"NEAR NATURE": A PILOT STUDY APPLYING PRINCIPLES OF LANDSCAPE PREFERENCE TO VR GAME DESIGN

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ABSTRACT

There is significant interest in investigating improved cognitive functioning and other psychological benefits of simulated natural environments through immersive technology and virtual reality (VR). With further development, mental health care and correctional institutions may benefit from using technology to bring simulations of natural scenery to people lacking access to the outdoors, thus offering calm and potentially reducing stress for confined people. Research into simulated natural scenery thus far has focused primarily on visual experience. Viewing naturalistic scenery on screen or a VR headset typically offers minimal interactivity, however. Current VR technology offers potential for experiences beyond the merely visual, including object engagement and gameplay, which is the subject of this paper.

This paper outlines a pilot study for the design of a video game prototype, illustrating specific landscape principles associated with mental well-being. Test players' experiences are observed and analyzed in order to inform subsequent iterations of design. The initial game design prototype integrates the Kaplans' theories of landscape preference, in particular "mystery" and "legibility," along with Attention Restoration Theory, and applies it through a common professional game design framework called Mechanics Dynamics Aesthetics (MDA). Initial player responses show positive experiences with elements of the game, including interactivity, exploration, and fascination. Players connected those experiences with feelings of happiness, calm, and relaxation. In general, the pilot game design seems to support continued use of the hybrid framework for a second cycle of game development. This paper discusses the limitations of the small initial sample size (n=6) and future plans for a larger research project; these plans include refinement of game play mechanics and testing more refined game iterations in specific settings with specific demographic groups.

Keywords

Landscape preference, attention restoration, virtual reality, game design, pilot study

1 INTRODUCTION

Researchers have long acknowledged the benefits of spending time in or looking at natural environments. Decades of research show both to be beneficial to physical and mental health. Ulrich's (1984) seminal study demonstrates that patients showed improvements in health as well as faster post-surgery recovery times when provided with a window view of trees. Berman et al. describes exposure to natural environments as a "cost free and side effect free therapy for mind" (2008, p.1). However, not everyone has immediate access to natural scenery. Some people may be confined indoors for extended periods of time. People may also not have access due to their health or living location. In such circumstances, people may be able to gain some benefits of natural scenery through technology-based near-nature simulations.Although seemingly dichotomous, technology and nature have integrative potential to offer some cognitive benefits when natural scenery is unavailable or out of reach. Ubiquitous technology has helped to generate a rich body of research in simulated natural environments and their effects on mental health. However, existing research focuses on primarily visual experiences and rarely considers interactivity or game play, even when technology allows for it.

1.1 Research objectives

Interactivity and game play have potential to enhance immersion, prolong the restorative effects of simulated natural environment or, at the very least, provide a new medium for restorative benefits. This paper describes the initial pilot study for a larger ongoing study designed to uncover compelling strategies for designing restorative experiences as well as uncovering commonalities in landscape design and game development. Specifically, the pilot study: 1) integrates theories of landscape preference and environmental behavior into an existing game design framework, 2) uses that framework to develop a prototype VR game with near-nature simulations, and then 3) observes responses from participants in actual game play. In a later stage, these responses may contribute to a second iteration of game development.

1.2 Comparing benefits of natural & simulated natural environments

Human experiences in nature, both real and simulated, have been studied extensively in the attempt to explain the nuances of nature perceptions, experiences, and effects on health. Especially since the 1970s, researchers have demonstrated that being in, or simply gazing at, natural landscapes can have a restorative effect on the mind, by providing a place to recover from the stressors of modern society (Ulrich 1983; Kaplan and Kaplan 1989). Mental restoration from nature has been evaluated by looking at improvements in concentration, memory, stress, mood, and impulse inhibition (Bratman et al. 2012). In a comparison study, people who walked though an arboretum preformed significantly better in a memory attention test than people who walked through an urban environment (Berman et al. 2008). Similarly, Park et al. (2007) found improvements in physiological markers of stress in people who spent only 15 minutes in a forest environment versus those who spent time in an urban environment. Further evidence can be found in literature on forest bathing, the practice of spending time in forests, which shows improved mood as well as improved markers of physical and mental health (Takayama et al. 2014; Li 2018; Park et al. 2010; Tsunetsugu et al. 2010).

Currently, there is growing interest in investigating improved mood, cognitive functioning, and other psychological benefits of simulated natural environments through immersive technology and virtual reality (VR) (Litleskare et al. 2020; Frost et al. 2022). This presents an opportunity to investigate whether such simulations can provide some benefit to people who do not have access to natural scenery. Several studies show similar benefits between viewing simulated environments and real ones. For example, self-reported data frow viewing simulated natural scenery shows improvements in mood and positive affect (Browning et al. 2020; Yu et al. 2018; Scates et al. 2020; Anderson et al. 2017; Schutte et al. 2017). Studies also show improvements in physical markers associated with stress such as skin conductivity, heart variability, and blood pressure (Valtchanov et al. 2010; Liszio et al. 2018; Gerber et al. 2017).

Many examples of simulated natural environment exposure for health focus primarily on visual experiences, including images (Kjellgren & Buhrkall 2010, Varkovetski 2015, Felsten 2009), video (Snell et al. 2019, De Kort et al. 2006), and VR (Browning et al. 2020; Yu et al. 2018; Scates et al. 2020). Recently, VR has become a common platform for exposure to simulations of natural environments. Litleskare (2020) suggests that the increase in fidelity VR provides by encapsulating people in an allencompassing virtual environment may enhance the restorative effect. In a study comparing a VR environment to one displayed on a screen, the VR environment showed increased reductions in stress as measured by heart variability and exhibited a higher level of immersion. In some cases, VR exposures perform similarly to actual environments. Browning et al. (2020) reported similar improvements in positive affect between a VR 360 video and an actual environment; similar to Mattila et al. (2020), which showed similar improvements in positive affect between survey scores in a VR environment and exposure to an actual environment.

Due to these potential benefits, sectors as diverse as healthcare and correctional institutions have experimented with allowing patients to view simulated environments in VR and showing videos of natural environments to inmates subjected to solitary confinement. In both cases, the simulations support feelings of calm and reductions in stress (Moran 2009; Popkin, 2017; Reynolds et al., 2020, Navarette et al., 2022).

1.3 Landscape preference and attention restoration theory

Landscape preference theory originates from ideas related to evolutionary psychology. Humans have a long history with natural landscapes that allow quick, subconscious judgments based on the physical attributes of the environment. These judgments originate from human needs such as food, shelter, and safety. Simply viewing such environments, especially those abundant in resources and places to retreat or hide, can improve mood and reduce feeling of anger and anxiety (Ulrich 1979). Roger Ulrich calls this the Nature Tranquility Hypothesis, often referred to in literature as Stress Reduction Theory (SRT). His theory suggests that images of natural landscapes, with features such as vegetation, trees, and water, alleviate arousal states (fight or flight responses) and counteract them with subconscious, emotional responses to preferred landscapes (Ulrich 1983).

Similarly, landscape research leaders Rachel and Stephen Kaplan postulate that humans have an inherent desire to understand and interact with their environment, and thus suggest landscape preference links to the basic human needs of understanding and exploration (Kaplan and Kaplan 1989). Their argument rests on the idea that people are more likely to prefer landscapes in which they can thrive and function effectively (Kaplan and Kaplan 1989). By studying the physical attributes of environments for patterns that predict preference, the Kaplans' landscape preference matrix identifies four informational variables: coherence, legibility, complexity, and mystery (Table 1; Kaplan and Kaplan 1989).

Table 1. Preference Model (Informational Variables) Kaplan and Kaplan 1989.

	Understanding	Exploration
Immediate	Coherence	Complexity
Inferred	Legibility	Mystery

Of the four variables, mystery is the most consistent predictor of preference (Kaplan and Kaplan 1989; Gifford 2002, p. 61). Mystery promises the viewer that more information will be found deeper in a scene or environment and, in making viewers wonder what is to be discovered, mystery subsequently encourages involvement through exploration (Kaplan and Kaplan 1989; Herzog and Bryce 2007). However, despite mystery's relatively high consistency for predicting preference, some research has found the opposite effect (Herzog and Kropscott 2004; Stamps 2004). This may be explained because, in these conflicting studies, the definition of mystery did not differentiate between high and low visual access. Low visual access is a view so obstructed that not enough information is visible to be a positive predictor of preference; instead, it might suggest fear and danger (Herzog and Bryce 2007). On the other hand, high visual access is positively related to landscape preference: it allows enough of a view, even if partial, so that the viewer can imagine what lies ahead and participate in exploration (Herzog and Bryce 2007).

Gimblett et al. (1985), expanded on Kaplan's earlier description of mystery (1982) by outlining attributes associated with the perception of mystery. The attributes include: screening, distance of view, spatial definition, physical accessibility, and radiant forest; each were shown to be associated with mystery and positive predictors of preference. Table 2 shows each attribute and its relationship to mystery perception. This framework of mystery is further substantiated by a study that compared perceived attributes of mystery in images of landscapes to quantitative mapping of the same landscapes in rural Indiana (Lynch and Gimblet 1992). Although still hypothetical, it suggests the use of this framework is justified for advancing descriptions of mystery, and provides a heuristic for creating virtual landscapes that players are likely to find mysterious.

Table 2. Physical Attributes of Mystery. Gimblet et al. 1985.

Mystery Perception	Low	Moderate	High
Screening	none	partial	partial to full
Distance of View	far	moderate	close
Spatial Definition	open	partially closed	enclosed
Physical Accessibility			defined path
Radiant Forest (shadow and light)			forest illumination

Through Attention Restoration Theory (ART), Rachel and Stephen Kaplan assert that cognitive benefits and reductions in stress stem from the ability of natural environments to restore attentional capacity. The beneficial effects of natural environments on attention restoration have been evaluated with tests on different cognitive functions and from both real and virtual environments (Hartig et al. 1991; Tennessen and Chimprich 1997; Berman et al. 2008; Felsten 2009).

ART suggests people respond to nature with involuntary attention or soft fascination, leading to cognitive restoration, whereas built environments require directed attention or hard fascination. Long periods of directed attention without time for restoration leads to cognitive fatigue and ultimately negative affect in mood, anger, and stress (Kaplan and Kaplan 1989; Kaplan 1995). Natural environments are thought to restore attention when they embody the following attributes (Kaplan 1995):

Being away describes the feeling of a new setting that frees someone from the typical mental activities that require directed attention.

Extent refers to the idea of the environment being part of a whole other world and of a scope that engages and occupies the majority of someone's thoughts.

Compatibility is when someone's expectations are met by the environment intuitively and without struggle.

Hard and soft fascination are key components of ART and, as they relate to mental restoration, are clearly distinct concepts (Kaplan 1995). Hard and soft fascination are synonymous with direct (concentrated, focused) and indirect (or involuntary) attention, respectively. Hard fascination requires directed attention which drains mental capacity leading to negative affect in mood, anger, and stress. Soft fascination requires indirect attention which leaves room for restoring mental capacity and leads potentially to reduction of stress and positive affect in mood (Kaplan 1995).

1.4 VR technology & game design

Many of the theories and principles behind the health effects and perceptions of experiencing natural environments–both real and simulated–resemble strategies used by game designers to create pleasurable game play experiences. In particular, Landscape Preference and Attention Restoration Theory (ART) are similar to game design strategies and standards. Principles from Landscape Preference, such as mystery and legibility, resemble principles of level design for games; that is, how game designers use visual cues to signal, encode, or otherwise communicate ideas of safety and danger to players, as well as guide them through virtual space.

VR headsets commonly used for research in simulated natural environments may also be used to play video games. This suggests that people can not only view simulated natural scenery, but may also interact and play in and with it, in many of the same ways they might play a video game. Current video game development platforms, or game engines, offer high fidelity graphics that produce convincing simulations in full 3D environments (as opposed to 360 degree images or videos of actual environments).

Further, Mattila et al's 2020 study showed improvements in attention restoration using the HTC-Vive Pro headset (a commercially available headset for which developers can build games).

However, although VR affords game play, a virtual environment is not necessarily the same as a game. There are several definitions of a game in both practice and research, most consisting of play, rules, obstacles, or systems (Eng 2024). This study uses Roger Caillois' ideas on play and games to define what a game is. Caillois (2001) defines games as playful activities, and further defines four categories of games. However, what is more important is how Caillois defines playful activities, which fall on a spectrum between *paidia* or chaos and *ludus* or ordered (Caillois 2001). Activities described as *paidia* include more free forms of play such as exploration and physics-based interactions whereas activities described as *ludus* include more structured forms of play such as time limits and goals. The prototype in this study uses the flexible definition of a game to allow affordances to emerge through the research and design process.

Although one could argue for the presence of other landscape preference principles in game design, both mystery and legibility closely match the working definition of game design strategies. One of the most well-known examples is the strategy behind the design of the landscape in the video game *The Legend of Zelda: Breath of the Wild* (Nintendo 2017). Game developers used a triangle principle to partially conceal interesting areas of the landscape to give a sense of mystery and encourage player exploration (Nishikawa 2017). First-hand accounts of how *Breath of the Wild* designers introduced triangulated composition into the landscape, aligns closely with the Kaplans' definition of mystery as a partial obstruction from foliage, land-form changes, or other structures, and the promise of further information upon exploration (1989). In other words, as players traverse across the landscape, physical landscape attributes partially obstruct views of areas of interest (paths, towers, shrines, villages, camps, and other structures), thus encouraging players to explore actively.

As interpreted by Stamps (2004), the principle of legibility expands to include finding one's way around an environment, being able to figure out where they are at any given moment and being able to find their way back to any given point in space. This is similar to the idea of wayfinding, a familiar concept in designing levels, or spaces, for games. Game designers use wayfinding to help players orient themselves and navigate in game space intuitively while minimizing frustration. Strategies that encourage wayfinding include visual cues, game play elements, and the overall layout of the game space (Wayfinding n.d.).

This overlap serves as a starting point to begin building a hybrid framework for designing a restorative VR game, that not only offers a visual exposure to natural scenery but allows people to interact and engage with the virtual environment in a way that could offer additional therapeutic benefits.

1.5 Game design frameworks & prototype development

As a relatively new practice, game design practitioners and scholars have been challenged to formalize a framework that bridged the design, research, and criticism of games. Game designers and scholars Robin Hunicke, Marc LeBlanc, Robert Zubek (2004) developed the Mechanics Dynamics Aesthetics (MDA) framework as a way to formally study and understand games. Today, the MDA framework is ubiquitous in the field of game development and is the most widely used framework for analyzing games. Over the past two decades, other frameworks have emerged, most of which are extensions of MDA for more specific applications, such as game-based learning (Winn 2009). Some separate other aspects of games from mechanics and put them into their own categories, such as technology or narrative (Schell 2019). Despite some criticism of its simplicity, however, MDA remains the most widely used framework in game analysis.

Since games, especially video games, comprise so many different elements, the MDA framework allows people to understand games through three simple components:

Mechanics or components are things like the code, rules, and other data such as the polygons that make up the environments.

Dynamics are digital systems that develop through inputs and outputs over time.

Aesthetics comprise the range of feelings experienced by the players or what makes the game engaging (not necessarily visual quality or style, but affect)

Indeed, precisely because it allows focus on developing mechanics and evaluating the aesthetic experiences of players, the simplicity of the MDA framework serves the current pilot study well. In particular, it allows flexibility when integrating ideas from other areas such as landscape design and environment behavior. In this study, the MDA allows us to scaffold landscape and environmental behavior ideas with standard game design principles in order to test certain game play scenarios. This strategy was used to design the game play for the first prototype.

Exploration. For example, one key component of the first prototype of the game is exploration (see section 3.2 below). The dynamics of exploration are supported by a set of mechanic components, along with accompanying aesthetics that potentially integrate elements of positive affect from the ART framework. The pilot design process follows:

1) Mechanics are designed first. That includes translating ideas of mystery and legibility from landscape preference into the virtual landscape of the game through the actual 3D models and images, landscape surface polygons and textures, and lighting and shadow information. These mechanics include setting the boundaries of the space and developing rules for how participants move within and through it (i.e. specific instructions for the game to move an avatar though virtual space).

2) Over time, those inputs and outputs allow participants to explore the environment, where **dynamic** exploration is a system of judging the landscape, providing the necessary inputs to incite movement, and then moving through virtual space within defined confines and boundaries.

3) And last, dynamic exploration suggests a choice of **aesthetic** treatments such as escape from reality, the forest feeling like part of a larger world (i.e. extent, from ART), and other feelings of positive affect such as happiness, fun, anticipation, or tranquility.

1.6 Summary

The mental health benefits of being in, or viewing, natural scenery are widely understood. With the increasing availability of technology, interest in providing simulated experiences to people without access to natural environments is growing. The majority of the research in this area, however, focuses primarily on visual experiences. We still seek to understand what other kinds of experiences and engagement with landscape can digital technology provide to those who may have no other access? The larger study (of which this is the first stage) therefore investigates virtual interactivity and, more specifically, video game play, as a new and potentially beneficial arena for mental health benefits. In particular, the basic research question of this smaller study concerns the efficacy of “near nature” simulations in VR games as a strategy for delivery of such benefits.

The first step in that goal therefore is to pilot test the development of VR game technology and observe its reception among actual users: first, in order to ascertain whether VR is a promising direction for further development and second, to understand which if any landscape preference principles have greater impact on users’ playing experience. The remaining sections of this paper outline that first step of investigation: the pilot study for a prototype design based on the integration of landscape preference, environment behavior, and game design frameworks.

2 METHODS

This research project employs a hybrid methodology that combines approaches from Research through Design (RtD) and qualitative data analysis. Because it resembles design practice, RtD allows researchers to gain new knowledge through abduction: creating new products, ‘experimenting’ with new processes, and assessing the results. In this pilot study, RtD allows for the development of graphics and game play, and production of rich, real-time feedback from gaming participants. According to Godin and Zahedi (2014), when the process is rigorous and documented, the resulting artifact is a source of analyzable data.

Participant Sample. For the pilot study, a small test population was chosen based on ease of researcher access. Game participants, recruited from local university video game clubs, ranged from 19 to 23 years old. The pilot study goals required participants with experience in VR, who were comfortable using a VR device and not subject to cybersickness (Rosa et al. 2016). This particular test group also tends to limit confounding responses (such as positive reactions to the novelty of VR or frustration from being unable to properly use the device) and thus are ideal participants to help develop potentially effective gameplay mechanics for the prototype. Improved mechanics can then be used to develop future iterations of the prototype, which is to be further developed, tested, and potentially applied for different populations.

For the purpose of the pilot study, a total of six participants played the initial protype for an average of 12 minutes each. Before play began, each participant was informed they could play as long as they liked (up to 20 minutes) and asked to provide feedback afterwards. Each participant was familiar with the Meta Quest 2 VR headset and basic controls, so operating instructions were unnecessary. Prior to playing the game, participants were told they were part of a research study, but no specific details about the game itself were provided.

After each participant played the game they responded to a survey; then, once everyone had played in the session, all participants engaged in an unstructured focus group discussion. During the focus group, participants discussed their overall experience and offered feedback on how the prototype could be improved for the next iteration. In addition, a point-of-view gameplay video was recorded from the unique perspective of each participant.

2.1 Survey questions

The follow-up survey was modeled after the short version of the Perceived Restorativeness Scale (PRS) developed by Berto (2005) to measure the restorative qualities of an environment. For the purposes of this study, the PRS instrument was modified from a Likert-scale format to open-ended questions (Table 3), a change inspired by a 2013 qualitative assessment of experiences from gardening and its effect on mental health and aging (Hawkins et al. 2013). In that study, data from the interviews were coded and themed against ideas from Attention Restoration Theory (ART) (Kaplan) and Stress Reduction Theory (Ulrich). Interestingly, *doing gardening*, as coined in the paper, was evaluated in addition to *being in the garden*, which illustrates how qualitative data can provide insights into people's activities and sense of presence in environments. Gaining nuanced data on what participants do in the virtual environments is critical to connect experiences of natural scenery with interactivity and game play.

Table 3. List of Survey Questions.

In what way does the VR nature experience feel like a place which is away from everyday demands? How does it enable you to relax and think about what interests you? (being-away)
What about the VR nature experience is fascinating? How does it encourage curiosity and allow you to discover things? (fascination)
Is the VR nature experience ordered and organized or chaotic and confusing and why? (coherence)
How does the experience feel in terms of scale? Does it feel like a world of its own? Do you feel restricted? Why? (scope)
Is the VR nature experience easy to orient and move? What do you like doing there? Is there anything you would like to do, but can’t? (compatibility)
Can you describe any positive feelings or emotions you experienced in response to the visuals?
Can you describe any negative feelings or emotions you experienced in response to the visuals?
Can you describe any positive feelings or emotions you experienced in response to interactivity?
Can you describe any negative feelings or emotions you experienced in response to interactivity?
What in the VR nature experience did you find that was relaxing or calming?
What in the VR nature experience did you find that was frustrating, challenging, or required effort?
Did you find yourself at any point in the experience daydreaming, planning, or reflecting? If so, what were you doing?
How did the VR nature experience affect your mood after playing?

2.2 Prototype development

The initial design prototype for this pilot study was developed in the Unreal Engine, a game development platform that allows high fidelity graphics and deployment to VR devices. Figure 1 illustrates how computer-generated imagery (CGI) was custom-made using digital imaging and 3d modeling software such as Photoshop and Blender. The design prototype is playable on any VR device, however for this pilot study, participants played on a Meta Quest 2, a common and relatively inexpensive device that can be played either tethered to a PC or standalone. For ease of recording each playthrough, participants played tethered to a PC.

Figure 1. Screenshot of prototype from participant view (2024). Created by Author.

In *Playing Nature: Ecology in Video Games*, Chang (2019) points out many video game environments are simply treated as background, and instead suggests designing them as real places to enhance a players' sense of immersion and connection. Therefore, for this pilot study, CGI foliage is modeled after native trees and plants found in the Piedmont region of North Carolina. Photos were taken of the leaves, bark, and ground textures and translated into 3D models and materials. Even bird sounds and animated butterflies derive from species native to the Piedmont region.

The prototype's landscape was carefully developed using Unreal Engine's landscape sculpting tools, foliage tools, and hand placing objects and nature artifacts. The landscape was designed to embody ideas of mystery and legibility from landscape preference literature. Mystery was expressed through winding paths and partially obstructing accessible areas with carefully placed foliage and light and shadow. Additionally, paths to new mystery areas were made to look accessible—a counter-intuitive component of mystery described by Gimblet et al. (1985)—through rendering slight depressions (compaction) in the landscape and ground material contrast (a darker colored dirt against lighter color dead leaves).

Legibility was implemented in the overall layout of the environment. The defined paths form two interlocking figure eight patterns, so that as long as players keeping following a defined path, they will find themselves back in a familiar area. There are also two large areas of interest on opposite sides of the environment, a grassy clearing and a pond, which serve as landmarks while exploring the forest. The boundaries are defined by increasingly thick tree lines that encourage players to remain in a carefully designed play area.

3 RESULTS OF THE INITIAL PLAYTEST

Results from the playtest in this pilot study provide rich qualitative feedback on the participants' gameplay experiences. Authors compiled all responses from each anonymized participant into a spreadsheet. These responses were also matched to timestamps in unique playthrough videos. Authors took note of what participants did in the game, as well as where they chose to explore, and how thoroughly they navigated the virtual space. Authors analyzed participant responses for repetition of key words and/or synonymous phrases that aligned with designed elements of the game including: mystery, exploration, legibility, fascination, and interactivity in general. The videos were used to corroborate some ideas, such as exploration, watching participants more through the entire virtual forest from their perspective and see what elements fascinated them. Authors also looked for indications of improved mood, feelings of calm, and other things related to ART. From preliminary analysis of the pilot design, three main themes emerged: **interactivity, exploration, and fascination**: and although all these concepts are connected, each player-participant responded positively to these three concepts in unique ways.

3.1 Interactivity

Interactivity was a critical element in the test player experience. Everyone wanted to manipulate or play with the environment in some way; to the extent they were able to interact, players described this aspect of the game as a positive experience. The playthrough videos show everyone (100% n=6) interacting with the virtual forest in every way they could: picking up virtual objects, trying to catch butterflies, and running their virtual hands through computer-generated water. The ability to interact with the environment in this way allowed the participants to reflect on experiences with forests as children. Two participants wrote:

"I found myself feeling like a little kid again, because it is hard to find things as an adult that I have never done."

"it was really fun to play around with! Felt like playing in the woods when I was a kid, no specific intentions but there were opportunities to play with physics [e.g. effects of gravity] and stuff"

Additionally, when asked for things they wanted to do or ways to improve the game, every participant (100% n=6) mentioned interactivity in some way. The first prototype allows them to pick up objects on the ground such as sticks, rocks, and pinecones–some people throwing them into other objects, making a game of their own. There are also butterflies that participants can follow, observe, and "touch" as well as wade a few feet into a pond. Even then, everyone really wanted more interaction with butterflies and more fauna and artifacts to interact with.

"I wanted to go deeper into the water and hold the butterflies. Maybe be able to interact with more objects."

"Yes, I would love to be able to interact more with the scene. I wanted to be able to grab the butterflies, or touch them and hold them, or have them land on my hands."

"I WANT TO INTERACT WITH MORE WILDLIFE!…It wouldn't be maybe as realistic but I think the appeal of a virtual world is to be able to interact with nature in a way you may not typically be able to."

3.2 Exploration

Exploration is another key finding. Participants used defined paths and areas of interest, such as a clearing and pond, to effortlessly navigate the environment. Every participant was able to find their way through the entire virtual forest with no mentions of frustration from getting lost. The virtual forest also felt large and expansive, supporting the idea of extent from ART, but was not bewildering.

"I felt that the world was big enough where I felt urged to explore, but not too big where I felt myself getting lost in unfamiliar places that caused anxiety. I could always find my way around but still felt that there was a wide space to wander in."

"Being able to walk around such a large space was also calming, because I did not feel trapped or claustrophobic while I explored."

Additionally, every participant (100% n=6) mentioned exploration or wandering as a positive experience. Exploration seemed to also occupy participants' thoughts serving as a mechanism to support a sense of presence and distraction from the real world outside the headset.

"I was busy exploring and enjoying my surroundings. While inside the nature space, I did not even think about planning anything for the rest of my day."

"Throughout my time in the space, I lost track of time and any sense of urgency to complete tasks because putting the headset on. I was busy exploring and enjoying my surroundings."

3.3 Fascination

Fascination played a significant role in both the design of the first prototype and the participants' individual experiences. The virtual environment embodies translated descriptions of fascination as drawn from ART literature. Every artifact designed with this in mind was mentioned several times in the response by every participant for every question. This includes the butterflies, flowers, colors, soft breezes moving the foliage, and even audio effects. Descriptions of fascination were commonly mentioned in conjunction with feelings of positive affect such as peace, calm, relaxing, happy, and excited. Additionally, soft fascination-based artifacts seemed to encourage free play that—much like exploration—some participants described as pleasantly distracting from reality and allowing mental room for reflection.

"The moving butterflies really captured my attention and made me feel like I was really in a forest.

"The attention to detail of each asset in the scene was very accurate and made the entire experience believable."

> "The butterflies and different types of plants and trees brings a lot of interest to the environment."

> "I found the color scene, the butterflies floating around, and the flowers especially relaxing.

"I especially like that there was no objective in this game, and that I could take my time to experience everything how I wanted to and take time to fully understand each aspect"

"Being with such peaceful colors and positive images like flowers and butterflies relaxed me and calmed me down."

4 DISCUSSION OF THEMES

Results from the pilot study suggest preliminary support for the underlying suppositions of this research project. The first round of playtesting generated a rich set of qualitative data on the role of interactivity and play in a near-nature experience. It also supports the value of studying a prototype design, based on a hybrid game development framework (integrating landscape preference, environment behavior, and restoration principles) for a VR game. Additionally, feedback provided by the participants will help develop the second iteration of the game for subsequent playtests and ultimately contribute to another collection of data. For instance, the non-directional design of the game, the fact there was no contest or goal (winning condition), adds an interesting dimension for comparison with other types of games.

Interactivity. Interactivity played a key role in each participant's experience. Interacting with the forest brought excitement and joy to the participants involved and kept them engaged throughout playthroughs, averaging 12 minutes. This is significant because in two other, earlier natural environment simulation studies, participants were not able to interact with anything and positive affect dropped after a relatively short period of time, between five to six minutes (Browning et al. 2020, Mattila et al. 2020). The playtimes in this study are more than twice as long, and according to the responses and playthrough videos, participants reported having a consistent pleasurable game play experience.

Nostalgia. In addition to play time, interactivity brought positive feelings of nostalgia as two participants reflected on time spent in forests as children. Reflection is a key component of ART, supported by the soft fascination of being in a natural environment and occupying one's mind to allow recovery from mental fatigue (Kaplan 1995; Basu et al. 2019). This also raises the question of whether interactivity may enhance a sense of presence by recalling and connecting a virtual place to another place from deep memory. It also invokes the power of bodily movement as a way to unlock positive memories and feelings.

Exploration. Similarly, exploration successfully occupied the minds of the participants, keeping them engrossed. As they explored or wandered in these virtual environments, playtest participants reported they lost track of time and a sense of urgency. This relates to the role of fascination in ART, and its ability to free someone's mind of stressors to allow room for reflection and restoration. It seems similar to going for a walk in a real environment (minus the bodily benefits of exercise). Player responses that mention reflection, distraction from reality, and positive nostalgic memories are strongly connected to the playtest design premise of wandering or exploration.

Extents. No one mentioned frustration from getting lost; instead, any mention of being "lost" was positive, aligned with the Kaplan's concept of extent, and allowed the virtual environment to envelop a player as an affective response to the perceived scope and scale of the digital world.

Intuitive Legibility. Further, as interpreted from both the text responses and player-point-of-view videos, the experience of exploration seemed effortless. Every participant successfully found their way through the entire virtual forest, by potentially reading the clues provided in the design which was based on mystery and legibility. Point of view videos show participants looking at defined paths or areas teased with mystery before proceeding forward. Legibility informed the surface textures which revealed paths and communicated accessibility to mysterious areas of the forest. The concepts of landscape preference came together nicely in the design of the first prototype, encouraging exploration as evident in the open-ended response and point of view videos. This provides support for landscape preference integrating with game design to ultimately provide experiences in line with ART and possible mental restoration.

Mystery. The success of exploration is directly related to the principles of landscape preference used in the design of the virtual landscape. Concepts from mystery informed the design of the landscape as well as the layout to create opportunities to partially screen areas of interest for a sense of mystery. Attributes of mystery were incorporated as much as possible in the overall design of the landscape, especially those outlined in Gimblet et al. (1985).

Fascination. Fascination is perhaps just as essential to the design of the prototype as it is to ART. Many of the experiences participants enjoyed interacting with were developed with fascination in mind. The objects and processes of the natural setting were designed into the prototype to capture attention effortlessly, fitting in with the definition of soft fascination. A procedural wind system moves the leaves and foliage, butterflies fly from flower to flower, a pond gently laps against moss-covered rocks: all aspects of the prototype that participants found fascinating. Not only did these fascinating qualities drive interactivity, but they were often connected to mentions of positive affect such as calm, relaxing, peace, happy, and excited. They also match responses to fascination in other studies such as one on inmates (Moran 2009) and gardening (Hawkins 2013).

5 CONCLUSION

The availability of advanced technology to render high fidelity virtual environments allows designers from many disciplines and areas of research to investigate and develop near-nature simulations. This paper outlines a pilot study, as the first step in that larger research agenda, to explore hybrid frameworks through the design of a VR game with the potential for multiple benefits—both commercial as well as therapeutic. A hybrid design strategy, combining landscape preference and environment and behavior theories with established game design frameworks, is applied in development of a prototype for a game set in a virtual forest. The prototype is then play-tested, and first person responses collected.

Incorporating more opportunities for interactivity seems to be one standout response from participants. Player responsiveness to certain objects, such as virtual butterflies, provides clues as to what to add. For instance, allowing butterflies to land on the virtual hands of the participants may be more fascinating, or adding more fauna such as birds or fireflies. Kaplan (1995) mentions sunsets and clouds as fascinating qualities of natural scenery. Also having a time-of-day change mechanic, for example, could create more moments of fascination, even interactivity, by allowing participants to control the time of day and reveal new things such as fireflies at dusk. These enhancements are being considered in development of the second-round prototype, along with other mechanic improvements that emerge from the design process.

Although it provides valuable preliminary evidence, the initial pilot study also has research limitations:

Sample Size. An obvious limitation of the pilot includes the small sample size (n=6). With a larger sample, however, the task of analyzing and coding qualitative responses grows exponentially, and requires the use of software tools for coding and clarifying preliminary themes.

Demographic monoculture. Participants were recruited from university video game clubs: as 'digital natives' so to speak, these test players have a proclivity towards interactive digital experiences. Although this selection was intentional (to limit confounding factors of novelty and frustration), one wonders if positive player responses are due to the pleasure of playing games rather than the mechanics of research-informed design (landscape preference and ART). So while the data collected from this first cycle is rich and significant, the authors understand that a larger, more diverse demographic sample is needed to draw clearer and more reliable conclusions.

Relevance. Related to these demographic limitations, the play-test group may not resemble potential beneficiaries of long term research outcomes (e.g. those confined indoors related to their healthcare or incarceration). Notably, all participants were able to use their whole bodies while playing the game. Considering people who may not be able to interact with the game in the same ways is important, and additional modes of input will be considered moving forward. However, once the game design frameworks and game mechanics are honed via prototyping strategies, it should then be possible to target specific vulnerable and/or marginalized populations for more focused research, ideally in collaboration with others.

Next Steps. Future stages of this work include comprehensive study of a developed "near-nature" game to validate specific aspects of the game and especially its effects on mood, affect, and stress; more focus on other demographics such as those from multiple age groups, backgrounds, and various experience with technology; and work with specific groups who are detached from natural scenery (due to health or institutionalization).

In conclusion, this small-scale pilot provides preliminary support for the broad benefits of interactivity and game play. It illustrates several ways to apply landscape preference and ideas of ART to a VR game in a virtual natural setting. It also supports game play and game design as a potential enhancement to the overreliance on visuality in game design, which dominates the literature. Further, the pilot design offers hope for developing effective game mechanics that may, eventually, be used to generate mental health benefits. Ultimately, this study moves toward development of additional tools available to landscape architects as well as health care providers working in a variety of settings. Our overarching hope is to create opportunities for landscape architects to partner with digital game developers to investigate new sources of mental well-being for those in low-access environments.

REFERENCES

Anderson, A. P., Mayer, M. D., Fellows, A. M., Cowan, D. R., Hegel, M. T., & Buckey, J. C. (2017). Relaxation with Immersive Natural Scenes Presented Using Virtual Reality. *Aerospace Medicine and Human Performance*, *88(6)*, 520–526. http://dx.doi.org.prox.lib.ncsu.edu/10.3357/AMHP.4747.2017

Basu, A., Duvall, J., & Kaplan, R. (2019). Attention restoration theory: Exploring the role of soft fascination and mental bandwidth. *Environment and Behavior*, *51*(9-10), 1055-1081.https://doi.org/10.1177/0013916518774400

Berman, M. G., Jonides, J., & Kaplan, S. (2008). The Cognitive Benefits of Interacting With Nature. *Psychological Science*, *19(12)*, 1207–1212. https://doi.org/10.1111/j.1467-9280.2008.02225.x

Berto, R. (2005). Exposure to restorative environments helps restore attentional capacity. *Journal of environmental psychology*, *25*(3), 249-259.

Browning, M. H., Mimnaugh, K. J., Van Riper, C. J., Laurent, H. K., & LaValle, S. M. (2020). Can simulated nature support mental health? Comparing short, single-doses of 360-degree nature videos in virtual reality with the outdoors. *Frontiers in psychology*, *10*, 2667.

Caillois, R. (2001). *Man, Play, and Games*. University of Illinois Press.

Chang, A. Y. (2019). *Playing nature: Ecology in video games* (Vol. 58). U of Minnesota Press.

De Kort, Y. A., Meijnders, A. L., Sponselee, A. A., & IJsselsteijn, W. A. (2006). What's wrong with virtual trees? Restoring from stress in a mediated environment. *Journal of environmental psychology*, *26*(4), 309-320.

Eng, D. (2024, April 16). *What is a Game?* Retrieved 08 13, 2024, from https://www.universityxp.com/blog/2024/4/16/what-is-a-game

Felsten, G. (2009). Where to take a study break on the college campus: An attention restoration theory perspective. *Journal of Environmental Psychology*, *29(1)*, 160–167. https://doi.org/10.1016/j.jenvp.2008.11.006

Frost, S., Kannis-Dymand, L., Schaffer, V., Millear, P., Allen, A., Stallman, H., & Atkinson-Nolte, J. (2022). Virtual immersion in nature and psychological well-being: A systematic literature review. *Journal of Environmental Psychology*, 80, 101765.

Gerber, S. M., Jeitziner, M.-M., Wyss, P., Chesham, A., Urwyler, P., Müri, R. M., Jakob, S. M., & Nef, T. (2017). Visuo-acoustic stimulation that helps you to relax: A virtual reality setup for patients in the intensive care unit. *Scientific Reports* (Nature Publisher Group); London, 7, 1–10. http://dx.doi.org.prox.lib.ncsu.edu/10.1038/s41598-017-13153-1

Gifford, R. (2002). *Environmental psychology: Principles and practice*. Optimal Books.

Gimblett, H. R., Itami, R. M., & Fitzgibbon, J. E. (1985). Mystery in an Information Processing Model of Landscape Preference. *Landscape Journal*, *4(2)*, 87–95. https://doi.org/10.3368/lj.4.2.87

Godin, D., & Zahedi, M. (2014). Aspects of Research through Design: A Literature Review. *DRS Biennial Conference Series*. https://dl.designresearchsociety.org/drs-conference-papers/drs2014/researchpapers/85

Hartig, T., Mang, M., & Evans, G. (1991). Restorative Effects of Natural Environment Experiences. *Environment and Behavior*, 23, 3–26. https://doi.org/10.1177/0013916591231001

Hawkins, J. L., Mercer, J., Thirlaway, K. J., & Clayton, D. A. (2013). “Doing” gardening and “being” at the allotment site: Exploring the benefits of allotment gardening for stress reduction and healthy aging. *Ecopsychology*, *5(2)*, 110-125.

Herzog, T. R., & Bryce, A. G. (2007). Mystery and Preference in Within-Forest Settings. *Environment and Behavior*, 39(6), 779–796. https://doi.org/10.1177/0013916506298796

Herzog, T. R., & Kropscott, L. S. (2004). Legibility, Mystery, and Visual Access as Predictors of Preference and Perceived Danger in Forest Settings without Pathways. *Environment and Behavior*, *36(5)*, 659–677. https://doi.org/10.1177/0013916504264138

Hunicke, R., LeBlanc, M., & Zubek, R. (2004). MDA: A Formal Approach to Game Design and Game Research. 5.

Kaplan, R., Kaplan, S. (1989). *The Experience of Nature: A Psychological Perspective*. New York: Cambridge University Press.

Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology*, *15(3)*, 169–182. https://doi.org/10.1016/0272-4944(95)90001-2

Kjellgren, A., & Buhrkall, H. (2010). A comparison of the restorative effect of a natural environment with that of a simulated natural environment. *Journal of Environmental Psychology*, *30(4)*, 464–472. https://doi.org/10.1016/j.jenvp.2010.01.011

Li, Q. (2018). *Forest Bathing: How Trees Can Help you Find Health and Happiness*. Viking.

Liszio, S., Graf, L., & Masuch, M. (2018). The relaxing effect of virtual nature: Immersive technology provides relief in acute stress situations. *Annual Review of CyberTherapy and Telemedicine*, 16, 87–93.

Litleskare, S., E. MacIntyre, T., & Calogiuri, G. (2020). Enable, reconnect and augment: a new ERA of virtual nature research and application. *International Journal of Environmental Research and Public Health*, *17(5)*, 1738.

Lynch, J. A., & Gimblett, R. H. (1992). Perceptual values in the cultural landscape: A computer model for assessing and mapping perceived mystery in rural environments. *Computers, environment and urban systems*, *16(5)*, 453-471.

Mattila, O., Korhonen, A., Pöyry, E., Hauru, K., Holopainen, J., & Parvinen, P. (2020). Restoration in a virtual reality forest environment. *Computers in Human Behavior*, 107, 106295. https://doi.org/10.1016/j.chb.2020.106295

Moran, D. (2019). Back to nature? Attention restoration theory and the restorative effects of nature contact in prison. *Health & Place*, 57, 35-43.

Navarrete, J., Navarro-Siurana, J., Herrero, R., Vara, M. D., Miragall, M., & Baños, R. (2022). Connecting to Nature through 360° Videos during COVID-19 Confinement: A Pilot Study of a Brief Psychological Intervention. *Journal of Healthcare Engineering*, 2022.

Nishikawa, Z. (2017, September 2). *The Perfect Game World of The Legend of Zelda BotW was Created Because Nintendo's Development Style Changed.* https://www.4gamer.net/games/341/G034168/20170901120/

Park, B. J., Tsunetsugu, Y., Kasetani, T., Hirano, H., Kagawa, T., Sato, M., & Miyazaki, Y. (2007). Physiological effects of shinrin-yoku (taking in the atmosphere of the forest)—using salivary cortisol and cerebral activity as indicators—. *Journal of physiological anthropology*, *26*(2), 123-128.

Popkin, G. (2017). Nature videos help to calm inmates in solitary confinement. *Nature*, *1(09)*, 2017.

Reynolds, L., Rogers, O., Benford, A., Ingwaldson, A., Vu, B., Holstege, T., & Alvarado, K. (2020). Virtual nature as an intervention for reducing stress and improving mood in people with substance use disorder. *Journal of addiction*, *2020*(1), 1892390.

Rosa, P. J., Morais, D., Gamito, P., Oliveira, J., & Saraiva, T. (2016). The immersive virtual reality experience: a typology of users revealed through multiple correspondence analysis combined with cluster analysis technique. *Cyberpsychology, behavior, and social networking*, *19(3)*, 209-216

Scates, D., Dickinson, J. I., Sullivan, K., Cline, H., & Balaraman, R. (2020). Using Nature-Inspired Virtual Reality as a Distraction to Reduce Stress and Pain Among Cancer Patients. *Environment and Behavior*, *52(8)*, 895–918. https://doi.org/10.1177/0013916520916259

Schell, J. (2019). Tenth Anniversary: *The Art of Game Design: A Book of Lenses*. AK Peters/CRC Press.

Schutte, N. S., Bhullar, N., Stilinović, E. J., & Richardson, K. (2017). The Impact of Virtual Environments on Restorativeness and Affect. *Ecopsychology*, 9(1), 1–7. https://doi.org/10.1089/eco.2016.0042

Snell, T. L., McLean, L. A., McAsey, F., Zhang, M., & Maggs, D. (2019). Nature streaming: Contrasting the effectiveness of perceived live and recorded videos of nature for restoration. *Environment and Behavior*, *51*(9-10), 1082-1105.

Stamps, A. E. (2004). Mystery, complexity, legibility and coherence: A meta-analysis. Journal of *Environmental Psychology*, 24(1), 1–16. https://doi.org/10.1016/S0272-4944(03)00023-9

Takayama, N., Korpela, K., Lee, J., Morikawa, T., Tsunetsugu, Y., Park, B. J., ... & Kagawa, T. (2014). Emotional, restorative and vitalizing effects of forest and urban environments at four sites in Japan. *International journal of environmental research and public health*, *11*(7), 7207-7230.

Tennessen, C. M., & Cimprich, B. (1995). Views to nature: Effects on attention. *Journal of Environmental Psychology*, 15(1), 77–85. https://doi.org/10.1016/0272-4944(95)90016-0

The Legend of Zelda: Breath of the Wild (Switch version) [Video game]. (2017). Nintendo.

Tsunetsugu, Y., Park, B. J., & Miyazaki, Y. (2010). Trends in research related to "Shinrin-yoku"(taking in the forest atmosphere or forest bathing) in Japan. *Environmental health and preventive medicine*, *15*, 27-37.

Ulrich, R. (1979). Visual Landscapes and Psychological Well-Being. *Landscape Research - Landscapes*, 4, 17–23. https://doi.org/10.1080/01426397908705892

Ulrich, R. (1983). Aesthetic and Affective Response to Natural Environment. *Human Behavior & Environment: Advances in Theory & Research*, 6, 85–125. https://doi.org/10.1007/978-1-4613-3539-9_4

Ulrich, R. S. (1984). View through a window may influence recovery from surgery. *Science*, 224(4647), 420-421.

Valtchanov, D., Barton, K. R., & Ellard, C. (2010). Restorative effects of virtual nature settings. *Cyberpsychology, Behavior, and Social Networking*, *13*(5), 503-512.

Varkovetski, M. (2015). The reduction of directed attention fatigue through exposure to visual nature stimuli: Exploring a natural therapy for fatigue. Studies by Undergraduate Researchers at Guelph; Guelph, 8(2), n/a.

Wayfinding. (n.d.). Retrieved August 15, 2024 from https://book.leveldesignbook.com/process/blockout/wayfinding

Winn, B. M. (2009). The design, play, and experience framework. *In Handbook of research on effective electronic gaming in education* (pp. 1010-1024). IGI Global.

Yeo, N. L., White, M. P., Alcock, I., Garside, R., Dean, S. G., Smalley, A. J., & Gatersleben, B. (2020). What is the best way of delivering virtual nature for improving mood? An experimental comparison of high definition TV, 360° video, and computer generated virtual reality. *Journal of Environmental Psychology*, 72, 101500. https://doi.org/10.1016/j.jenvp.2020.101500

Yu, C.-P., Lee, H.-Y., & Luo, X.-Y. (2018). The effect of virtual reality forest and urban environments on physiological and psychological responses. *Urban Forestry & Urban Greening*, 35, 106–114. https://doi.org/10.1016/j.ufug.2018.08.013