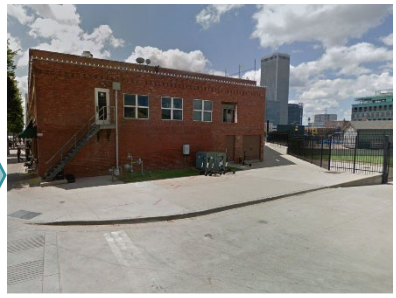
- Sad
- Reminiscent
- Small
- Tight
- Trapped
- Tonneled
- Busy
- Closed
- Confused
- Urban
- Stressed

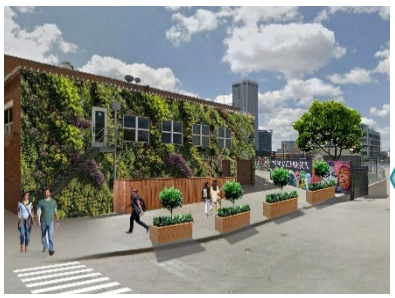


- Peaceful
- Reminiscent
- Active
- Hopeful
- Excited
- Happy
- Busy
- Good
- Energetic
- Indifferent

Blank Wall

- Happy
- Ambivalent
- Neutral
- Positive
- Hopeful
- Peaceful
- Bored
- Blind
- Alone
- Unhappy





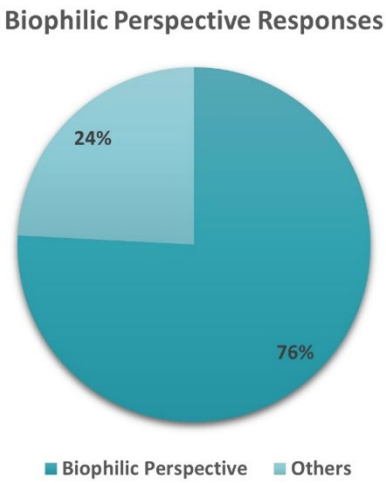
- Hopeful
- Happy
- Chill
- Outsider
- Comfortable
- Uncomfortable
- Relaxed
- Connected
- Refreshed

Parking Lot

- Tired
- Hurried
- Enclosed
- Crowded
- Small
- Curious
- Trapped
- Drained
- Cold
- Bored
- Busy

- Relaxed
- Creative
- Content
- Happy
- Cheerful
- Energined
- Calm
- Bright
- Comfortable

It is possible to notice that in both questions the responses have an established pattern. With minor exceptions, biophilic images had more positive statements than non-biophilic images. There was less repetition of words associated with non-biophilic images, and most had a negative meaning, words like bored, busy, unhappy. In the responses associated with the biophilic image, there were a great many words with similar significance as shown in fig. 25. It is important to note that the first non-biophilic image (the Jenks pedestrian bridge) was the image that received the most positives responses of the non-biophilic images and only one negative response. I believe that this may have happened because the Jenks pedestrian bridge was the first non-biophilic image to be shown in the experiment, forcing the participant to opine without having another image to compare. It is noticed when the responses of the second non-biophilic image are compared with the first one. The responses of the participant became predominantly negative, after being exposed to the biophilic images. This pattern brought me some conclusions. People are used to gray, arid, concrete-filled urban environments, making them find these places attractive at the first sight, but after being exposed to a biophilic images, they can see that these places could be more attractive and generate more positive feelings.



(Fig.25: Biophilic perspective reposnses of the questionnaire)

For the analysis of the quantitative responses of the questionnaire, the statistical technique of factor analysis was used. First, the data was organized in a spreadsheet, where the images were identified by numbers from 1 to 8, and the questions were identified as 3 to 13 as follows:

(For the complete questionnaire, see appendix 3)

The questions were identified as 3 to 13 as follows:

Q3 - This place is beautiful.

Q4 - This place is comfortable.

Q5 - This place promotes health.

Q6 - If I could choose, I would visit this place often.

Q7 - This place stresses me.

Q8 - This place makes me feel happy.

Q9 - If I could choose, I would rarely visit this place.

Q10 - This is a pleasant place.

Q11 - This place makes me feel well.

Q12 - I believe this place promotes my well-being.

Q13 - This place makes me feel safe.

The images were also divided between the control and treatment group, where control was the non-biophilic images and treatment was the biophilic images and were also numbered 1 and 2, respectively. As previously mentioned, the answers to the questions were scaled using The Likert Scale. The values ranged from 1 to 5, where 1 represents the *strongly disagree* of the scale, and 5 is the *Strongly agree*. With the values organized in the spreadsheet, the SPSS software was used for data analysis. The first test to be performed was the correlation matrix, in which I verified the level of correlation between the variables in order to minimize the number of factors. In this test, the value 1 means perfect correlation, and the closer the value gets to 1, the greater the correlation between the variables. Below is the correlation matrix of the questions responses to the control and treatment group :

Correlation Matrix

	Cont x Treat	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13
Cont x Treat	1.000	.694	.614	.518	.592	-.488	.680	-.580	.680	.646	.694	.579
Q3	.694	1.000	.885	.722	.753	-.683	.818	-.739	.764	.757	.730	.677
Q4	.614	.885	1.000	.699	.786	-.689	.794	-.760	.740	.753	.719	.685
Q5	.518	.722	.699	1.000	.645	-.587	.640	-.618	.657	.692	.754	.634
Q6	.592	.753	.786	.645	1.000	-.746	.854	-.856	.783	.836	.768	.722
Q7	-.488	-.683	-.689	-.587	-.746	1.000	-.793	.751	-.759	-.778	-.709	-.758
Q8	.680	.818	.794	.640	.854	-.793	1.000	-.822	.859	.887	.812	.764
Q9	-.580	-.739	-.760	-.618	-.856	.751	-.822	1.000	-.802	-.798	-.807	-.699
Q10	.680	.764	.740	.657	.783	-.759	.859	-.802	1.000	.869	.840	.750
Q11	.646	.757	.753	.692	.836	-.778	.887	-.798	.869	1.000	.888	.777
Q12	.694	.730	.719	.754	.768	-.709	.812	-.807	.840	.888	1.000	.756
Q13	.579	.677	.685	.634	.722	-.758	.764	-.699	.750	.777	.756	1.000

(Fig.26: Correlation matrix of quantitative data of the questionnaire)

As seen in the previous matrix, the vast majority of variables have a high correlation, except for questions Q7 and Q9, which can be explained by the fact that the questions are negative questions, which would be expected to render responses the opposite way to the other questions. The KMO test (Kaiser-Meyer measure) and The Bartlett's test of sphericity were also performed. The KMO test verifies the adequacy of data sampling, indicating the proportion of variance in variables that might be caused by underlying factors. KMO values between 0.8 and 1 indicate the sampling is adequate and the factor analysis may be useful. And values below 0.5 indicate that the factor analysis won't be useful. Bartlett's test of sphericity, as explained on the IBM SPSS Statistics website, tests the hypothesis that the correlation matrix is an identity matrix, which would indicate that the variables are unrelated, and therefore, unsuitable for structure detection. Small values (less than 0.05) of the significance level indicate that factor analysis may be useful with this study's data. As can be seen in the table, the KMO value of .939 was found, which indicates that the data sample is adequate. The Bartlett's test was 0.001. These tests are ways of validating the data to verify that the factor analysis will be well implemented. As the test results were positive, the analysis factor proceeded. Below is the table of total variation explained. It is possible to verify the total variance explained by each factor. This is perhaps the most relevant information in this initial analysis because it explains how many factors can be associated with the correlations shown in the correlation matrix. Since there is only only component founded, only one factor

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.939
Bartlett's Test of Sphericity	Approx. Chi-Square	1281.599
	df	66
	Sig.	<.001

(Fig.27: KMO and Bartlett's test of que questionnaire data)

relates to all variables. Below, the value found of 75.85% is seen in the table, which means that 75.85% of the correlation is explained by this factor.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	9.102	75.851	75.851	9.102	75.851	75.851
2	.606	5.047	80.898			
3	.506	4.220	85.118			
4	.439	3.659	88.778			
5	.340	2.835	91.613			
6	.231	1.928	93.540			
7	.199	1.659	95.199			
8	.174	1.449	96.648			
9	.137	1.144	97.792			
10	.115	.959	98.751			
11	.084	.704	99.455			
12	.065	.545	100.000			

Extraction Method: Principal Component Analysis.

(Fig.28: Total Variance explained of que questionnaire data)

As only one correlation factor was found, I attributed this factor to the main hypothesis of the research that people had expressed significant differences in the perception of stress and well-being when they viewed biophilic images. In this initial analysis, I saw that the biophilic images had positive effects on the research participants. Therefore, the factor found in this factor analysis was called the Biophilic Perception factor.

Another quantitative analysis was conducted comparing the questionnaire responses of the control and treatment groups. In this comparison, it is possible to see how places are perceived differently in their two forms: biophilic and non-biophilic.

For the following graphs, the following captions were considered:

Image Code

Q - Question

1 – Strongly Disagree

2 – Disagree

3- Neutral

4 – Agree

5 – Strongly Agree

Cont x Treat

1 – Control group – Non-biophilic.

2 – Treatment group – Biophilic.

Frequency

Number of reponses

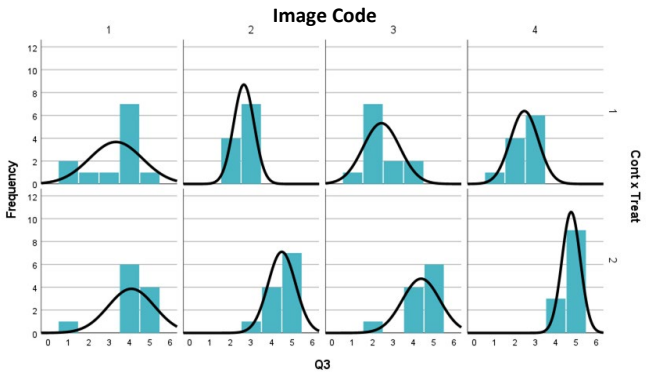


Image Code
1
2
3
4
Frequency
Cont x Treat
Q3

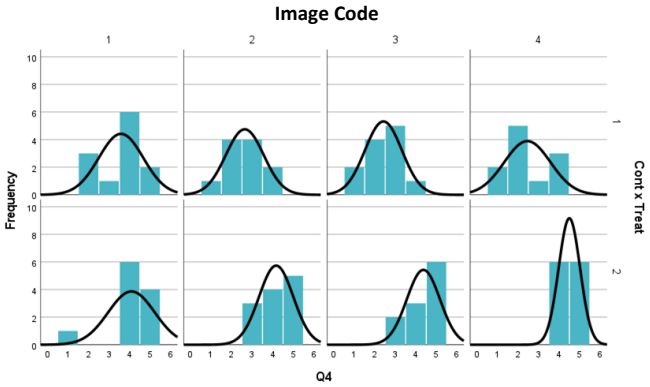


Image Code
1
2
3
4
Frequency
Cont x Treat
Q4

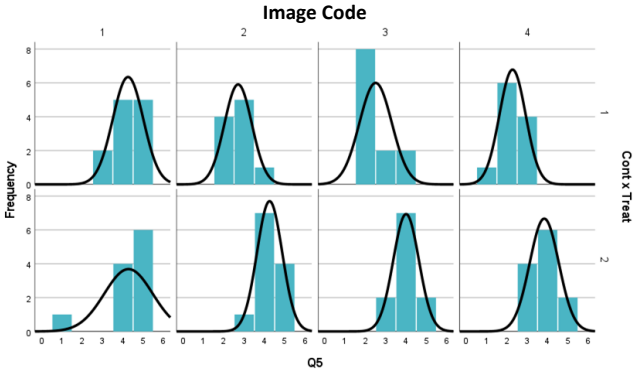
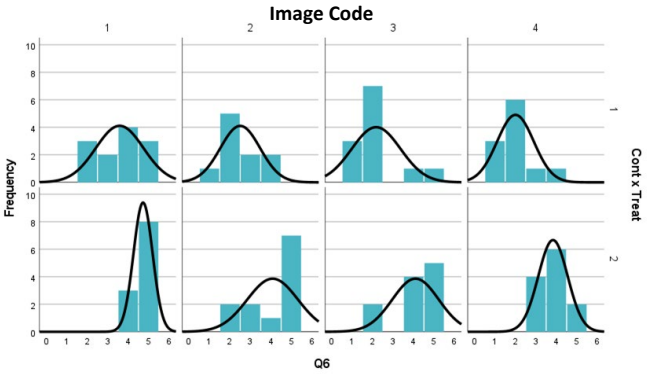


Image Code
1
2
3
4
Frequency
Cont x Treat
Q5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2
3
4
Frequency
Cont x Treat
Q6

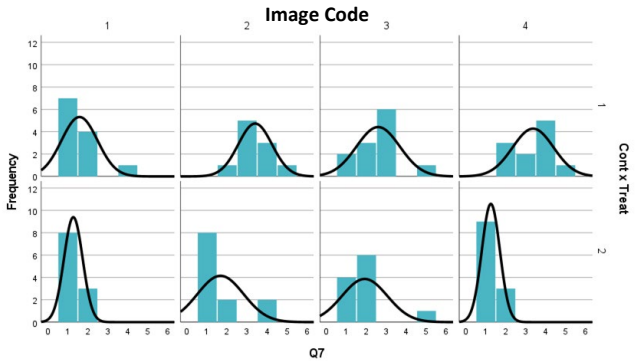
Image Code
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2
3
4
Frequency
Cont x Treat
Q7

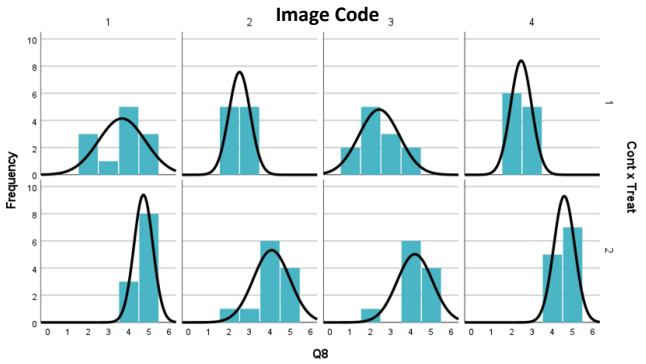
Image Code
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2
3
4
Frequency
Cont x Treat
Q8

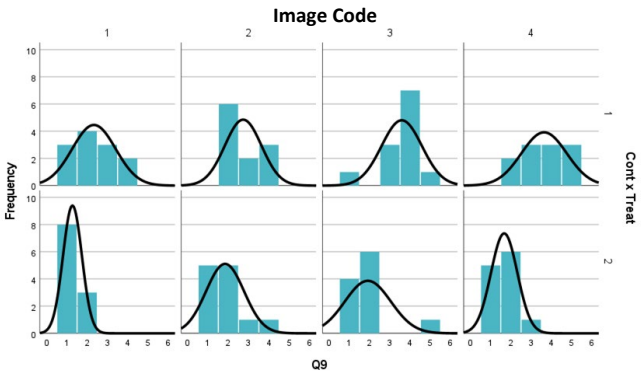
Image Code
1
2
3
4
Frequency
Cont x Treat
Q9

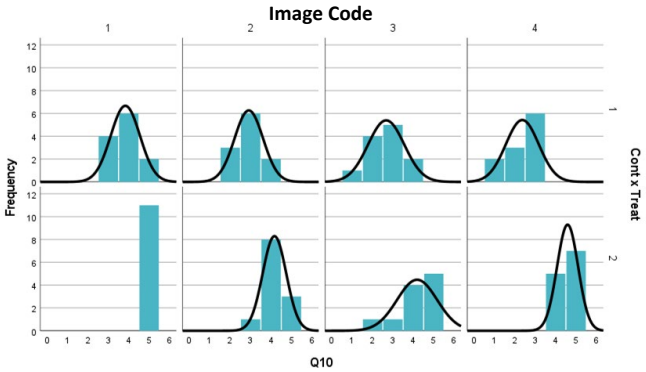
Image Code
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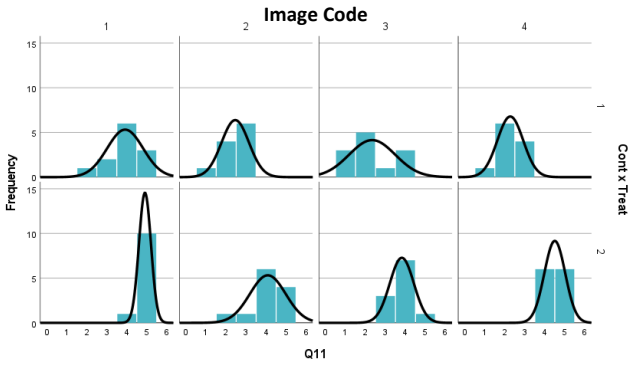
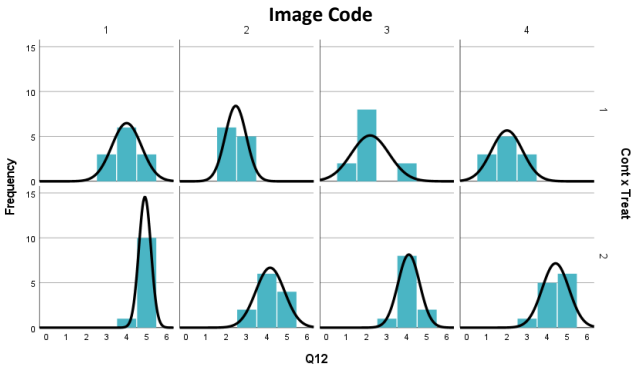
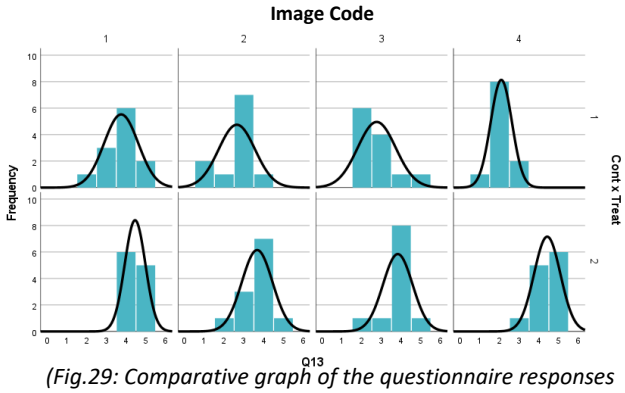
2
3
4
Frequency
Cont x Treat
Q10







(Fig.29: Comparative graph of the questionnaire responses for the treatment and control group)

When analyzing the graphs, it is interesting to note that the control and treatment groups have different diagrams. When I verified that most of the questions had positive answers for the biophilic images and negative answers for non-biophilic images, I found that the main hypothesis of the research could be confirmed. Another important fact that draws attention when comparing the graphs is that *image 1* behaves differently when compared to other non-biophilic images. I*mage 1* has more positive responses than the other non-biophilic images which confirm the assumption of the qualitative collected data, that this may have happened because the Jenks pedestrian bridge (image 1) was the first non-biophilic image to be shown in the experiment, forcing the participant to respond without having another image to compare. The Other graphs that also have different visual behavior are the graphs of the questions Q7 and Q9. And like as also seen in the correlation matrix in the factor analysis, this is because these two questions are negative so it is expected to behave in the opposite way to positive questions. With this, we can verify that people have a perception of well-being when biofílic images are seen. The last quantitative data to be analyzed are the data collected by using the GSR Sensor. The GSR collected data were a measure of the perspiration of the participants' hands while looking at an image. Specifically, these data were collected in an attempt to obtain a physiological response of subjects who looked at biophilic images. For these data, factor analysis was also used. However,

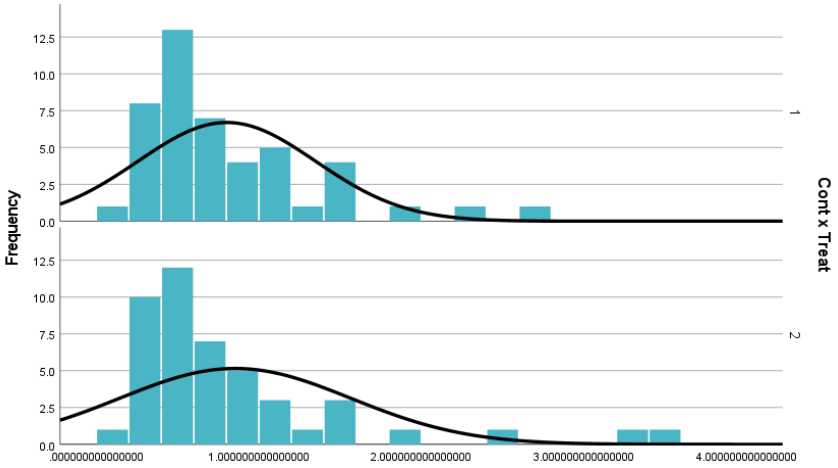
unlike the questionnaire data, the GSR data did not show a great correlation number, as shown in the correlation matrix below.

Correlation Matrix

	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	GSR IMG AVRG
Q3	1.000	.885	.722	.753	-.683	.818	-.739	.764	.757	.730	.677	.017
Q4	.885	1.000	.699	.786	-.689	.794	-.760	.740	.753	.719	.685	.108
Q5	.722	.699	1.000	.645	-.587	.640	-.618	.657	.692	.754	.634	-.202
Q6	.753	.786	.645	1.000	-.746	.854	-.856	.783	.836	.768	.722	.140
Q7	-.683	-.689	-.587	-.746	1.000	-.793	.751	-.759	-.778	-.709	-.758	-.029
Q8	.818	.794	.640	.854	-.793	1.000	-.822	.859	.887	.812	.764	.000
Q9	-.739	-.760	-.618	-.856	.751	-.822	1.000	-.802	-.798	-.807	-.699	.011
Q10	.764	.740	.657	.783	-.759	.859	-.802	1.000	.869	.840	.750	.062
Q11	.757	.753	.692	.836	-.778	.887	-.798	.869	1.000	.888	.777	.030
Q12	.730	.719	.754	.768	-.709	.812	-.807	.840	.888	1.000	.756	-.084
Q13	.677	.685	.634	.722	-.758	.764	-.699	.750	.777	.756	1.000	.076
GSR IMG AVRG	.017	.108	-.202	.140	-.029	.000	.011	.062	.030	-.084	.076	1.000

(Fig.30: Correlation matrix of que questionnaire responses and GSR data)

This correlation matrix is a record of the quantitative responses of the questionnaire and the quantitative responses of the GSR. It shows that there is little correction between the two since significant correlation values must be greater than .5. The matrix shows that all the correlation values with the GSR data are less than .00. In an attempt to try to find some representative correlation, a comparative graph of the GSR values was made with the control and treatment groups. And nor was any significant value found as shown on the graphic below. In the graph, it is easy to see that the control and treatment groups behave in a very similar way, with no changes suggesting any physiological response to biophilic or non-biophilic images. After these two tests, I concluded that the data collected by the GSR did not generate relevant information for this research. Thus, it was not possible to collect physiological responses to biophilic and non-biophilic images as was the initial objective. I believe that happened was because the the fact that the equipment may not be the most appropriate for this type of data



(Fig.31: Comparative graph of the GSR data for the treatment and control

collection or perhaps because the biophilic and non-biophilic images are not able to generate any measurable physiological responses. For a more accurate answer, further research and uses of different equipment would be necessary. Only then would I be able to validate the effectiveness of the GSR equipment.

Conclusion

The first idea of this study was to try to find psychological and physiological evidence that could relate biophilic urban spaces with positive emotional states, however with the lack of substantial data from the GSR, I was able just to find psychological or perceptual evidence. After analyzing all the data collected, I can conclude that there was a significant positive emotional state response to what I call a biophilic perspective based on the questionnaire responses. It is interesting to notice that the qualitative and quantitative data of the questionnaire indicates the same behavior, confirming that people feel better when viewing images of biophilic urban spaces. Therefore, this research confirmed the main hypothesis: There is be a significant difference in stress and well-being perception in subjects viewing biophilic urban spaces. But I cannot say that with these answers a pattern of behavior was established. It remains necessary to perform further research to obtain physiological data to confirm a significant psychological impact of biophilic design on humans. Since it was not possible to obtain this data with the use of the GSR sensor, I suggest the use of more appropriate equipment to obtain very accurate physiological readings. Perhaps an EEG sensor or an MRI. With that, I conclude that my data analysis indicates that biophilic images provoked more positive emotional states than do non-biophilic images. Consequently, from that conclusion, I infer that biophilic urban spaces can promote a sense of well-being in people experiencing those spaces.

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Fig. 1 – Graphic of the number of people living in urban and rural areas.Taken from the *One world in data* website (September 27, 2018.) https://ourworldindata.org/how-urban-is-the-world

Fig. 2 – Graphics of the the responses collected on a opinion survey made by Virginia Paiva on July, 28th 2020.

Fig. 3 – Graphic illustration of the summary of the research methodology made by Virginia Paiva.

Fig. 4 - Hanging gardens of Babylon. (2002, February 25). Wikipedia, the free encyclopedia. Retrieved September 22, 2020, https://en.wikipedia.org/wiki/Hanging_Gardens_of_Babylon

Fig. 5 – Photo of gardens of the Inhotim Museum. Taken by Virginia Paiva.

APPENDIX 1

Consent form

701-A-1

Signed Consent to Participate in Research

Would you like to be involved in research at the University of Oklahoma?

I am Virginia Paiva from the Urban Design Studio and I invite you to participate in my research project entitled Biophilic Urban Design, designing healing spaces by nature. This research is being conducted at OU-Tulsa. You were selected as a possible participant because you are an OU student or employee. You must be at least 18 years of age to participate in this study.

Please read this document and contact me to ask any questions that you may have BEFORE agreeing to take part in my research.

What is the purpose of this research? The purpose of this research is to investigate the relationship between nature and stress levels, as part of my professional project to conclude the master's course in Urban Design at the University of Oklahoma. The research will be in-person and it will last approximately 30 minutes. The purpose of the study is to measure the stress generated by images that will be shown to you. Two independent measurements of stress will be employed as participants view the images: a questionnaire and the galvanic skin response (GSR) logger sensor. The GSR measures the reaction of the human body to stressful stimuli through two rings that are placed on your fingers. The equipment is extremely comfortable and does not generate pain or discomfort.

How many participants will be in this research? Approximately 30 people.

What will I be asked to do? The experiment will start with you sitting in a comfortable chair. The instruction (me) will set up the GSR logger sensor on your fingers. You will be asked to breathe and try to relax for a few minutes. While you try to relax the instructor will calibrate the equipment. After calibration of the equipment, the experiment will be started with your consent. The experiment begins with the start of the measurement of emotions through the GSR and the participant will be asked how he feels about his stress level at that moment. After this, the instructor will show you 4 images consecutively, and after each image you will be asked how you feel considering your stress levels. There will be a total of 4 images and 5 questions. With that the experiment will be finished.

How long will this take? Your participation will take approximately 30 minutes.

What are the risks and/or benefits if I participate*?* There are no benefits from being in this research**.**

Risks related to COVID-19*: Participation in this research requires social contact with the researcher. According to the CDC (www.cdc.gov), the virus that causes COVID-19 is spreading very easily and sustainably between people. Older adults and people who have severe underlying medical conditions like heart or lung disease or diabetes seem to be at higher risk for developing serious complications from COVID-19 illness. This research protocol includes precautions that follow the CDC guidelines and comply with the current state and/or local restrictions on allowable personal interactions.* The equipment and all the furniture that the participant uses will be cleaned before and after each experiment.

Will I be compensated for participating? You will not be reimbursed for your time and participation in this research.

Who will see my information? In research reports, there will be no information that will make it possible to identify you.

You have the right to access the research data that has been collected about you as a part of

Revised 01/01/2019
Page 1 of 2

this research. However, you may not have access to this information until the entire research has completely finished and you consent to this temporary restriction.

Do I have to participate? No. If you do not participate, you will not be penalized or lose benefits or services unrelated to the research. If you decide to participate, you don't have to answer any question and can stop participating at any time.

Will my identity be anonymous or confidential? Your name will not be retained or linked with your responses.

What will happen to my data in the future? The information collected will not contain any personal information about you and will only be used for the purpose of this research. The information will be securely stored in a folder with a password to which only I will have access to. We might share the data with other researchers or use it in future research without obtaining additional consent from you.

Will I be contacted again? No.

Who do I contact with questions, concerns or complaints? If you have questions, concerns or complaints about the research or have experienced a research-related injury, contact me at 918-720-6919 or email at virginia.fpaiva@ou.edu.

You can also contact the University of Oklahoma – Norman Campus Institutional Review Board (OU-NC IRB) at 405-325-8110 or irb@ou.edu if you have questions about your rights as a research participant, concerns, or complaints about the research and wish to talk to someone other than the researcher(s) or if you cannot reach the researcher(s).

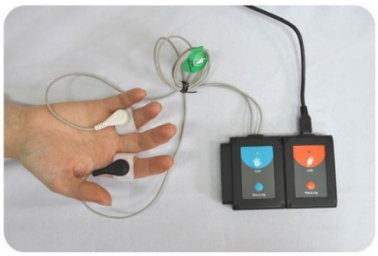
You will be given a copy of this document for your records. By providing information to the researcher(s), I am agreeing to participate in this research.

Participant Signature	Print Name	Date
Signature of Researcher Obtaining Consent	Print Name	Date

APPENDIX 2

Recruiment email

I invite you to participate in a research study that aims to investigate the relationship between nature, stress levels, and well-being as part of my professional project to conclude the master's course in Urban Design at the University of Oklahoma. The research will be in-person and set by appointment. It will be held at OU-Tulsa and it will last approximately 30 minutes. You will not be compensated for participating in the study. The purpose of the study is to measure the stress generated by images that will be shown to participants. Two independent measurements of stress will be employed as participants view the images: a questionnaire and the galvanic skin response (GSR) logger sensor (image 1). The GSR measures the reaction of the human body to stressful stimuli through two rings that are placed on the participants' fingers. the equipment is extremely comfortable and does not generate pain or discomfort. No personal information will be questioned. If you are interested in participating, or have any questions about the procedure, please contact me using my contact information below:



1. The galvanic skin response (GSR) logger

Virginia Paiva
Urban Design Studio
Email: virginia.fpaiva@ou.edu
Phone: 918-720-6919

COVID-19 precautions: *For this research to be carried out safely, it is mandatory to use the mask during the entire time of the experiment. All equipment and furniture will be cleaned at the end of each session.*

Thank you for your time!

The University of Oklahoma is an equal opportunity institution. Please advise me if you need accommodation for a disability.

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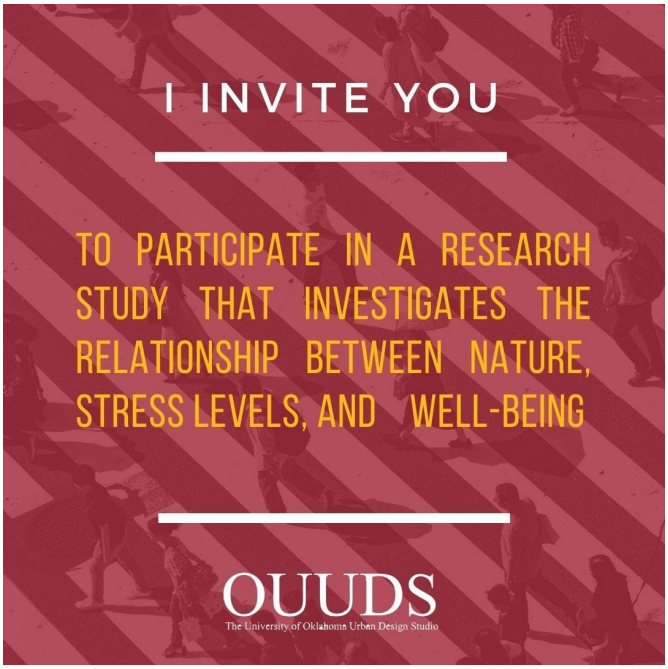
Recruiment social midia post



I invite you, OU-Tulsa staff and students, to participate in a research study that aims to investigate the relationship between nature, stress levels, and well-being, as part of my professional project to conclude the master's course in Urban Design at the University of Oklahoma. The research will be in-person and set by appointment. It will be held at OU-Tulsa and it will last approximately 30 minutes. You will not be compensated for participating in the study. The purpose of the study is to measure the stress generated by images that will be shown to participants. Two independent measurements of stress will be employed as participants view the images: a questionnaire and the galvanic skin response (GSR) logger sensor. The GSR measures the reaction of the human body to stressful stimuli through two rings that are placed on the participants' fingers. the equipment is extremely comfortable and does not generate pain or discomfort. No personal information will be questioned. If you are interested in participating or have any questions about the procedure, please contact me using my contact information below:
Virginia Paiva
Urban Design Studio
Email: virginia.fpaiva@ou.edu
Phone: 918-720-6919
COVID-19 precautions: For this research to be carried out safely, it is mandatory to use the mask during the entire time of the experiment. All equipment and furniture will be cleaned at the end of each session.

The University of Oklahoma is an equal opportunity institution. Please advise me if you need accommodation for a disability.

APPENDIX 3

Questionnaire

Participant number _____
Image number _____

1. Describe this picture in one word.

_____

2. In one word, how does this image makes you feel?

_____

For the following section, indicate if you agree or disagree.

3. This place is beautiful.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
○	○	○	○	○

4. This place is comfortable.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
○	○	○	○	○

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Participant number _____
Image number _____

5. This place promotes health.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
○	○	○	○	○

6. If I could choose, I would visit this place often.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
○	○	○	○	○

7. This place stresses me.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
○	○	○	○	○

8. This place makes me feel happy.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
○	○	○	○	○

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Participant number _____
Image number _____

9. If I could choose, I would rarely visit this place.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
○	○	○	○	○

10. This is a pleasant place.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
○	○	○	○	○

11. This place makes me feel well.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
○	○	○	○	○

12. I believe this place promotes my well-being.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
○	○	○	○	○

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3

Participant number _____
Image number _____

13. This place makes me feel safe.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
○	○	○	○	○

Thank you!

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APPENDIX 4

IRB Outcome Letter

The UNIVERSITY of OKLAHOMA

Institutional Review Board for the Protection of Human Subjects

Approval of Study Modification – Expedited Review – AP0

Date: March 24, 2021 **IRB#:** 13101

Principal Investigator: Virginia Paiva **Reference No: 713944**

Study Title: Biophilic Urban Spaces. Designing healing Spaces through nature.

Approval Date: 03/24/2021

Modification Description:
I will be changing the questionnaire (taking off one question). I will also change the way to show the images to the participants. Instead of showing it using printed borders, I will be using a monitor to show the images. And last, I will be adding a new way of recruitment. I will be using the OUUDS and OU-Tulsa social media to invite for the research experiment.

The review and approval of this submission is based on the determination that the study, as amended, will continue to be conducted in a manner consistent with the requirements of 45 CFR 46.

To view the approved documents for this submission, open this study from the My Studies option, go to Submission History, go to Completed Submissions tab and then click the Details icon.

If the consent form(s) were revised as a part of this modification, discontinue use of all previous versions of the consent form.

If you have questions about this notification or using iRIS, contact the HRPP office at (405) 325-8110 or irb@ou.edu. The HRPP Administrator assigned for this submission: Kat L Braswell.

Cordially,

Aimee Franklin, Ph.D.
Chair, Institutional Review Board