

EXPLORING THE RELATIONSHIP BETWEEN THE LANDSCAPE, OLFACTORY STIMULI AND MOOD THROUGH VIRTUAL REALITY

by

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(Under the Direction of Jessica Fernandez)

ABSTRACT

In the midst of the COVID-19 public health emergency, a mental health crisis emerged for college students. Empirical evidence demonstrates the benefits of nature experiences for mental health. However, most research focuses on the visual and auditory benefits of nature. Emerging studies suggest natural smells may maximize the healing powers of nature for people. In spite of its ubiquitous presence, smell remains one of the least understood senses and there is a need to broaden research on how natural smells affect people's health and well-being. Landscape architects may be able to create more immersive and engaging spaces by intentionally incorporating smell into design. This paper will focus on the relationship between smell and mood in a campus landscape environment using virtual reality.

INDEX WORDS: Landscape Architecture, Virtual Reality, Olfactory, Smell, Mood, Mental Health

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STIMULI AND MOOD THROUGH VIRTUAL REALITY

by

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DEDICATION

To Mom & Dad- you never doubted, always supported, and constantly loved. You are the reason behind my successes and the inspiration behind my endeavors. As I head out into the world, I go with confidence because of the strength you gave me. I love you both more than you'll ever know.

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CHAPTER 1

INTRODUCTION

1.1 Problem Statement

Evidence that exposure to nature can benefit people has accumulated rapidly over the years but due to the dominance of the visual and auditory sense in humans, most research on nature experiences heavily focuses on the visual and auditory benefits (Franco et al., 2017). However, more attention is now being directed towards the sense of smell and the psychological effects of smell on human behavior. Despite the fact that smell is often considered a minor sense compared to vision, audio, and touch, emerging research suggests that humans use it more often than traditionally thought (Shepherd, 2004). People's senses often work together, providing a multitude of benefits at once. A deeper understanding of how nature benefits people through the full range of senses reveals a more complete picture of how health and well-being are interdependent on nature (Franco et al., 2017).

When designing a space, landscape architects can incorporate specific characteristics of the natural world that better connect humans to their environment. Designing with intentional planting choices specifically for smell, landscape architects may be able to create more immersive and engaging experiences. Furthermore, better allocating fragrant plants may open an opportunity to mindfully absorb additional mental health benefits from a landscape such as relaxation and restoration. Enhancing more senses may also help people who have full or partial loss in one or more of the five senses to experience the natural world in new ways.

This thesis will aim to answer the following questions:

1. *What is the relationship between mood and scent in a campus landscape?*
2. *What is the relationship between scent and level of comfort, visual satisfaction and olfactory satisfaction in a campus environment?*
3. *Are there differences in findings when considering gender?*

This study uses virtual reality and pre and post-experience surveys to understand the relationship between smell, mood, and site perceptions in a campus environment for traditional college-age students. The following chapters include an introduction that frames the problem statement, literature review which summaries existing research related to this topic, methodology which shares the research methods used, results and analysis which gives a detailed account of the data collected, and a conclusion which provides a summary of the research and the implications for landscape design. Findings reveal that people who are exposed to a natural scent have a greater increase in positive aspects of mood as well as in overall comfort, olfactory satisfaction, and visual satisfaction. During a time when mental health is declining due to the effects and aftermath of the COVID-19 pandemic, this study provides a critical step towards maximizing the benefits that students receive from campus environments. Institutional Review Board approval was received for this study.

CHAPTER 2

LITERATURE REVIEW

2.1 Student Mental Health

During the outbreak of the COVID-19 pandemic, there was a major concern regarding the mental health of vulnerable populations, including college students. The COVID-19 pandemic has drastically altered the college experience for emerging adults, resulting in increased stress and a decline in positive mental health (Halliburton et al., 2021). Stress was already a major challenge for young adult college students before the COVID-19 pandemic arose, with 65.7% reporting “overwhelming anxiety” and 58.7% reporting “more than average” or “tremendous” stress in the previous year (ACHA, 2019). For students, the COVID-19 pandemic drastically exacerbated some of the already existing stressors, and given the vulnerability of this population, there is a critical need to address these concerns and provide resources to aid in improving their mental health. Although researchers have compiled evidence of the value of spending time in nature, there is still a growing disconnect from nature, making it important to optimize the little contact people do have.

Interest in nature as a therapeutic resource has been studied for ages. Several studies on environmental psychology have shown that spending time in natural environments can reduce stress (Franco et al., 2017; Ulrich et al., 1991) and improve moods (Berman et al., 2008; Berman et al., 2012; Nisbet & Zelenski, 2011; Ryan et al., 2010). Exposure to nature is especially

beneficial to populations suffering from high levels of stress and attentional demands, and may benefit from positive distractions and temporary escapes from their immediate circumstances (Ulrich et al., 1991). The accessibility of natural spaces on most college campuses makes nature contact a potentially attractive intervention strategy for college students suffering from mental health issues. It is now common for counselors at universities to recommend to students to spend time in nature as a preventative and supportive mental health and well-being intervention (Meredith et al., 2020). Benefits from nature may be enhanced if students are more involved or immersed in their brief outdoor experiences through the full range of senses. People's subjective will dictates how they perceive taste and touch, whereas vision, olfaction and audition usually emerge from unconscious behavior. Therefore, the built environment can only be partially grasped through taste and touch, and vision, hearing and smell most often serve as principal mediums for perceiving an environment (Ba & Kang, 2019b).

2.2 Therapeutic Gardens

In recent years, therapeutic gardens have become increasingly popular as people become more aware of the power of outdoor experiences in garden landscapes. A therapeutic garden is an environment purposefully designed to facilitate interaction with the healing elements of nature and are commonly used in healthcare environments. For example, the therapeutic garden at Kernan Hospital in Baltimore, Maryland, was designed to support patients' recovery. The garden is composed of many elements such as textures, colors scents and sounds to accommodate different senses and abilities (*Healing Therapeutic Garden at Kernan Hospital*, 2018). There are many sub-types of therapeutic gardens such as sensory gardens, tranquility gardens, healing gardens, rehabilitation gardens, restorative gardens and meditative gardens. All of these gardens

share common elements of sensory stimulating plant selections that provide a visually pleasing, audible, tactile, scented and even tasty experience (Souter-Brown, 2015). Many of these gardens focus specifically on scent such as the fragrance garden at the Morton Arboretum in Lisle, Illinois. This secluded, half-acre garden contains a plethora of fragrant flowers where visitors are meant to relax and reflect (*Fragrance Garden*, 2023). The characteristics that make up therapeutic landscapes are capable of healing people both physically and mentally, which is why we should not confine these elements to only a specific kind of landscape. Landscape architects should consider treating all outdoor spaces they design as therapeutic gardens to ensure users of a space are maximizing the health benefits they receive from nature.

2.3 The Power of Smell

The perception of smell consists not only of the sensation of odors but also experiences and emotions associated with these sensations. Smell preferences are often highly personal, linked to specific feelings and memories (Fox, 1999). The ability of scents to trigger the recall of memories, events, people, and emotions is known as the *Proust* phenomenon (Chu & Downes, 2000). The most important implication of this phenomenon is that compared to other sensory modalities, a smell-evoked memory is richer in emotional content, more vivid, and autobiographically older, often reaching back into childhood (Giada et al., 2022). The processing of smell can be affected by cultural background, environment and psychological state (Strugnell & Jones, 1999). The same scent may evoke positive emotions in one individual and negative emotions in another. People's preferences for odors can vary depending on how much value is placed on the objects associated with that odor, so smells that remind people of nature can

generate any of the positive feelings associated with it. Therefore, nature smells can function as a trigger for nature in general and might provide nature benefits indirectly (Franco et al., 2017).

No matter what environment we find ourselves in, we are surrounded by smells, whether they are natural or anthropogenic. Typically, people perceive natural scents as pleasant and relaxing, allowing a person to be present in the moment and disconnect from external stressors (Rezvanipour et al., 2021). Many natural odors have been found to facilitate stress reduction and support mental recovery (Pálsdóttir et al., 2021). Several natural odors have been shown to evoke the feeling of joy and improve mood such as *Convallaria majalis* (Liliaceae), *Jasminum sambac* (Oleaceae), and *Rosa x alba* (Rosaceae) (Weber & Heuberger, 2008). The olfactory properties of lavender, rosemary, and chamomile essential oils have been shown to positively influence mood and cognitive performance (Moss et al., 2003). The aroma of rose essential oil has been found to induce physiological and psychological relaxation (Kim et al., 2016) and lavender essential oils has been studied extensively regarding its effects on cognition, mood and subjective workload (Moss et al., 2003).

There have been numerous studies on how smell can influence human behavior. For example, studies show that consumer behavior can be manipulated by the presence of pleasant ambient odors by increasing the amount of time that people remain in the store (Knasko, 1995) and can also increase consumption levels such as in-store spending (Herrmann et al., 2013). Orange and lavender essential oils have been proven to reduce anxiety of patients in a dental office (Lehrner et al., 2005). In a recent Virtual Reality (VR) study, the results showed the olfactory stimuli of nature may be better at decreasing stress than visual stimuli and auditory stimuli (Hedblom et al., 2019). Yet, odor perception remains largely unexplored, particularly in relation to the outdoor environment.

2.4 Connection Between Smell and Mood

The olfactory system has often been linked to mood related aspects due to its uniqueness in the wiring of the brain. Unlike other senses, it is not first processed by the thalamus. Instead, the smell signal is sent straight to the hypothalamus, the brain's region involved in stress responses, in addition to the olfactory cortex where odors are processed and perceived (Yeager, 2020). This essentially means that a single breath in of an odor can affect one's mood simultaneously. The direct link between smell and the limbic system, the part of the brain that deals with emotions, suggests a potential avenue through which nature benefits can be received through smell (Franco et al., 2017). No other sensory systems have this kind of deep access (Herz, 1998). The close link between odor and emotion has made olfactory stimulation a promising method for mood induction in the landscape for landscape architects and designers which has mostly applied this in specialty settings.

2.5 Olfactory Stimulation in Virtual Reality Applications

Virtual Reality (VR) allows the simulation of real-life situations in a three-dimensional computer-generated environment in which the user can interact with their surroundings as though it were real. VR is powerful technology that can simulate highly realistic virtual environments, which offers a chance to receive health benefits *via* virtual nature (Bohil et al., 2011; Browning et al., 2019; Mattila et al., 2020). A recent study showed that six minutes of nature exposure in a VR environment produced similar effects as six minutes in an outdoor environment (Browning et al., 2019). Although there has been a dominance of visual and auditory information in virtual reality research to date, recent studies have highlighted olfactory stimulation as a potentially

powerful yet underutilized tool (Aiken & Berry, 2015; Chen, 2006; Hedblom et al., 2019).

Olfaction stimulation has been used in VR for military training (Vlahos, 2006), the treatment of posttraumatic stress disorder (PTSD) (Aiken & Berry, 2015; Herz, 2021), and is now popular in VR gaming (Niedenthal et al., 2023). According to Chen (2006), scents are very evocative in the virtual world because they can add novelty, enhance mental state, and strengthen presence. Our sense of smell serves as a constant communication device to inform us about our immediate environment; therefore, smell should play a key role in a simulated or virtual environment that can also be translated to real world situations.

CHAPTER 3

RESEARCH METHODS AND STUDY DESIGN

3.1 Chapter Overview

The research design relied primarily on quantitative methods and a descriptive social survey design to gather data from participants. Surveys took a cross-sectional design, self-administered over the course of approximately three weeks. The specifics of the survey creation process, question selection, and procedure will be discussed in this chapter.

3.2 Participants

To meet statistical significance, the goal was to reach a sample of 60 university students between the ages of 18 and 30. Participants were recruited through the College of Environment and Design at the University of Georgia. Most candidates were approached by email and were recruited on a voluntary basis, though some trials may be encouraged by course instructors where students were offered extra credit if they participated. Eligible participants had to be students at the University of Georgia between the ages of 18 and 30. Exclusion criteria included allergies or unusual sensitivities to everyday fragrances like those in perfumes or blooming plants.

3.3 Materials

Field research in an active environment may allow factors such as air temperature and wind to have an impact on the detection of odors. Therefore, virtual reality was used for this study

because it allows for more accurate control over sensory stimuli. The experiment was implemented in a laboratory equipped with devices for creating a VR environment. The enclosed laboratory allowed 4 participants at a time to participate in the study while safely maintaining at least 6 feet of distance (see Figure 1 for lab layout). Participants interacted with a virtual environment portraying a college campus that was built and modified in SketchUp and was then brought into a rendering software called Enscape. The headset was HTC's VIVE Cosmos head mounted device with full visual immersion. Using the HTC's VIVE Cosmos controllers, participants were able to have full control of movement within the virtual environment.

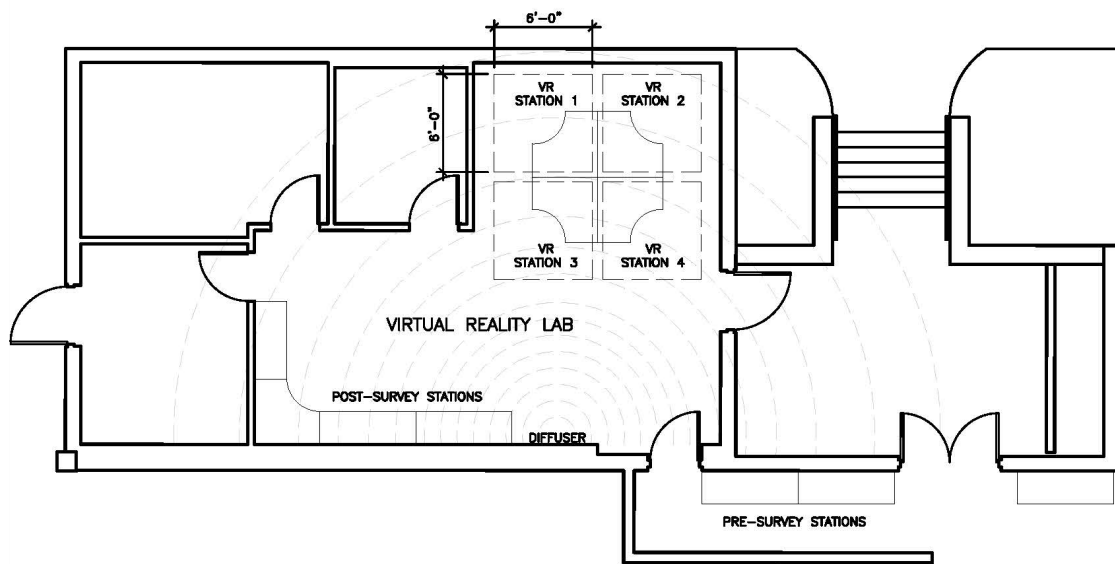


Figure 1. *Layout of the virtual reality lab where study took place.*

To meet the relationship between scent and mood in the landscape, half (30) of the participants were exposed to a scent. For the odor stimulus, the scent of gardenia was chosen for this study. While the scent of gardenia on mood induction has not yet been used in a research

context, it was chosen for this study due to the potential mood enhancing benefits of floral scents and to its familiarity in Georgia, where the study took place. Essential oils, whose ingredients are extracted from natural sources, can accurately replicate the selected fragrance. Essential oils are typically distilled from plant matter and possess the odor of the original tissue (Franco, Shanahan, Fuller, 2017). An essential oil of gardenia was emitted using an electric diffuser to generate the smell for the with-odor scenario. The dispensed oil was used per recommended directions on the bottle, 3 drops of the essential oil to every 100ml of water. The diffuser was switched on in the closed room 10 minutes prior to the experiment and was placed in an area where it could not be seen by participants. A variety of flowering shrubs were present in the model so the visual senses were congruent with the olfactory senses.

3.4 Measures/Survey

A 2-part survey was used to measure and record information from participants for the study. The online Qualtrics survey pre-test includes 1) “Are you between the ages of 18-30?” and, 2) “Do you consider yourself allergic or unusually sensitive to everyday fragrances like those in perfumes or from blooming plants?”. If participants were not in the correct age group or indicated they are sensitive and/or allergic to fragrances as stated, they were informed they were not eligible for this study. If participants indicated they were within the ages of 18 and 30 and have no allergies or unusual sensitivities to fragrances, they were then prompted to complete an initial screening survey that uses proven measures to assess the current mood of the individual. The survey includes the Brief Mood Introspection Scale (BMIS) which was developed by Gashke and Mayer (1988). The BMIS is an open-source mood scale consisting of 16 mood-adjectives to which a person responds how well each adjective describes their present mood (see

Figure 3). The BMIS is a four-point Meddis Style scale (XX= definitely do not feel; X = do not feel; V= slightly feel; VV= definitely feel). The scale can yield measures of overall pleasant-unpleasant mood, arousal-calm mood, positive-tired and negative-relaxed mood. The scale does not measure a neutral mood state, but rather illustrates the multifaceted range of factors of the human mood that can be scored and defined. This dynamic measure quantifies an assortment of emotions and states, putting a general mood into various buckets and identifying relationships between those areas.

For scoring, positively worded adjectives are added up and negatively worded adjectives use reverse scoring. See Figure 2 for how each scale is scored.

| The Four BMIS Factor-Based Subscales: Two Pairs of Scales | | | | | | | | |
|---|---------------------------------------|-----------------------------|-----------------------------|-----------------------------|---|-----------------------------|-----------------------------|-----------------------------|
| The 16 BMIS Mood Adj. | Pair 1: Unrotated Two-Factor Solution | | | | Pair 2: Varimax-Rotated Two-Factor Solution | | | |
| | <i>Pleasant-Unpleas.</i> | | <i>Arousal-Calm</i> | | <i>Positive-Tired</i> | | <i>Negative-Relaxed</i> | |
| | Positively- Worded Items | Negatively- Worded Items | Positively- Worded Items | Negatively- Worded Items | Positively- Worded Items | Negatively- Worded Items | Positively- Worded Items | Negatively- Worded Items |
| Lively | x | | x | | x | | | |
| Happy | x | | | | | | | |
| Sad | | x | x | | | | x | |
| Tired | | x | | x | | x | | |
| Caring | x | | x | | x | | | |
| Content | x | | | | | | | |
| Gloomy | | x | x | | | | x | |
| Jittery | | x | x | | | | x | |
| Drowsy | | x | | | | x | | |
| Grouchy | | x | | | | | | |
| Peppy | x | | x | | x | | | |
| Nervous | | x | x | | | | x | |
| Calm | x | | | x | | | | x |
| Loving | x | | x | | x | | | |
| Fed up | | x | x | | | | x | |
| Active | x | | x | | x | | | |
| Totals | | | | | | | | |
| PW Items | 8 | | 10 | | 5 | | 4 | |
| NW items | | 8 | | 2 | | 2 | | 1 |
| Scale Total | 16 | | 12 | | 7 | | 6 | |

Figure 2. *The BMIS items and the scales they fall on (Mayer, 1988).*

Brief Mood Introspection Scale (BMIS)

by John D. Mayer

INSTRUCTIONS: Circle the response on the scale below that indicates how well each adjective or phrase describes your present mood.

(definitely do not feel) (do not feel) (slightly feel) (definitely feel)

| | XX | X | V | VV | | | | | |
|---------|----|---|---|----|---------|----|---|---|----|
| Lively | XX | X | V | VV | Drowsy | XX | X | V | VV |
| Happy | XX | X | V | VV | Grouchy | XX | X | V | VV |
| Sad | XX | X | V | VV | Peppy | XX | X | V | VV |
| Tired | XX | X | V | VV | Nervous | XX | X | V | VV |
| Caring | XX | X | V | VV | Calm | XX | X | V | VV |
| Content | XX | X | V | VV | Loving | XX | X | V | VV |
| Gloomy | XX | X | V | VV | Fed up | XX | X | V | VV |
| Jittery | XX | X | V | VV | Active | XX | X | V | VV |

Figure 3. *The BMIS scale (Mayer, 1988).*

The post-survey included the same Brief Mood Introspection Scale (BMIS) survey with additional questions where participants were asked to rate the following aspects on a 5-point Likert scale:

| | Very comfortable | Comfortable | Neither comfortable nor uncomfortable | Uncomfortable | Very uncomfortable |
|--|-----------------------|-----------------------|---------------------------------------|-----------------------|-----------------------|
| How well would you rate your overall comfort in the VR environment? | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| | Very satisfied | Satisfied | Moderate | Unsatisfied | Very unsatisfied |
| How would you rate your visual satisfaction in the VR environment? | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| How would you rate your olfactory(smell) satisfaction during your VR experience? | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

Participants in the with-odor group included additional questions:

| | Very well | Well | Moderate | Not well | Very not well |
|-------------------------------------|-----------|------|----------|----------|---------------|
| How well do you think the smell you | | | | | |

| | | | | | |
|--|-----------------------|-----------------------|---------------------------------|-----------------------|-----------------------|
| experienced matched the environment? | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| | Very familiar | Somewhat familiar | Neither familiar nor unfamiliar | Somewhat unfamiliar | Very unfamiliar |
| How familiar are you with the fragrance you smelled? | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| | Very much liked | Somewhat liked | Neither liked nor disliked | Somewhat disliked | Disliked very much |
| How well did you like or not like the smell you experienced? | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| | Very strong | Strong | Neutral | Light | Very light |
| How intense was the fragrance you experienced? | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

Table 1. Additional questions were asked where participants rated the following aspects on a 5-point (Ba & Kang, 2019a).

Questions were adapted from a research study by Meihui Ba and Jian Kang in 2019 where the study investigated the effect of a fragrant tree on the perception of traffic noise. Having finished all the ratings, participants were asked to answer some additional questions 1) “Have you used VR before? If yes, how would you describe your VR use?” and 2) “Do you have anything to add about your experience?”. The post-survey also included general demographic information (age, gender, race, education level).

3.5 Procedure

Participants met the researcher at a computer station outside of the closed VR lab so that they would not be able to smell any fragrance prior to beginning the experiment. All participants were informed regarding the content of the experiment and signed a consent form. Before entering the lab, participants completed the pre-survey. Eligible participants were then prompted to complete the Brief Mood Introspection Scale (BMIS) survey. After completing the pre-survey, participants were led by the researcher into the VR lab and to a VR station. Participants were randomly

assigned to one of the two conditions, resulting in 30 participants in the with-odor group and 30 participants in the without-odor group. Participants in the with-odor group were not informed of the odor.

Before beginning the experiment, the researcher gave a brief tutorial on how to properly wear the headset and use the controllers. Participants were given 3 minutes to get acclimated with the VR headset and controllers. Participants were informed that they had the right to withdraw from the experiment at any given time. For 10 minutes, participants explored a virtual environment that portrays a university campus. Participants had full control over where they wanted to go within the virtual environment using the controllers. The participants were encouraged to maintain attention to their VR surroundings for the 10 minutes. After the 10 minutes, all participants returned to a survey station adjacent to the VR stations to complete the post-survey. The post survey, using Qualtrics survey software, included the Brief Mood Introspection Scale (BMIS) and questions where participants were asked to rate overall comfort (very comfortable to very uncomfortable), visual satisfaction (very satisfied to very unsatisfied), and olfactory satisfaction (very satisfied to very unsatisfied) on a 5-point Likert scale. Participants in the with-odor group had additional questions where they were asked to rate how well the smell matched the environment (very well to not very well), familiarity with the fragrance (very familiar to very unfamiliar), how well you liked the smell (very much liked to very much disliked) and fragrance intensity (very strong to very light). All participants answered general demographic questions, questions on prior VR experience, and an open-ended question asking if they had any additional comments to make about their experience. In total, the experiment took approximately 20-25 minutes to complete.

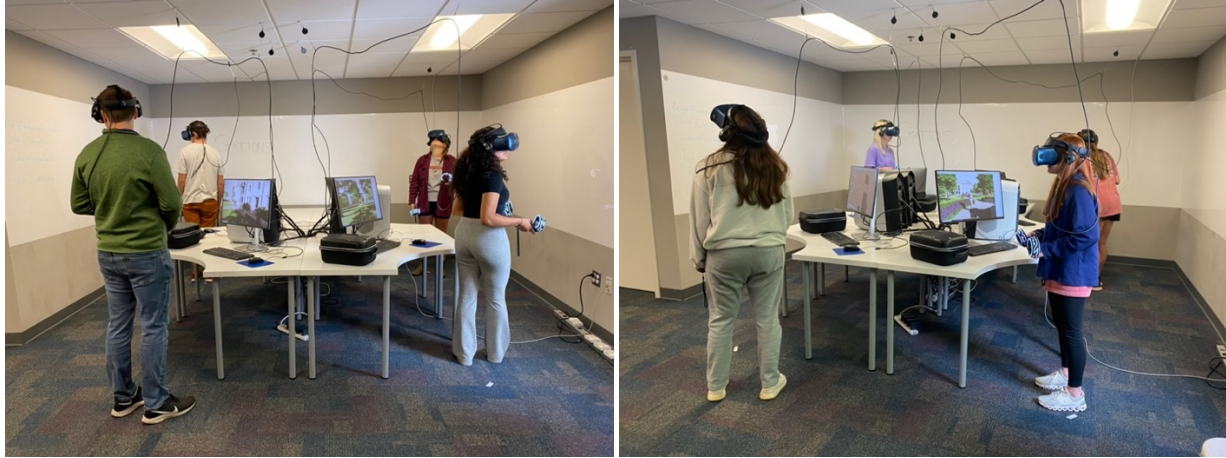


Figure 4. *Photos of participants taking part in study.*

3.6 Pilot Study

A pilot study was taken before the beginning of the experiment to identify logistical problems which might occur or to uncover any potential issues with survey design or the virtual environment. Four individuals took part in the pilot study and completed the study from start to finish. A result of survey pre-testing feedback was the re-configuration of several survey questions and revision of where online page breaks occurred between the questions. Some changes to the 3D model of the campus environment were discussed such as creating a boundary for the space, as well as minor changes to hardscape materials and vegetation. All changes were made before the study implementation.



Figure 5. *Bird's eye view of the campus virtual environment.*



Figure 6. *View of fountain area.*



Figure 7. *View from balcony.*



Figure 8. *Building view.*



Figure 9. *View of some featured plantings.*



Figure 10. *Sidewalk view.*



Figure 11. *Controllers used to teleport.*

CHAPTER 4

RESULTS AND ANALYSIS

4.1 Chapter Overview

This chapter presents the key findings and results found through a comprehensive analysis of the survey data. The participant demographics and overall results for the mood screening questions are summarized.

4.2 Participant Sample

Analyses were based on a sample of 60 university students between the ages of 18 and 30. Standard demographic information was collected in the post-survey to identify certain groups who are more or less likely to experience an improvement in mood after being exposed to a natural scent. The final survey section can be seen in Appendix A. Participants were asked to answer questions regarding their age, gender, race and year in school. Participants were given the option to select “not listed” and write in a response for the demographic questions regarding race and gender.

There were 38 individuals who identified as female (63.33% of the participants), 21 who identified as male (35% of the participants) and 1 participant who identified as non-conforming/gender variant (1.66% of the participants). Of the 60 participants, 49 identified as white, making up 81.66% of the participants. Of the additional 11 participants, 5 identified as Asian, 1 as black or African American, 2 as mixed race, 1 as European, 1 as Hispanic/Latino,

and 1 as Asian-American. The distribution of participants' gender and race are displayed below in Figures 12-13.

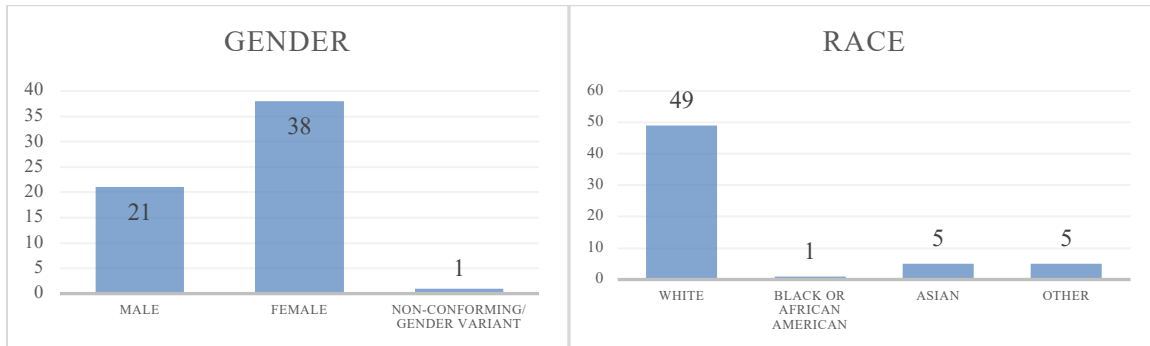


Figure 12. *Participant Gender Distribution* Figure 13. *Participant Race Distribution*

Participants were asked to identify with a specific age range and were given the options of 18-19, 20-21, 22-25, 26-30, 30+. Of the categories, 20% of the participants identified as 18-19, 53.33% identified as 20-21, 20% identified as 22-25, and 6.66% identified as 26-30. No one identified as 30+, verifying that all participants fell within the target population age parameter. Participants were also asked their year in school, where 33.33% were undergraduate sophomores, 40% were juniors, 10% were seniors, 15% were masters level graduate students, and 1.66% were doctoral students. The distribution of participants age and year in school are displayed in Figures 14-15.

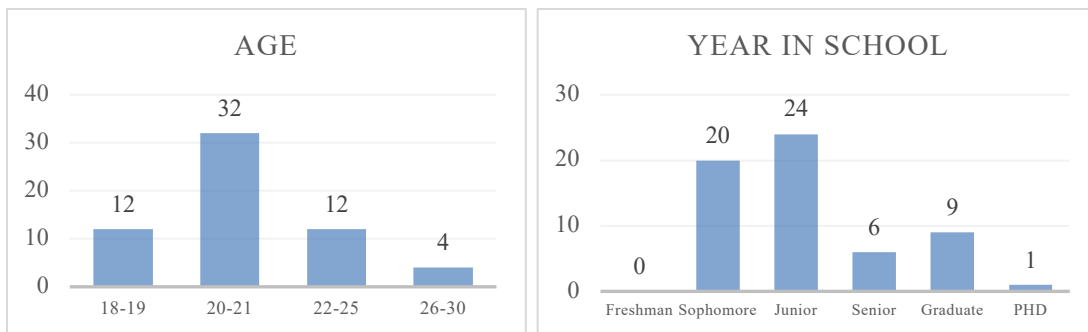


Figure 14. *Participant Age Distribution* Figure 15. *Participant Year in School Distribution*

4.3 Brief Mood Introspection Scale (BMIS) Screening Results

Participants completed the Brief Mood Introspection Scale (BMIS) in both the pre and post-survey. The Brief Mood Introspection Scale (BMIS) is an open-source mood scale consisting of 16 mood-adjectives where a person indicates how well each adjective describes their present mood (see Figure 3). The BMIS is a four-point Meddis Style scale (XX= definitely do not feel; X = do not feel; V= slightly feel; VV= definitely feel). The scale can yield measures of overall pleasant-unpleasant mood, arousal-calm mood, positive-tired and negative-relaxed mood (Mayer, 1988).

These metrics were used to assess the participant's condition prior to the experiment and were compared with their answers following the experiment to identify any changes in mood. To measure the internal consistency of the scales, Cronbach's Alpha revealed a high level of scale reliability for both the scent survey measures (0.83) and the no-scent survey measures (0.86). A recommend minimum α coefficient is often between 0.65 and 0.8, and both groups exceeded these standards. For the pleasant-unpleasant scale, negative items (i.e., jittery, sad, fed up, grouchy, tired, drowsy, gloomy, nervous) were subtracted from the sum of ratings for positive items (i.e., content, loving, peppy, happy, caring, lively, calm, active). The group that did not receive smell experienced a 9.85% increase from the pre-survey to the post-survey in the pleasantness facet of mood, while the group that received smell experienced an 18.5% increase. This indicates that the group that received smell experienced a greater increase in pleasantness of mood than the group with no smell. The Pleasant-Unpleasant scale was the primary focus of this study; however, positive results were also found for the arousal-calm mood, positive-tired and negative-relaxed mood. For the arousal-calm scale, low arousal adjectives (i.e., calm, tired) were subtracted from the sum of high arousal adjectives (i.e., active, caring, fed up, gloomy, jittery,

lively, loving, nervous, peppy, sad). The group that did not receive smell experienced a 9.06% increase from the pre survey to the post survey, while the group that received smell experienced a 18.26% increase. This indicates a higher level of arousal when smell was introduced.

For the positive–tired scale, positive adjectives (i.e., active, caring, lively, loving, and peppy) were directly summed and tired adjectives (i.e., drowsy and tired) were reverse scored. The group that did not receive smell experienced an 11.29% increase from the pre survey to the post survey, while the group that received smell experienced a 24.62% increase, indicating a more positive mood. For the negative–relaxed scale, negative adjectives (i.e., fed up, gloomy, jittery, nervous, and sad) were directly summed and relaxed adjectives (i.e., calm) were reverse scored. The group that did not receive smell experienced a 10.27% increase from the pre survey to the post survey, while the group that received smell experienced a 14.42% increase. While this was the least significant difference among moods between smell and no smell experiments, it implies that all moods (not just pleasant, aroused, and positive) were amplified when smell was introduced as part of the experiment. Because negative moods were reverse scored, the higher the score, the less negative the response.

| Question | NS_PreMean | NS_PostMean | % Change NS_Pre to NS_Post | S_PreMean | S_PostMean | % Change S_Pre to S_Post | Difference in % Change NS to S |
|----------------|------------|-------------|----------------------------------|-----------|------------|--------------------------------|-----------------------------------|
| Pleasant_Final | 47.40 | 52.07 | 9.85% | 45.40 | 53.80 | 18.50% | 8.66 |
| Positive_Final | 18.90 | 21.03 | 11.29% | 17.73 | 22.10 | 24.62% | 13.34 |
| Arousal_Final | 34.97 | 38.13 | 9.06% | 33.40 | 39.50 | 18.26% | 9.21 |
| Negative_Final | 18.50 | 20.40 | 10.27% | 18.03 | 20.63 | 14.42% | 4.15 |

Table 2. *The final scores of overall pleasant-unpleasant mood, arousal-calm mood, positive-tired and negative-relaxed mood. NS indicates the group with no smell and S indicates the group with smell.*

When looking at gender, males experienced a greater percentage change in mood compared to females. For the unpleasant-pleasant scale, males experienced a 20.06% increase in pleasant mood and females had a 17.97% increase. For the positive-tired scale, males experienced a 29.85% increase and females had a 22.86% increase, indicating a more positive response among males. For the arousal-calm scale, males experienced a 20.46% increase and females had a 17.5% increase, indicating a more aroused mood among males. For the negative-relaxed scale, males increased by 16.2% and females increased by 13.78%, signifying that all moods were more enhanced among males.

Because only one participant identified as non-conforming/gender variant, results were not substantial enough to be used in a comparative nature. However, this individual also experienced a greater increase in mood following the experiment.

Subscale - Male

| Question | NS_PreMean | NS_PostMean | % Change NS_Pre to NS_Post | S_PreMean | S_PostMean | % Change S_Pre to S_Post | Difference in % Change NS to S |
|----------------|------------|-------------|----------------------------|-----------|------------|--------------------------|--------------------------------|
| Pleasant_Final | 48.31 | 53.15 | 10.03% | 43.63 | 52.38 | 20.06% | 10.03 |
| Positive_Final | 19.54 | 21.69 | 11.02% | 16.75 | 21.75 | 29.85% | 18.83 |
| Arousal_Final | 36.00 | 39.15 | 8.76% | 32.38 | 39.00 | 20.46% | 11.70 |
| Negative_Final | 18.77 | 20.85 | 11.07% | 17.75 | 20.63 | 16.20% | 5.13 |

Subscale - Female

| Question | NS_PreMean | NS_PostMean | % Change NS_Pre to NS_Post | S_PreMean | S_PostMean | % Change S_Pre to S_Post | Difference in % Change NS to S |
|----------------|------------|-------------|----------------------------|-----------|------------|--------------------------|--------------------------------|
| Pleasant_Final | 47.25 | 51.75 | 9.52% | 46.05 | 54.32 | 17.97% | 8.44 |
| Positive_Final | 18.50 | 20.69 | 11.82% | 18.09 | 22.23 | 22.86% | 11.04 |
| Arousal_Final | 34.50 | 37.69 | 9.24% | 33.77 | 39.68 | 17.50% | 8.26 |
| Negative_Final | 18.56 | 20.25 | 9.09% | 18.14 | 20.64 | 13.78% | 4.69 |

Subscale - Non-conforming/Gender variant

| Question | NS_PreMean | NS_PostMean | % Change NS_Pre to NS_Post | S_PreMean | S_PostMean | % Change S_Pre to S_Post |
|----------------|------------|-------------|----------------------------------|-----------|------------|--------------------------------|
| Pleasant_Final | 38.00 | 43.00 | 13.16% | | | |
| Arousal_Final | 29.00 | 32.00 | 10.34% | | | |
| Negative_Final | 14.00 | 17.00 | 21.43% | | | |
| Positive_Final | 17.00 | 18.00 | 5.88% | | | |

Table 3. *The final scores of overall pleasant-unpleasant mood, arousal-calm mood, positive-tired and negative-relaxed mood between the different genders.*

4.4 Supplemental Questions on Scent, Comfort, and Visual Satisfaction

In addition to the BMIS, participants were asked to rate following aspects on a 5-point Likert scale: overall comfort, visual satisfaction, and olfactory satisfaction. The group that received the smell also were asked to rate how well the smell matched the environment (congruency), their familiarity with the smell, the intensity of the smell, and if they liked or disliked the smell. Questions are shown in Table 1, pages 10-11.

| Question | NS_PostMean | S_PostMean | % Change NS_Post to S_Post | Difference NS_Post to S_Post |
|------------------------|-------------|------------|----------------------------------|------------------------------------|
| Congruency | | 3.90 | | 3.90 |
| Familiarity | | 3.63 | | 3.63 |
| Intensity | | 3.53 | | 3.53 |
| Liked or disliked | | 4.07 | | 4.07 |
| Olfactory Satisfaction | 3.13 | 4.10 | 30.85% | 0.97 |
| Overall comfort | 4.13 | 4.53 | 9.68% | 0.40 |
| Visual Satisfaction | 4.57 | 4.67 | 2.19% | 0.10 |

Table 4. *The mean scores, percent change, and difference from no smell to smell.*

The group that received the smell experienced a greater increase in olfactory satisfaction, overall comfort, and visual satisfaction than the control group. Olfactory satisfaction had the

strongest increase with 30.85% percent followed by overall comfort with 9.68% and visual satisfaction with 2.19% percent. Women ranked higher in congruency, overall comfort, and visual satisfaction, and men in all other categories, though the categories of congruency, liked or disliked, olfactory satisfaction, and visual satisfaction had insignificant differences. The largest difference between males and females was familiarity of scent, with males being more familiar with the gardenia smell.

| Question | Female | Male |
|------------------------|--------|------|
| Congruency | 3.91 | 3.88 |
| Familiarity | 3.45 | 4.13 |
| Intensity | 3.36 | 4.00 |
| Liked or disliked | 4.05 | 4.13 |
| Olfactory Satisfaction | 4.09 | 4.13 |
| Overall comfort | 4.64 | 4.25 |
| Visual Satisfaction | 4.68 | 4.63 |

Table 5. Averages of 5-point Likert scale questions for males and females, with 1 being the lowest and 5 the highest.

4.5 Univariate General Mood

The individual mood indices that comprised the BMIS scale were also measured independently as a part of this study. When looking at the individual moods, the group that received smell had an increase in all positive adjectives and a decrease in all negative adjectives, when considering the reverse scoring of negative adjectives. For the no smell group, all adjectives increased except for loving and caring. When comparing the no smell group with the smell group, the smell group had a higher percent increase than the no smell group except for the mood indicators of grouchy, gloomy, and nervous. The largest differences in percent change comparing the smell group with control group are as follows: active, loving, caring, (less) tired,

(less) fed up, happy, lively, content, (less) jittery, clam, (less) drowsy, peppy, (less) sad, (less) grouchy, (less) gloomy, and (less) nervous. The largest difference from pre to post in both the smell group and control group was tired (s =44.07%, ns=29.03%) and drowsy (s= 36.62%, ns= 30.26%), indicating that many of the participants felt more awake following the experiment.

| Question | NS_PreMean | NS_PostMean | Difference NS_Pre to NS_Post | % Change NS_Pre to NS_Post | S_PreMean | S_PostMean | Difference S_Pre to S_Post | % Change S_Pre to S_Post | Difference in % Change NS to S | BMISS SubType |
|--------------|-------------|-------------|------------------------------|----------------------------|-------------|-------------|----------------------------|--------------------------|--------------------------------|---------------|
| Active | 3.03 | 3.13 | 0.10 | 3.30% | 2.47 | 3.13 | 0.67 | 27.03% | 23.73 | Positive |
| Loving | 2.80 | 2.67 | -0.13 | -4.76% | 2.77 | 3.13 | 0.37 | 13.25% | 18.01 | Positive |
| Caring | 3.07 | 2.87 | -0.20 | -6.52% | 3.00 | 3.27 | 0.27 | 8.89% | 15.41 | Positive |
| Tired | 2.07 | 2.67 | 0.60 | 29.03% | 1.97 | 2.83 | 0.87 | 44.07% | 15.04 | Negative |
| Fed Up | 3.17 | 3.57 | 0.40 | 12.63% | 2.83 | 3.60 | 0.77 | 27.06% | 14.43 | Negative |
| Happy | 3.53 | 3.77 | 0.23 | 6.60% | 3.13 | 3.77 | 0.63 | 20.21% | 13.61 | Positive |
| Lively | 3.17 | 3.63 | 0.47 | 14.74% | 2.83 | 3.60 | 0.77 | 27.06% | 12.32 | Positive |
| Content | 3.13 | 3.23 | 0.10 | 3.19% | 3.17 | 3.60 | 0.43 | 13.68% | 10.49 | Positive |
| Jittery | 2.83 | 2.97 | 0.13 | 4.71% | 2.47 | 2.83 | 0.37 | 14.86% | 10.16 | Negative |
| Calm | 3.20 | 3.23 | 0.03 | 1.04% | 3.10 | 3.33 | 0.23 | 7.53% | 6.49 | Positive |
| Drowsy | 2.53 | 3.30 | 0.77 | 30.26% | 2.37 | 3.23 | 0.87 | 36.62% | 6.36 | Negative |
| Peppy | 2.33 | 2.77 | 0.43 | 18.57% | 2.33 | 2.90 | 0.57 | 24.29% | 5.71 | Positive |
| Sad | 3.30 | 3.60 | 0.30 | 9.09% | 3.27 | 3.63 | 0.37 | 11.22% | 2.13 | Negative |
| Grouchy | 3.23 | 3.63 | 0.40 | 12.37% | 3.33 | 3.70 | 0.37 | 11.00% | -1.37 | Negative |
| Gloomy | 3.03 | 3.50 | 0.47 | 15.38% | 3.20 | 3.63 | 0.43 | 13.54% | -1.84 | Negative |
| Nervous | 2.97 | 3.53 | 0.57 | 19.10% | 3.17 | 3.60 | 0.43 | 13.68% | -5.42 | Negative |
| Total | 2.96 | 3.25 | 0.29 | 9.85% | 2.84 | 3.36 | 0.53 | 18.50% | 8.66 | |

Table 6. Mean scores and percentage change from pre to post for both groups.

4.6 Spearman’s Rank Correlations

For correlations, we found a few additional points of interest. Spearman’s rank correlation measures the strength and direction (positive or negative) of a relationship between two different variables. For this study, $P < 0.005$ was considered statistically significant based upon initial analyses. For the smell group, congruency, liked or disliked, and intensity all positively correlated with olfactory satisfaction. Interestingly, as familiarity increased, overall comfort decreased. Analyses also examined the effects of age, race and VR use. None of these

analyses yielded significant effects. The impact on mood exerted similar effects on participants regardless of their ethnic background, age or how often they have used VR.

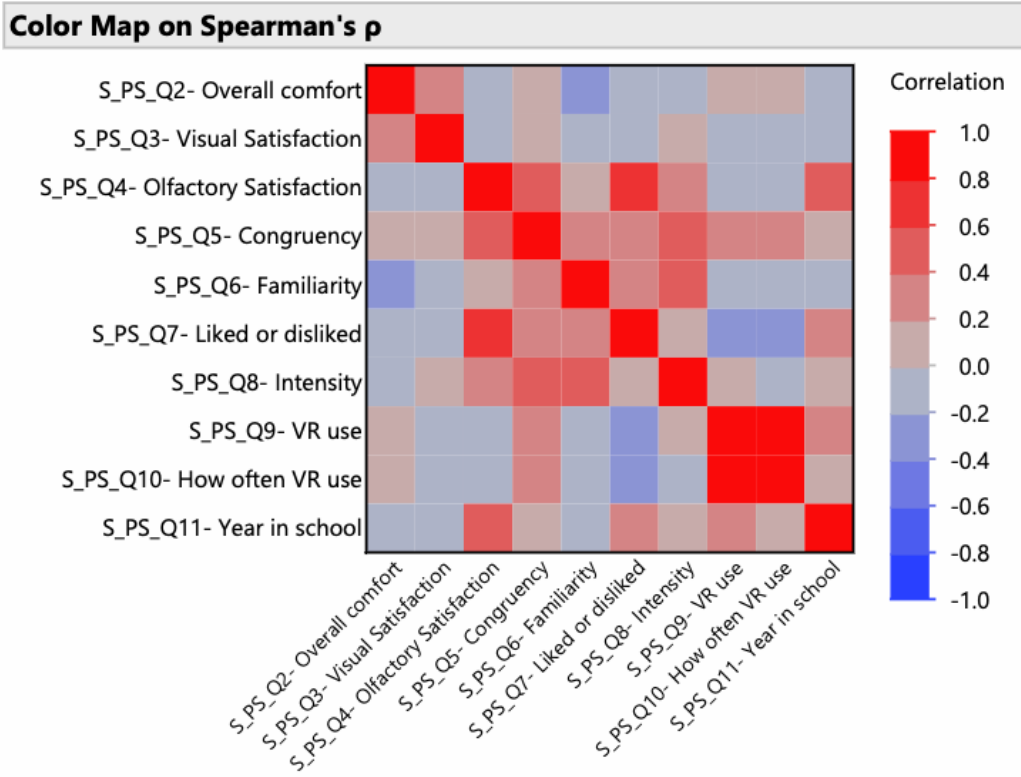


Table 7. Color map of Spearman's rank correlations.

CHAPTER 5

DISCUSSION AND CONCLUSION

5.1 Chapter Overview

This study investigated the relationship between a natural floral odor and mood. A VR laboratory experiment was carried out where participants experienced a virtual campus environment. The control group did not receive any olfactory stimulus, and the groups with the smell were exposed to the odor of gardenia using an essential oil diffuser and naturally extracted gardenia oil. Participants took a mood screening survey before and after the experiment and the results were then compared to see how their mood changed. In the following chapter, the results of the study are discussed including possible implications for landscape architectural design. The study's specific limitations are reviewed, and suggestions are made for future research on this topic. While this research is not conclusive in nature, it establishes a baseline for further study and should act as a catalyst for additional investigation on the effects of smell on mood in a built environment.

5.2 Discussion of Findings

This study was formed based on the observation of the gap in literature on the knowledge of how nature smells effect mood in the built environment. These preliminary results suggest that people who are exposed to a natural smell experience a greater increase in positive aspects of mood, including pleasant-unpleasant mood, arousal-calm mood, positive-tired and negative-

relaxed mood, than people who are not. All participants in this experiment experienced a greater increase in positive mood. However, the participants that were exposed to the odor had a higher increase than those who did not receive smell. Although this speculation requires more rigorous assessment, the data implies that natural odors may be a powerful tool in improving mental health and well-being related to mood in outdoor environments. The observation of improvement in mood as a result of a natural odor exposure is consistent with current findings that nature smells improve mood (Kim et al., 2016; Moss et al., 2003; Pálsdóttir et al., 2021; Weber & Heuberger, 2008), yet this is the first time to the author's knowledge that a study has linked natural smells to the built environment and more specifically a virtual campus landscape. The potential of odors in creating and experiencing places is significant and, therefore, cannot be ignored.

Findings show that males had a greater increase in various facets of mood than females following the experiment. Interestingly, current literature states that women are usually more sensitive to odors compared with men (Kobal et al., 2001; Koelega, 1994). Women report more frequent evocations of emotional memories by odors and stronger feelings of happiness, sadness, well-being, and reduction of stress following odor exposure (Martin et al., 2001). However, the results of this experiment indicated that males were more impacted by the natural smell than the females. This may be explained because males also rated the intensity of the smells as stronger and indicated they were more familiar with the smell than the females (see Table 5, page 21) Yet, males have also been shown to respond to stimuli such as virtual reality in a more positive way. Females may be less comfortable and confident in virtual learning environments (Ausburn et al., 2009).

5.3 Significance for Outdoor Space Design

Scent is an important component and is often ignored by landscape architects. With the abundance of options involved in designing a landscape, it's easy to overlook fragrances in favor of colors, forms, or textures. When designing an outdoor space, landscape architects should incorporate strategic aromatic plantings to stimulate positive moods for users who are engaging in the space. Orchestrating plants to bloom at different times of the year could create seasonal interest. The use of multiple fragrant plantings can ensure year-round enjoyment of the area. To capture these benefits, aromatic plants should be carefully arranged where site user will not be overwhelmed by overly intense fragrances that may aggravate those who have allergies. A design can feature different zones to stimulate individual senses at different times, or everything can be enjoyed simultaneously in a multi-sensory mix. Enhancing more senses may also help people who have full or partial loss in one or more of the five senses experience the natural world in new ways. There is a growing disconnect from nature, making it important to optimize the little contact people do have. By not harnessing the full power of scent, landscape architects are missing out on opportunity to create more immersive spaces that allows users to reconnect with the world around them.

5.4 Recommendations for Future Work and Limitations

It is acknowledged that other parts of the experiment may have contributed to the mood improvement. Therefore, we do not claim that overall mood improvement is solely due to the scent experience. In the open-ended short answer section of the survey, many of the responses discussed how much they enjoyed the use of virtual reality (see Appendix D). This may indicate that the increase in mood may have been influenced by VR. While VR has been shown to

simulate highly realistic virtual environments and offer a chance to receive health benefits via virtual nature (Bohil et al., 2011; Browning et al., 2019; Mattila et al., 2020), some researchers may see it as a limitation. Nevertheless, it facilitated an experimental design which could not have otherwise taken place.

A main challenge in involving odors as influencing factors in mood evaluations is that odor perception differs greatly across individuals. The same scent may evoke positive emotions in one individual and negative emotions in another. Research has shown that, not only do different odors have different thresholds for detection and identification, but also threshold of the same odor varies among individuals (Kaye, 2001). Herz (1998) states that for an odor to elicit any sort of response, an individual first has to learn to associate it with an event. Therefore, an odor may have no personal significance until it becomes connected to something that has meaning (Herz, 1998).

The current findings can facilitate future research and can be expanded in a number of directions. While the study only covered the fragrance of gardenia, future studies can concentrate on other aromatic plants. The congruency and intensity for the odor in this study were high; future studies can target odors with low congruency and/or intensity. Another avenue for future research lies within the user demographics. This study was limited due to its sample size and the target population chosen. All participants were university students, so further research is needed to assess whether these effects generalize to populations of different age groups. However, as discussed in earlier sections, young adults, particularly college students, are at high risk of mental health related issues, so research examining mood impact of natural smells within this population is extremely important.

Much of the participant sample identified as female (63.33%) and white (81.66%). Because of the overrepresentation of certain groups in this sample, no true demographic trends were observed regarding the effect of smell on mood for different ages, genders, or races. An ideal sample would have equal representation of all groups requiring comparison to generate the most statistically sound results. The results also showed that males had a greater improvement in mood than females suggesting sex differences in olfactory perception. It is important to understand that different people may experience places differently, and also that this may be a limitation in comparing gendered responses in this study.

5.5 Conclusion

Although typically neglected given our visually dominant nature (Hutmacher, 2019), there is a growing realization that nature smells may have a positive impact on our mood and well-being. This study contributes to the research on the restorative effects of nature smells on mental health and well-being specifically related to the experience of an outdoor environment. The healing powers of nature in general is very well understood in current literature, but to maximize the full benefits we may receive from nature, we must reveal a complete picture through the full range of senses.

The results of this study have significant implications for landscape architects. By understanding how natural smells can be used for mood regulation, designers can incorporate strategic aromatic plantings to create more immersive spaces that support the well-being of the users. Designers must consider the olfactory, visual, auditory, and tactile aspects of the built environment because our senses work together to influence how we perceive, and respond to, the multisensory atmosphere of the spaces in which we live, work, and play. Although a growing

number of researchers have begun to stress the importance of looking beyond the purely visual aspects of design, they still lack a comprehensive understanding of how multisensory interactions drive our holistic response to the built environments in which we spend so much of our lives.

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APPENDIX A – SURVEYS

Pre-Survey

Start of Block: Default Question Block

Q0 Please insert your anonymous study code that was provided to you.

Q00 Are you between the ages of 18-30?

Yes

No

Q000 Do you consider yourself allergic or unusually sensitive to everyday fragrances like those in perfumes or from blooming plants?

Yes

No

Skip To: End of Survey If Do you consider yourself allergic or unusually sensitive to everyday fragrances like those in per... = Yes

Page Break

Q1 Please rate your current mood.

| | Definitely do not feel (1) | Do not feel (2) | Slightly feel (3) | Definitely feel (4) |
|--------------|-------------------------------|-----------------------|-----------------------|------------------------|
| Lively (1) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Happy (2) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Sad (3) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Tired (4) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Caring (5) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Content (6) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Gloomy (7) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Jittery (8) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Drowsy (9) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Grouchy (10) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Peppy (11) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Nervous (12) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Calm (13) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

Loving (14)

Fed up (15)

Active (16)

End of Block: Default Question Block

Post Survey (students with fragrance)

Start of Block: Default Question Block

Q0 Please insert your anonymous study code that was provided to you.

Page Break

Q1 Please rate your current mood.

| | Definitely do not feel (1) | Do not feel (2) | Slightly feel (3) | Definitely feel (4) |
|--------------|-------------------------------|-----------------------|-----------------------|------------------------|
| Lively (1) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Happy (2) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Sad (3) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Tired (4) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Caring (5) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Content (6) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Gloomy (7) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Jittery (8) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Drowsy (9) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Grouchy (10) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Peppy (11) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Nervous (12) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Calm (13) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

Loving (14)



Fed up (15)



Active (16)



Page Break

Q2 How would you rate your overall comfort in the VR environment?

- Very uncomfortable (1)
 - Uncomfortable (2)
 - Neither comfortable or uncomfortable (3)
 - Comfortable (4)
 - Very comfortable (5)
-

Q3 How would you rate your visual satisfaction in the VR environment?

- Very unsatisfied (1)
 - Unsatisfied (2)
 - Moderate (3)
 - Satisfied (4)
 - Very satisfied (5)
-

Q4 How would you rate your olfactory (smell) satisfaction during your VR experience?

- Very unsatisfied (1)
- Unsatisfied (2)
- Moderate (3)
- Satisfied (4)
- Very satisfied (5)

Q5 How well do you think the smell you experienced matched the environment?

- Very not well (1)
 - Not well (2)
 - Moderate (3)
 - Well (4)
 - Very well (5)
-

Q6 How familiar are you with the fragrance you smelled?

- Very unfamiliar (1)
 - Somewhat unfamiliar (2)
 - Neither familiar or unfamiliar (3)
 - Somewhat familiar (4)
 - Very familiar (5)
-

Q7 How well did you like or not like the smell you experienced?

- Disliked very much (1)
 - Somewhat disliked (2)
 - Neither liked or disliked (3)
 - Somewhat liked (4)
 - Very much liked (5)
-

Q8 How intense was the fragrance you experienced?

- Very light (1)
 - Light (2)
 - Neutral (3)
 - Strong (4)
 - Very strong (5)
-

Page Break

End of Block: Default Question Block

Start of Block: Block 2

Q9 Have you used VR before?

Yes

No

Q10 If yes, how would you describe your VR use?

Daily

Weekly

Monthly

Yearly

Not applicable

End of Block: Block 2

Start of Block: Block 3

Q11 Year in school:

Freshman

Sophomore

Junior

Senior

Graduate

Other _____

Q12 Age:

18-19

20-21

22-25

26-30

30+

Q13 To which gender identity do you most identify?

- Male
- Female
- Transgender female
- Transgender male
- Non-conforming / Gender Variant
- Not listed
- Prefer not to say

Q14 How would you best describe yourself?

- American Indian or Alaska Native
- Asian
- Black or African American
- Native Hawaiian or Other Pacific Islander
- White
- Other (Please specify) _____
- Prefer not to say

Page Break

Q15 Do you have anything to add about your experience?

End of Block: Block 3

Post Survey (students without fragrance)

Start of Block: Default Question Block

Q0 Please insert your anonymous study code that was provided to you.

Page Break

Q1 Please rate your current mood.

| | Definitely do not feel (1) | Do not feel (2) | Slightly feel (3) | Definitely feel (4) |
|--------------|-------------------------------|-----------------------|-----------------------|------------------------|
| Lively (1) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Happy (2) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Sad (3) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Tired (4) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Caring (5) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Content (6) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Gloomy (7) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Jittery (8) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Drowsy (9) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Grouchy (10) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Peppy (11) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Nervous (12) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Calm (13) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

Loving (14)



Fed up (15)



Active (16)



Page Break

Q2 How would you rate your overall comfort in the VR environment?

- Very uncomfortable (1)
 - Uncomfortable (2)
 - Neither comfortable or uncomfortable (3)
 - Comfortable (4)
 - Very comfortable (5)
-

Q3 How would you rate your visual satisfaction in the VR environment?

- Very unsatisfied (1)
 - Unsatisfied (2)
 - Moderate (3)
 - Satisfied (4)
 - Very satisfied (5)
-

Q4 How would you rate your olfactory (smell) satisfaction during your VR experience?

- Very unsatisfied (1)
- Unsatisfied (2)
- Moderate (3)
- Satisfied (4)
- Very satisfied (5)

End of Block: Default Question Block

Start of Block: Block 2

Q9 Have you used VR before?

Yes

No

Q10 If yes, how would you describe your VR use?

Daily

Weekly

Monthly

Yearly

Not applicable

End of Block: Block 2

Start of Block: Block 3

Q11 Year in school:

- Freshman
 - Sophomore
 - Junior
 - Senior
 - Graduate
 - Other _____
-

Q12 Age:

- 18-19
 - 20-21
 - 22-25
 - 26-30
 - 30+
-

Q13 To which gender identity do you most identify?

- Male
 - Female
 - Transgender female
 - Transgender male
 - Non-conforming / Gender Variant
 - Not listed
 - Prefer not to say
-

Q14 How would you best describe yourself?

- American Indian or Alaska Native
 - Asian
 - Black or African American
 - Native Hawaiian or Other Pacific Islander
 - White
 - Other (Please specify) _____
 - Prefer not to say
-

Page Break

Q15 Do you have anything to add about your experience?

End of Block: Block 3

APPENDIX B – PROMOTIONAL EMAIL

Hello everyone,

My name is Morgane Coleman, and I am a master's student in the College of Environment and Design. I am inviting you to take part in a VR research study entitled **Exploring the Relationship Between the Landscape, Olfactory Stimuli and Mood Through Virtual Reality**.

Your participation will involve: (1) using the VR equipment to experience a VR environment for about 10 minutes; and (2) completing a before and after survey. The surveys should take no more than 5-10 minutes to complete.

This study invites participants that are UGA students between the ages of 18-30. Students who are unusually sensitive or allergic to fragrances such as perfumes and blooming plants are not eligible to participate.

If you are eligible and would like to participate in this study, please follow the link [anonymous google form] and fill out the sign-up sheet. Only the researcher will see your name and schedule.

If you would like to request additional information about this study, please feel free to send an e-mail to mcc79279@uga.edu. This research will be performed under the supervision of Dr. Jessica Fernandez, who can be reached at jf46062@uga.edu.

Thank you for your consideration!

Sincerely,
Morgane Coleman

APPENDIX C– CONSENT FORM

UNIVERSITY OF GEORGIA CONSENT FORM

Relationship Between Olfactory Stimuli and Mood in a VR Built Environment

You are being asked to take part in a research study. The information in this form will help you decide if you want to be in the study. Please ask the researcher(s) if there is anything that is not clear or if you need more information.

Dear Participant:

My name is Morgane Coleman and I am a graduate student in the College of Environment and Design at the University of Georgia. I am conducting this research study under the supervision of Dr. Jessica Fernandez, Assistant Professor in the same Department.

The purpose of this study is to examine the relationship between smell, mood, and site perceptions in a campus environment for college-age students. Participation in the study is voluntary. You may choose not to participate or stop at any time without penalty or loss of benefits to which you are otherwise entitled.

If you agree to participate in this study, you will be asked to:

- Provide information including your age, gender, ethnicity, and education level.
- Before the lab VR experiment, complete one online survey questionnaire to identify current mood. You do not have to answer any questions that you do not wish to answer. The online survey should take no more than 3-5 minutes to complete.
- Use the VR equipment to navigate in a virtual campus environment in the VR Lab (room 031) in the College of Environment and Design for about 10 minutes plus a 2-3 minute introduction. Detailed instructions will be provided upon your sign-up.
- After navigating in the VR environment, complete an online survey questionnaire with additional questions about your VR experience. You do not have to answer any questions that you do not wish to answer. The online survey should take no more than 5-7 minutes to complete.

- A total of 20-25 min will be required to complete the VR experience and the online pre-and post-survey.

Confidentiality

We will take steps to protect your privacy. The confidentiality of any answers you provide to the survey, including general demographic information such as age and race, will be maintained to the degree permitted by the technology used. However, internet communications are insecure and there is a limit to the confidentiality that can be guaranteed due to the technology itself.

Once materials are received by the researcher, standard confidentiality procedures will be employed. The data collected about the participant will be confidential as IP addresses are being stripped upon data submission. The data will remain secure by being sent as an encrypted file.

The researcher's computer will also enable a firewall that will block unauthorized access. De-identified Information obtained from this research may be used for future studies (or shared with other researchers) without obtaining your additional consent.

Fragrance related potential risk

Some participants will be exposed to a floral fragrance during their VR experience. If you are sensitive to floral fragrances, this study may pose a greater risk for you. You may stop this study at any given time.

VR related potential risk

You may experience motion sickness or fall down while wearing the virtual reality headset. The experimenter will explain how you can take breaks during the experiment to relieve it. The researcher will observe participants' behavior closely to guard against accidents. There will be no hazard nearby the VR system. You may stop this study at any given time if you are experiencing any discomfort or motion sickness.

Covid-related potential risk

Although the study team will attempt to reduce the risk of COVID- 19 infection during your participation, there is still a risk that you may become ill with this infection. This could lead to severe respiratory or organ failure, and death. These complications would be more likely if you have one of the higher-risk health conditions. Please review your health history with the study team member to see if you have one of these conditions. Following the CDC announcement, people at increased risk will be excluded from this research.

If you are interested in participating or have questions about this research, please feel free to contact me at mcc79279@uga.edu or Dr. Jessica Fernandez at jf46062@uga.edu. If you have any questions or concerns regarding your rights as a research participant in this study, you may contact the Institutional Review Board (IRB) Chairperson at 706.542.3199 or irb@uga.edu.

If you agree to participate in this research study, please sign below:

| | | |
|--------------------|-----------|-------|
| _____ | _____ | _____ |
| Name of Researcher | Signature | Date |

| | | |
|---------------------|-----------|-------|
| _____ | _____ | _____ |
| Name of Participant | Signature | Date |

Please keep one copy and return the signed copy to the research

APPENDIX D- OPEN ENDED RESPONSES FROM SURVEY

Q15 - Do you have anything to add about your experience?

Group with smell:

"I thought it was very interesting to exciting to do as it was something that I have never experienced before."

"This experience was incredible and definitely the future of Landscape Architecture. I am obsessed with this."

"Smell reminded me of the home I grew up in!"

"So fun! Love how multisensory it was."

"It was very cool to use VR to jump into the site! I felt like I was in the space and the addition of scent made the experience feel more than just virtual. I feel like the pleasant scent enhanced my mood as well as interaction with the site."

"Loved the campus feel of the model and overall moving through the space felt comfortable."

"It was very fun and smelled good."

"I thought the VR experience was really cool and agree that with this program it would be easier to use to show project details to a client rather than a drawing or 3D model. I think if there could be a sound effect to match the breeze or birds that could be really COOL."

"VR was very cool!"

"VR environment felt just like a campus!"

"Thanks for the experience, it's amazing!"

"The model looked great compared to others I had seen before! I also liked having control over my movement in the model."

"I really enjoyed my experience in VR. This was my third time in VR so it helped being familiar with it. The scent was really calming, and I felt more physically present in the space because there were other sensual factors that helped me feel present in the space."

"The VR experience was lovely, and I really enjoyed this experience."

"I thought the experience was very helpful with getting to feel what a space is like. It was a completely immersive experience."

"I had a great time!"

Group without smell:

"The movement of the trees from wind added a lot of reality to the experience."

"Great effects with trees!"

"Super cool and informative."

"I think this is great step towards the future of our program."

"Very immersive!"

"Was really cool, definitely want to do again! Good tool for our major."