Perceived Restoration of Hotel Lobbies: An Examination of Biophilic Design Attribute Organized Complexity and Attention Restoration Theory

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ABSTRACT

Previous researchers have shown that a sense of connection with nature can improve human health and well-being. Attention Restoration Theory (ART) frequently uses immersion in natural or nature-inspired environments as a means of helping people recover from mental fatigue, stress, and exhaustion. Simultaneously, biophilic design has become increasingly influential in design fields, and has been associated with a wide array of benefits in human performance, health outcomes, and quality of life. Some design principles that are promoted in the biophilic design literature, such as the use of natural light, have been strongly supported by empirical research findings. Other components of biophilic design, however, particularly those related to more abstract elements and indirect invocations of nature, have received less empirical study. The current research focused on the principle of "organized complexity" as it is advocated in the biophilic design literature. An interior design based around the principle of organized complexity was created for a hotel lobby, a vital service-industry context that has not received much attention in biophilic design research compared to other settings such as healthcare and retail.

Three different designs were created for the hotel lobby, each of which was very similar except for the level of organized complexity. For example, identical carpet patterns were used in each design, but the intricacy and size of the pattern was adjusted for low-, medium-, and high-complexity conditions. A randomized between-subject study was carried out by immersing participants in virtual-reality models of these designs, and obtaining and triangulating their fatigue-related and environmental preference responses

on three survey instruments. Potential moderator variables were also considered, including gender, prior experience with virtual-reality, and prior experience working or studying in design professions. The results of the study did not show a statistically significant relationship between the objective organized complexity levels and attention restoration. However, the findings did indicate a positive relationship between *perceived* environmental complexity and attention restoration, as well as a correlation between self-reported environmental preferences and attention restoration. These findings appear to indicate that individual baselines and preferences are a crucial factor in the benefits associated with organized complexity in biophilic design. Further research will need to be carried out to confirm this result and to determine if any demographic patterns can be identified in these environmental preferences and benefits.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ART – Attention Restoration Theory

FAS – Fatigue Assessment Scale

GMD – Goldstein Museum of Design

PRS – Perceived Restoration Scale

CHAPTER 1: INTRODUCTION

Background and Context

In his influential paper titled, "A Theory of Human Motivation," Maslow (1943) presented a hierarchical order of human needs in five main categories. This model begins with basic physiological needs and then continues through the needs for safety, love and belonging, esteem, and self-actualization. Maslow suggested that people must satisfy these needs, step by step, starting from the "lower" physiological needs and proceeding toward the "higher" goal of self-actualization, in order to achieve fulfillment. Once a "lower" need has been satisfied, higher needs then emerge and become the primary focus of a person's attention (Maslow, 1943, p. 375).

In modern societies, the physiological goals of procuring food and shelter are usually integrated into broader economic and social activities. For most people, the effort required to meet fundamental needs is not based on immediate physical actions (i.e., gathering food), but rather on various specialized jobs that require sustained attention. This means that in today's world, focused, long-term attention is a fundamental resource for meeting all levels of human needs. James (1892), in his book *Psychology: Briefer Course,* divides attention into two categories: voluntary/active and involuntary/passive. Voluntary attention requires engaged effort to sustain, while involuntary attention is a reflexive response to a stimulus (James, 1892). Voluntary attention is the form that is most vital and often-challenged in the modern world, as it allows people to focus on the task that is in front of them and to avoid distractions while they are completing the

activities that are necessary to meet their basic human needs (Felsten, 2009; James, 1892; Kaplan & Kaplan, 1989).

When people constantly direct their voluntary attention to the same task, they may experience a decrease in their attention capacity (Kaplan & Kaplan, 1989). With prolonged use of directed attention, the effectiveness of work and the human ability to focus tend to decrease, while performance errors and irritability increase (Staats & Hartig, 2004). This exhaustion caused by the constant use of mental resources is called "mental fatigue," and if it continues unabated, it can lead to a variety of negative consequences, including anger, aggression, and even violence (S. Kaplan, 1987). Kaplan and Kaplan (1989) suggested that resting the overworked capacity of voluntary attention can help individuals in the modern world to recover from mental fatigue, and they created Attention Restoration Theory (ART) as means to achieve this recovery. According to the ART literature, some environments have characteristics that enable people to recover more rapidly from mental fatigue (Hartig, Kaiser, & Bowler, 1997; Kaplan & Kaplan, 1989). Environments that promote connection with nature feature prominently in this literature, and a variety of such restorative natural environments have been tested in previous studies, confirming their association with mental fatigue recovery (Beatley, 2010; S. Kaplan, 1995).

The emphasis in the ART literature on using natural environments to support mental fatigue recovery dovetails with the broader concept of biophilic design, which has been defined as: "the deliberate attempt to design for the inherent human affinity for nature in the built environment" (Kellert, 2018, p. 15). Biophilic design aims to restore

the connections between humans and nature, with an emphasis on the human health benefits of integrating natural elements into the built environment (Kellert, 2018). Similar to the ART research findings, literature in biophilic design has established a link between the use of natural elements in the design of buildings and the restoration of human mental focus and attention capabilities (Alvarsson, Wiens, & Nilsson, 2010; Beute & de Kort, 2013; Felsten, 2009; Kellert & Calabrese, 2015; Ulrich et al., 1991; Völker & Kistemann, 2011; Wilson, 1984; Zadeh, Shepley, Williams, & Chung, 2014).

The effects of natural elements for restoring mental focus and attention capacity have been studied extensively in regard to views to parks and forests (Karmanov & Hamel, 2008; Pazhouhanfar & Mustafa Kamal, 2014; Van den Berg, Jorgensen, & Wilson, 2014; Van den Berg, Koole, & Van der Wulp, 2003). Researchers have also looked at the value of incorporating natural elements directly into interior settings, particularly in hospitals (Nejati, Rodiek, & Shepley, 2016), schools (Amicone, Petruccelli, De Dominicis, Gherardini, Costantino, Perucchini, and Bonaiuto, 2018; Felsten, 2009), retail spaces (Joye, Willems, Brengman, & Wolf, 2010; Rosenbaum, Otalora, & Ramírez, 2016), and senior housing (Rosenbaum, Sweeney, & Massiah, 2014). A few researchers have examined mental fatigue reduction associated with natural elements in hotels, but these studies have been limited to hotel restaurants (Rosenbaum, 2009) and overall vacation experiences (Kirillova & Lehto, 2016; Lehto, 2013). The current study examined the setting of a hotel lobby as a potential nexus of respite for travelers and for members of the local community. It investigated the effects of incorporating biophilic design principles in a hotel lobby in relation to restoring mental fatigue.

Research Questions

Biophilic design literature has identified a specific set of ecological features that are present in human experiences of nature, and that can be replicated in built environments. These include some of the more obvious ecological features such as natural light or views to natural landscapes, but they also encompass conceptual design features such as the evolved human needs for prospect and refuge, or patterns and textures that indirectly replicate natural geometries (Kellert, 2008, 2018; Kellert & Calabrese, 2015). The current study focused on the concept of "organized complexity," which has been discussed in the biophilic design literature but has seen little empirical testing in regard to its human impacts in the built environment. The study investigated hotel lobby designs based around the biophilic design attribute of organized complexity and evaluated the correlation of these designs with human attention restoration. The specific research questions that were addressed in the study were:

RQ1. Will the hotel lobby designs tested in this study have a greater perceived restorative potential if they integrate higher levels of organized complexity?

RQ2. Will the hotel lobby designs tested in this study be rated more highly in self-reported user preferences if they integrate higher levels of organized complexity?

RQ3. Will there be a relationship between the perceived restorative potential of the hotel lobby designs and their rating in self-reported user preferences?

RQ4. Will there be a gender difference in the reported restorative potential of the hotel lobby designs?

RQ5. Will participants' mental fatigue levels at the time of the experiment affect their perceptions of restorative potential in the hotel lobby designs?

RQ6. Will participants' prior experience with virtual reality affect their perceptions of restorative potential in the hotel lobby designs?

RQ7. Will participant's prior experience studying or working in design professions affect their perceptions of restorative potential in the hotel lobby designs?

Significance of the Research

In the contemporary urbanized world, hotel lobbies often serve as a space of respite for city dwellers who struggle with mental fatigue (Green, 2017). In addition to their function as a resting spot for travelers, many hotel lobbies are also popular sites for social gatherings and personal respite among members of the local community. For the most part, hotels have embraced this role and have been supportive toward various personal uses, local community meetings, and entertainment gatherings, all of which can create additional revenue for the hotel (Green, 2017). To create a restful lobby environment, many hotels have incorporated elements of biophilic design. In theory, such designs should positively affect the guests' experience, leading to increased reputation, status, and patronage (Green, 2017); and employee experience leading to less absenteeism and better work performance (Kweon et al., 2008; Lerner and Stopka, 2016). However, little empirical research has been carried out to analyze the success of these designs in hotel lobbies or what effects they might have on users' attitudes and outlooks toward the hotel. The current study addresses this research gap by directly investigating the impact of a biophilic design in a hotel lobby on users' recovery from mental fatigue and their perceptions of the building.

The study also addresses a lack of research in biophilic design related to the concept of organized complexity. The biophilic design literature includes a significant

number of studies on other proposed ecological attributes (natural lighting, natural textures and materials, etc.), linking these design features to stress reduction, cognitive performance, emotional mood, and various other human reactions. It is curious that organized complexity, despite being prominently featured in biophilic design theory, has not received similar empirical treatment (Salingaros, 2017; Sharifi & Sabernejad, 2016). The current study used Attention Restoration Theory (ART) as a basis for investigating the effects of different levels of organized complexity in reducing mental fatigue for guests in a hotel lobby. The findings provide important evidence to better understanding the role of organized complexity in biophilic design and its ability to improve the health and well-being of users of interior built environments.

Limitations

The sample size for this study was relatively limited; it included 91 adults located in the Minneapolis / Saint Paul metropolitan area. Caution should be used when generalizing any of the study's findings to broader population segments or to other geographical regions. In addition, the study only examined one implementation of the organized complexity design principle in the context of a hotel lobby. The findings of the study can lend support to the value and potential outcomes of other designs based around organized complexity, but due to the unique nature of each site and each interior design, the results may not transfer smoothly to all designs based on this principle (especially in different types of buildings). The study is limited to examining mental fatigue reduction and does not address other theories, principles, elements, and attributes related to biophilic design. Finally, the data-collection technique used in this study involved the virtual-reality design of an interior space with three different levels of complexity. This approach can allow for

the collection of valuable data that could not otherwise be obtained—since it is difficult or impossible to actually renovate an entire building for testing purposes—however, it is important to note that human responses to the virtual environment may not be entirely equivalent to responses in real-world buildings.

Definitions of Key Terms

Atmospherics. Aspects of a design that are intended to produce specific emotional effects and/or encourage particular user behaviors (Kotler, 1973).

Attention. Concentrated awareness toward a particular phenomenon or task, along with reduced focus on other stimuli (McCallum, 2015).

Biophilia. An evolutionary mediated tendency of humans to feel affinity for and comfort within ecologically robust environments (Wilson, 1984, p. 31).

Biophilic Design. An effort to incite biophilic reactions through the design of the built environment, thereby improving human health and well-being (Kellert, 2018, p. 15).

Complexity. The degree of detail or information-richness in an environment (Heaps & Handel, 1999, p. 301).

Connectedness with Nature. The conscious awareness of being embedded within or a part of the natural environment (Schultz, 2002, p. 67).

Mental Fatigue. The loss of physical, psychological, and social capacities due to concentrated, long-term mental effort (Hartig, Korpela, Evans, & Gärling, 1997).

Restoration. The process of renewing, recovering, or reestablishing physical, psychological, and social capabilities (Hartig, 2004).

Restorative Environment. An environment—often a natural setting—that is associated with more rapid restoration of capabilities (Hartig, 2004).

CHAPTER 2: LITERATURE REVIEW

Introduction

The literature review for this study began with the broader theoretical foundations of attention restoration theory followed by biophilic design. It then focused more specifically on the "organized complexity" design attribute as it appears in the biophilic literature, along with the very limited previous research on empirically evaluating the human effects of organized complexity in the built environment. Next, the literature related to prior applications of biophilic design in service industry contexts (hotel lobbies in particular) was analyzed. Finally, the review considered findings about individual and demographic differences in human responses to biophilic designs. Each of these topics is discussed in detail in the following sections.

Attention Restoration Theory (ART)

The current understanding of human attention generally follows William James's influential dichotomy of voluntary vs. involuntary attention (James, 1892). Overall, attention is understood as: "the concentration of awareness on some phenomenon to the exclusion of other stimuli" (McCallum, 2015, para. 1). Involuntary attention is a passive, effortless, and quick reaction to some outside effect, such as when a person turns their head to see where a certain unexpected sound came from (Eimer, Nattkemper, Schröger, & Prinz, 1996; James, 1892). In contrast, voluntary attention is active and task-oriented, and is experienced as a form of sustained mental effort (Eimer et al., 1996; James, 1892). In today's society, nearly all productive economic activity requires the use of ongoing voluntary attention.

Rachel Kaplan and Stephen Kaplan pioneered the concept of Attention Restoration Theory (ART) in their book *The Experience of Nature* (Kaplan & Kaplan, 1989). They argued that the effort required for modern individuals to focus voluntary attention on the same task for long periods of time leads to "mental fatigue," a worn-out state associated with deteriorated capacities, a higher likelihood of errors, and in extreme cases an increase in hostile or anti-social behavior (Hartig, Kaiser, & Bowler, 1997; Kaplan & Kaplan, 1989). Anyone can experience mental fatigue after long hours of work or study, especially after completing the same task over and over again. The consequences of this fatigue can sometimes be dramatic—Kaplan and Kaplan (1989, p. 180) mentioned air-traffic controllers as a profession that is highly susceptible to mental fatigue and in which errors due to this fatigue can have horrifying consequences. The basic remedy for this problem, according to Kaplan and Kaplan (1989), is for individuals to take breaks in which the mental capacity of voluntary attention is rested and restored.

Sleep is the body's primary means of resting and restoring the mental capacity for attention, but for individuals who exert extensive voluntary attention throughout each and every day, even normal sleep patterns may be insufficient to maintain optimal functioning. Hence, Kaplan and Kaplan (1989) proposed ART as a supplemental means of resting these mental capacities. The ART process relies heavily on immersing individuals into environments that encourage mental relaxation. These contexts are called "restorative environments" in ART, and they are associated with a specific set of qualities that promote desired forms of rest. The four key components of effective restorative environments are summarized in the ART literature as: "being away," "fascination," "extent," and "compatibility" (Kaplan & Kaplan, 1989, p. 182-185) (See Figure 1).

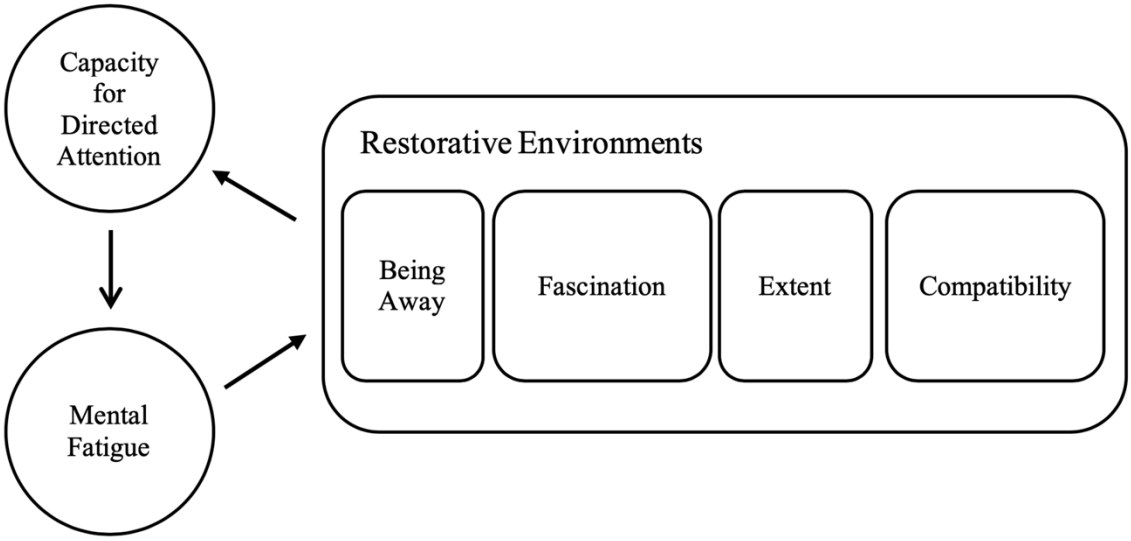

Figure 1. The theoretical framework of Attention Restoration Theory (ART).

Four Components of Restorative Environments in ART

The first component of restorative environments, as described in the ART literature, is called "being away." This is defined as a change of scenery in relation to the physical context of the workspace (Kaplan & Kaplan, 1989; S. Kaplan, 2001, p. 481). The change of scenery does not have to be drastic; it can even be another area in the same building. However, according to ART theory, the restorative environment needs to involve a change of physical patterns and cognitive content, thereby directing human cognitive resources in a different direction compared to the work environment that is producing the mental fatigue (Kaplan & Kaplan, 1989; S. Kaplan, 1995).

The second component of restorative environments, labeled as "fascination" in the ART literature, is defined as complex environmental features that incite relaxed curiosity. S. Kaplan (2001, p. 481) has described these environmental features as "patterns that hold one's attention effortlessly." In one of the earliest formulations of the approach that would later become known as ART, R. Kaplan (1974) described the theme

of fascination in the context of gardening, emphasizing that engaged curiosity about natural processes is often tied to comforting memories and to a relaxation of urgent, task-oriented voluntary attention. In addition to this, later Kaplan (1995) suggested to use the term 'fascination' instead of 'involuntary attention' claiming that the effortless state of involuntary attention is intrinsically compelling (p. 172). The ART approach suggests that immersing oneself in relaxed, non-utilitarian fascination can distract the mind from obsession with focused tasks and thus promote mental restoration (R. Kaplan, 1974; Kaplan & Kaplan, 1989).

The third component of restorative environments, as defined in the ART literature, is the "extent" of the surroundings. This means that the immediately present elements of the environment are perceived as being interrelated with a much broader world, which provides a feeling of expansive belonging (Kaplan & Kaplan, 1989). The feeling of extent or interrelatedness does not necessarily mean that the restorative environment has to be physically large, but rather that its components incite an awareness of being connected to larger contexts and processes that are beyond the individual's control. This sense of involvement helps to relax the controlling aspects of task-oriented attention, and in the ART literature, it is regarded as necessary for a successful implementation of the prior components of "fascination" and "being away" (Kaplan & Kaplan, 1989, p. 184).

The fourth and final component of restorative environments that is presented in the ART literature is "compatibility" with the interests, goals, and outlooks of an individual. Even if an environment meets the other three parameters for mental restoration, it is not likely to be effective if it feels alien to the participants (Kaplan &

Kaplan, 1989; S. Kaplan, 1983, 2001). Thus, the design of restorative environments needs to be tailored through familiarity with the personal and cultural backgrounds of the individuals who will be using them. When an environment is compatible with an individual's needs, the user will not have to make any particular mental effort to fit in, interpret, or adapt to the restorative context (Kaplan & Kaplan, 1989).

ART Applications and Empirical Research

Previous studies on restorative environments using the ART model have mostly focused on large-scale settings. For example, Karmanov and Hamel (2008) assessed the restorative potential of natural environments vs. urban environments. These researchers evaluated mental fatigue and relative levels of "fascination" among participants who were asked to watch videos of a natural scene and a contemporary urban scene. Karmanov and Hamel (2008) used a scale that they designed to assess how dull or exciting the scenes from the videos are. Results indicated that participants in the study rated the urban environment as more "interesting," while they rated the natural environment as more "attractive." The study's authors suggested that the complex layout of urban spaces may create a sense of mystery, intrigue, and potential exploration for many participants, which in the right contexts can offer restorative potential under the ART approach.

Of greater interest for the current study is previous studies that applied the ART model to analyze interior environments. These studies are relatively rare in the literature, but a few researchers have previously applied ART in the context of museums (S. Kaplan, Bardwell, & Slakter, 1993), arcades (Rosenbaum, 2009), senior centers (Rosenbaum et al., 2014), hospitals (Nejati et al., 2016), shopping malls (Rosenbaum,

Otalora, & Ramírez, 2016), and classrooms (Van den Berg, Wesselius, Maas, & Tanja-Dijkstra, 2017). The conclusions of these studies provide general evidence that interior designs can help to create a restorative benefit, as well as some indications of the types of design features that are effective for this purpose.

S. Kaplan, Bardwell, and Slakter (1993) found that museums usually have restorative effects on their visitors, and that these effects are greater for individuals who are frequent patrons of museums. These researchers analyzed the familiarization aspect for new patrons. They determined that wayfinding problems, as well as the overall confusion in navigating an unfamiliar environment, caused the lack of mental fatigue restoration. To some extent, the greater restorative benefits experienced by frequent visitors was correlated with the "compatibility" principle in ART, as these regular patrons often felt a strong personal affinity with the art world and therefore a greater sense of relaxation in the museums. However, additional design features such as confusing signs and directions also contributed to the lack of restorative effects among new visitors.

Rosenbaum (2009) examined the restorative value of arcades for teenage and college-aged participants. The study provided strong evidence that these environments fulfilled all four of the ART components for their patrons ("being away," "fascination," "extent," and "compatibility"), and that they provided significant restorative effects in relation to mental fatigue. This finding supports the conclusion that commercial service establishments can be restorative environments under the ART framework (Rosenbaum, 2009). The researcher also argued that promoting the restorative aspects of service environments can be commercially rewarding—from a managerial perspective, the restorative features of the arcade were seen as creating greater revenues, higher levels of

customer satisfaction, improved customer loyalty, and a greater likelihood of customers promoting the arcade to their peers (Rosenbaum, 2009).

A more recent study by Rosenbaum and colleagues (2014) examined community-oriented senior centers from an attention restoration perspective. This research aimed to determine if these environments were successful in helping seniors to reduce their fatigue levels and enhance their quality of life. The researchers used survey questionnaires to measure the participants' perceived restoration and fatigue levels, and they also conducted extended interviews to obtain qualitative feedback about the aspects of the senior centers that the participants felt were most restorative. The findings indicated that these environments provided significant restoration for seniors in accordance with the ART model, particularly through the sense of being away (or "escape") and through their compatibility with the needs of elderly individuals. The researchers also found that the perceived restorative benefits of the senior centers were strongly correlated with the extent to which the participants engaged in the activities offered by those centers.

Nejati and colleagues (2016) analyzed the restorative qualities of hospital staff break-rooms based on the visual stimuli present in these environments. The variables in this study included the décor, lighting, views from windows, and access to nearby outdoor environments. To evaluate the human effects of changes in these design variables, the researchers used images that they digitally manipulated to create different break-room conditions. Hospital staff participants then provided feedback on the desirability and restorative potential of the altered break-rooms shown in the images. The results supported the restorative value of direct views to nature and direct access to nature, as well as the value of nature-inspired artworks. This study is significant in that it

indicates that changing specific design variables in an indoor environment can potentially enhance participants' responses to the overall space.

Rosenbaum, Otalora, and Ramírez (2016) used the ART framework to analyze commercial store designs in a shopping mall. The researchers found that shopping experiences that met the ART criteria ("being away," "fascination," "extent," and "compatibility") were associated with reduced mental fatigue in customers. The study also indicated that individuals who experienced restoration from mental fatigue in the shopping mall were more likely to talk positively about the commercial environment and to promote it to their peers. The researchers described this outcome as an "emotional bond" between the customers and the retail environment (Rosenbaum, Otalora, & Ramírez, 2016, p. 163). However, the study did not find any relationship between the amount of money that the customers spent during a single trip and the positive attention restoration that they experienced. No gender- or age-related effects were found in relation to the reported restorative effects of these commercial environments.

Van den Berg, Wesselius, Maas, and Tanja-Dijkstra (2017) analyzed the effects of a natural classroom design ("green walls" that incorporated living plants) in relation to attention restoration among elementary school students. The researchers measured a variety of response variables, including cognitive performance, emotional and social well-being, and self-reported environmental evaluations by the students, in addition to tests of voluntary attention capacities. The students in this study responded very positively to the "green walls" in their self-reports, and the cognitive performance and attention tests indicated a mentally restorative effect compared to classrooms with traditional walls. Interestingly, this study found no correlation between the green walls

and the measurements of students' emotional and social well-being. The positive restorative effect of the environment thus appeared to be an individual factor related to personal mental fatigue, which acted tangentially to the larger social and emotional context of the children's lives.

Overall, the literature of the ART framework pioneered by Kaplan and Kaplan (1989) has focused primarily on the restorative value of immersion in natural environments. The studies discussed in this section, however, indicate how ART has also been applied in the context of interior design, to evaluate the restorative human effects of specific design variables. There is reasonably solid evidence that interior environments adhering to the ART formula— "being away," "fascination," "extent," and "compatibility"—can help to promote the reduction of mental fatigue and the restoration of users' attention capacities. The current study provides a further development and expansion of this literature by evaluating the restorative potential of an ART-applicable design in the context of a hotel lobby.

Biophilia

The term "biophilia" was originally coined by the psychoanalyst and humanist Erich Fromm, who defined it succinctly as, "love of life" (Fromm, 1964, p. 39). Twenty years later, the biologist Edward O. Wilson further developed this concept as a hypothesis about the relationship between humans and nature (Wilson, 1984). Wilson interpreted biophilia as the "innately emotional affiliation of human beings to other living organisms" (Wilson, 1993, p. 31). According to Wilson's hypothesis, evolutionary processes have created an intrinsic link between human mental health and the experience of immersion in a robust ecological environment (Wilson, 1984). In more recent years,

this outlook has been adopted by a wide range of researchers, including those in the design field who found strong evidence that the built environment can enhance human well-being by honoring the innate predisposition that humans have towards natural settings (Kellert, 1993; Ulrich, 1993).

Biophilic theorists also acknowledge that humans can have an evolutionarily mediated *phobic* response to some natural elements. Typical human reactions to snakes, spiders, or rot are examples of "biophobic" experiences (Fromm, 1964; Kellert, 2018; Ulrich, 1993). However, these negative human reactions are usually of little interest to architectural designers, who are generally concerned with what elements can be incorporated into their work to promote beneficial human experiences. Thus, the elements of nature that have supported physical human flourishing, such as clear-flowing water and open views to fertile landscapes, are those that biophilic design theorists seek to address. In conceptual terms, the arguments for integrating such elements into the built environment are often grounded on *biologically prepared learning*, the view that humans' responses to the environment transfer genetically through the generations and remain similar to the reactions that were beneficial to our distant ancestors (Kellert, 2012; Kellert & Calabrese, 2015; Ryan, Browning, Clancy, Andrews, & Kallianpurkar, 2014; Ulrich, 1993; Wilson, 1984). The biophilia hypothesis claims that this foundation of biologically prepared learning in regard to the environment does not quickly change to meet the imperatives of modern urban spaces, and that therefore our designs should adapt to take into account these innate human dispositions (Wilson, 1993).

The late Stephen R. Kellert, Professor Emeritus of Social Ecology and influential biophilic design theorist, proposed a variety of different categorizations of biophilic

principles. Starting in a 1993 volume, *The Biophilia Hypothesis*, which he co-edited along with Edward O. Wilson, Kellert proposed a nine-part list of values or orientations toward nature based on the concept of human ecological dependencies. Twenty-five years later, in his book *Nature by Design* (Kellert, 2018), he presented a revised list that had been reduced to eight orientations toward nature (Table 1). Each of the values in Kellert's schema is derived from his understanding of practical benefits that have increased the chances of human survival over evolutionary time-frames. Kellert (2018, p. 6) suggested that people of different ages, cultures, and individual backgrounds might prioritize different biophilic values in different ways, but that the overall set of evolved needs and orientations in relation to nature should be understood as similar for all humans.

Table 1.

Human Orientations Toward Nature in the Work of Stephen R. Kellert

Name of Orientation		Definition	Human Benefits
(Kellert, 1993)	**(Kellert, 2018)**		
Utilitarian	*Exploitation*	Obtaining material and practical benefits from nature.	Security, prosperity, and cultivating practical skills.
Naturalistic	—	Satisfaction from direct contact and involvement with nature.	Mental and physical development.
Scientific	*Intellect*	Systematically understanding nature and its structure.	Cognitive skills, critical thinking, and observation.
Aesthetic	*Attraction*	Contemplation of desirable beauty in nature.	Inspiration, creativity, and sense of harmony.
Symbolic	*Symbolism*	Using nature to represent and communicate abstract thoughts.	Enhanced capacities of language and intellect.
Humanistic	*Affection*	Emotional attachment and love towards nature.	Feelings of connection and sense of belonging.
Moralistic	*Spirituality*	Finding meaning, purpose, or larger relevance in nature.	Sense of meaningful existence and peace.
Dominionistic	*Control*	Mastering, dominating and controlling nature.	Cognitive and mechanical skills; feelings of power.
Negativistic	*Aversion*	Avoiding potential threats and sources of fear from nature.	Security, safety, and self-defense.

The concept of biophilic design is based on the belief that most of these evolved needs are being poorly met by contemporary urban spaces (Kellert, 2018; Kellert, Heerwagen, & Mador, 2008). The lack of natural elements in urban contexts is regarded in this literature as leading to a decline in human capacities and well-being, based on the absence of the diverse mental and physical benefits that humans gain from interacting with robust natural environments (Kellert, 2018). In response, these theorists argue for a "deliberate attempt to design for the inherent human affinity for nature" (Kellert, 2018, p. 15). Biophilic design aims to create spaces for human life and work that promote users'

conscious awareness of being part of a natural environment. This design approach encompasses a wide range of possible environmental features, and it also claims a wide array of potential human benefits (both of these topics will be addressed in more detail below). The overall principles of effective biophilic design have recently been listed by Kellert as follows:

- Integrating nature into a built environment in a way that supports human health and well-being, instead of just being a decorative element.
- Adopting a holistic approach to design that encourages the creation of an overall ecological experience rather than just individual components.
- Establishing an engaging, stimulating, and consistent theme that promotes an overarching natural experience.
- Incorporating diverse elements into the design that can satisfy the different expectations and experiences of nature that arise from users' individual backgrounds.
- Creating environments that people can get attached to emotionally.
- Encouraging a sense of community through design and connecting individuals to other human and non-human life forms.
- Adopting a holistic approach through varied settings to create a continuous, repeated exposure to the biophilic experience.
- Encouraging authentic engagements with natural elements, materials, and processes, rather than artificial experiences.

- Promoting symbiotic relationships with nature, in which people benefit from the environment while also preserving and sustaining it (Kellert, 2018, p. 18-22).

Attributes of Biophilic Designs

Various biophilic design theorists have suggested different ways in which the principles of biophilia can be implemented in the built environment. Heerwagen and Gregory (2008) suggested that to implement biophilia in building design, designers first need to understand how nature creates certain feelings that supports well-being. After this initial understanding, researchers claimed that designers must examine form, material, and space as ways to integrate nature in the built environment (Heerwagen, & Gregory, 2008, p. 236). Heerwagen and Gregory (2008) developed a design palette consisting of seven attributes to integrate biophilia into built environment. Additionally, Hildebrand (2008), an architect, suggested five characteristics that he defines as applicable to integrate into architecture. He named these characteristics as *survival-advantageous characteristics* (Hildebrand, 2008, p. 264). A 2014 study by Browning, Ryan, and Clancy (2014) proposes 14 patterns of biophilic design with three major categories (nature in the space, natural analogues, nature of the space) to achieve a holistic integration of biophilia into built environment (Refer to Appendix A).

The most robust and comprehensive analysis has again been presented by Stephen R. Kellert. In an early article, Kellert (2008) initially proposed two dimensions, six elements, and seventy attributes of biophilic design. The two main dimensions in this account included organic/naturalistic design principles, related to the ways in which shapes and forms come together to convey a sense of immersion in nature; and place-based design principles, related to communicating the natural "spirit" or ecological

significance of a particular location (Kellert, 2008). More recently, Kellert's analysis of biophilic design has consolidated into a new formulation, consisting of three main dimensions and twenty-five attributes (Kellert, 2018). This current, and very influential, breakdown of biophilic design is oriented around the primary dimensions of (a) direct experiences of nature, (b) indirect experiences of nature, and (c) experiences of space and place (Figure 2).

In Kellert's (2018) schema, the category "direct experiences of nature" refers to incorporating ecological elements into a design, for example by using natural light, flowing water, local flora and fauna, and/or views to exterior natural areas. The category "indirect experiences of nature" refers to the use of materials, textures, colors, shapes, and patterns than evoke natural environments and create an awareness of human relationships with the larger ecosystem. Finally, the category "experiences of place and space" refers to overarching attributes of the designed environment that link it thematically with its surroundings. Attributes that are included in this third category include designing for prospect and refuge, organized complexity, mobility, and the integration of parts, among others.

For the current research study, Kellert's (2018) biophilic design attribute of "organized complexity," located under the "experiences of place and space" element, provides the primary design principle that is being tested. This biophilic design attribute, along with others in the "space and place" element, has seen relatively little empirical investigation in comparison to those design strategies included under "direct experiences of nature" and "indirect experiences of nature." The significance of the organized

complexity design approach, and research related to this topic, will be discussed more extensively a few pages below.

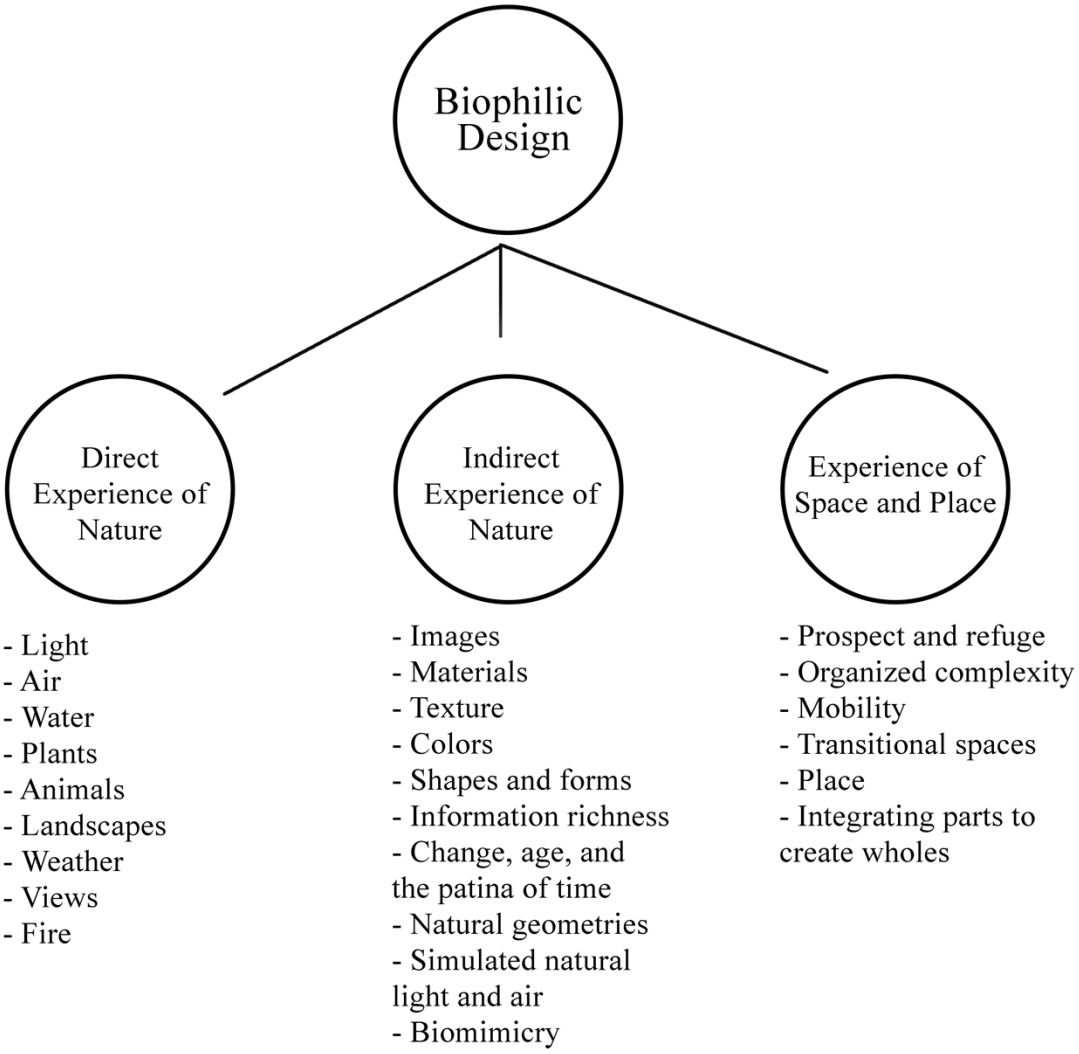

Figure 2. Biophilic design framework as presented by Kellert (2018).

Research on the Human Health Effects of Biophilic Design

Many studies have supported a link between implementations of biophilic design and positive human health outcomes. The majority of this research literature is focused on what Kellert (2018) would call "direct experiences of nature." For example, Kaplan,

Talbot, and Kaplan (1989) found that workers in an office building with views to a natural environment had lower stress levels, fewer health problems, and greater reported job satisfaction compared to individuals working in offices with views to other buildings. Similarly, Hartig and colleagues (2003) found that people relaxing in a room with views to nature had a faster decline in stress levels, as measured by decreases in diastolic blood pressure, compared to individuals in a windowless room. Shibata and Suzuki (2004) found that the addition of indoor plants in an office space helped to improve participants' mood and task-performance, compared to the use of artificial decorations.

Other studies have examined the human effects of indirect representations of nature. Kweon, Ulrich, Walker, and Tassinary (2008) found that male employees experienced less stress and were less likely to become angry if they worked in an office with posters depicting natural scenery. This soothing effect was stronger than that provided by art posters (Kweon et al., 2008). A similar study by Ulrich, Lundén, and Eltinge (1993) found that patients who had undergone heart surgery were less anxious and required lower doses of painkillers when they recovered in rooms containing pictures of water and trees, compared to those who recovered in rooms with pictures of abstract art. It should be noted that many studies in this category would not qualify as full-fledged biophilic designs, according to Kellert's (2018) principles, since they examined nature-oriented "decorative elements," rather than holistic ecological experiences. Nonetheless, even when examining the inclusion of potted plants or pictures of nature in interior designs, these researchers have found significant positive health impacts.

Yin and colleagues (2018) conducted an interesting and nuanced study in which they used four different environments to test both real-world and virtual-reality-based

biophilic designs. Participants in this study were asked to complete tasks in one of the four environments: (a) real-world biophilic design, (b) virtual-reality biophilic design, (c) real-world non-biophilic design, and (d) virtual non-biophilic design. The researchers found that participants' stress levels, measured through blood-pressure and skin-conductance, were relatively lower in both the real and virtual biophilic settings. In addition, the participants performed better on cognitive tasks in both the real and virtual biophilic settings, compared to the real and virtual non-biophilic environments. The findings in this study proved to be very similar for the real and virtual environments, indicating that today's high-resolution virtual immersion can be a useful tool for assessing human responses to different environmental designs (Yin et al., 2018).

Organizations such as the *United States Green Building Council*, the *International WELL Building Institute*, and the *International Living Future Institute* have incorporated aspects of biophilic design into their sustainability standards and certification requirements. This is based on a recognition of the overwhelming research evidence that biophilic design can contribute to improved health outcomes, and the view that human health, well-being, and consciousness of natural connections are intrinsic aspects of sustainable construction (Kellert, 2008; Totaforti, 2018). The WELL Building Standards have incorporated biophilic design under two features, called "Biophilia I – Qualitative" and "Biophilia II – Quantitative" (International WELL Building Institute, 2019). The Living Building Challenge 4.0 standards of the International Living Future Institute have incorporated biophilic design as one of their twenty required imperatives ("Imperative 19") (International Living Future Institute, 2019). The United States Green Building Council's LEED, or Leadership in Energy and Environmental Design, offers a Pilot-

Credit EQpc123: *Designing with Nature, Biophilic Design for the Indoor Environment* to incorporate elements of nature in the design of interior environments.

The Organized Complexity Attribute

The biophilic design of a hotel lobby analyzed in the current study was developed based on Kellert's (2018) understanding of "organized complexity" as an important aspect of human affinity toward nature. There is good evidence that the human brain is hard-wired to respond in positive ways to environments that include detailed and complex patterns, likely because such patterns are a signature of healthy organic growth (Salingaros & Madsen, 2008). A variety of biophilic design theorists have adopted this conclusion, arguing that information-rich environments that are organized into some kind of logical pattern are appealing to humans and can promote their cognitive equilibrium and sense of mental and emotional comfort (Abdelaal & Soebarto, 2018; Hildebrand, 2008; Kellert, 2018; Kellert & Calabrese, 2015; Ryan et al., 2014; Salingaros, 2014, 2018).

Early discussions of organized complexity in design can be found in scholars such as Osborne and Farley (1970), who described the value of visual stimulation emerging from the use of line, direction, shape, size, color, and texture in a detailed and rhythmic pattern. Other designers have theorized about the degree of symmetry that is desirable in design, noting that information complexity increases with irregularity, asymmetry, and detail; and decreases with repetition, similarity, and homogeneity (Berlyne, 1974; Feldman, 1997; Pieters, Wedel, & Zhang, 2007; Van Der Helm, 2000; Wolfe, Horowitz, & Kenner, 2005). "Complexity" in design can be defined as how much information is present in the environment, while "organization" is determined by the patterns into which that information is arranged (Ramzy, 2015).

The goal of "organized complexity," as discussed by Kellert (2018, p. 91), is to integrate rich detail and variety into the environment while using patterns that are organized enough to avoid any sense of confusion or chaos. If an environment does not include enough complexity then it will likely be regarded as uninteresting and monotonous, but too much disorganized complexity may cause people to feel bewildered and overwhelmed (Hildebrand, 2008; Kellert, 2018; Kellert & Calabrese, 2015; Salingaros, 2006, 2018). Salingaros (2014, 2018) has developed a method for analyzing the relative organized complexity of an environment based on: (a) the number and variety of different design elements, (b) the symmetries and connections among the elements, and (c) the number of noticeably different size scales. Based on these factors Salingaros presented a list of seven injunctions to achieve effective organized complexity in design:

1. Connect parts by using different and repetitious geometries.
2. Use flows to create natural paths without creating grids.
3. Use different symmetries at various scales, but no overall single symmetry.
4. Create spatial interactions using symmetry and similarity.
5. Create ever-changing repetition.
6. Create a systematic structure with a series of adaptive steps.
7. Create a dynamic process, not a static ornament. (Salingaros, 2018, p. 52-53)

Salingaros (2012, 2018) studied fractals in nature to understand the different size scales and variations. An example of fractals with different iterations is the Koch curve illustrated in Figure 3 created by mathematician Helge von Koch (1904). Fractal geometries exist on various scale in both natural and built environments (Salingaros, 2012; Ryan, 2015). Salingaros, also a mathematician, claimed fractal geometries evoke

excitement and created organized complexity (2012). Organized complexity of fractal geometries emerges in different scales in the built environment and nature (Salingaros, 2012; Ryan, 2015). Patterns, ornamentation, and details are some interpretations of organized complexity in micro scale while flow, spatial organization, and three-dimensional organizations have shaped through solid and void relationships and hierarchies are in meso scale (Ryan, 2015). In macro scale, dynamic systems that change over time such as street grids or transport infrastructure are the interpretations of organized complexity (Salingaros, 2012; Ryan, 2015).

Figure 3. Fractal geometries with different levels of iteration adapted from Koch, H. V. (1904).

In addition to the scholarship of Salingaros (2014, 2018), Kellert and Calabrese (2015), and Kellert (2018), the concept of organized complexity has also appeared as a prominent recommended feature of biophilic design in works by Hildebrand (2008) and by Ryan and colleagues (2014). Abdelaal and Soebarto (2018) used this concept in their analysis of traditional Islamic architecture, pointing out that the fractal geometries and hierarchical symmetry prevalent in certain historical schools of Islamic design precisely fits the definition of "organized complexity" as discussed by today's biophilic design theorists, and that these patterns were also consciously intended to incite a sense of physical comfort and connection with nature (Figure 3). In a similar fashion, Ramzy

(2015) claimed that architects from various historical cultures have used organized complexity and other principles that are familiar to current biophilic design.

A notable study conducted by Pazhouhanfar and Mustafa Kamal (2014) examined organized complexity in the context of Attention Restoration Theory (ART). These researchers sought to determine if organized complexity in the environment was related to restorative effects for reducing mental fatigue. The goal of this previous study was thus very similar to the current research, though Pazhouhanfar and Kamal (2014) conducted their analysis in relation to external urban landscapes (manicured city park spaces) rather than interior designs. Their results indicated that the complexity of natural elements in the landscape contributed significantly to self-reported mental restoration effects. The current study provided a similar, but more detailed analysis regarding the application of organized complexity in the interior design of a hotel lobby.

There is some debate among designers about whether the value of organized complexity for human comfort increases linearly in an endless fashion, perhaps even down to the microscopic, fractal level (as is common in natural environments). Some designers hold this view of an endless linear correlation; whereas others have suggested that preferences for organized complexity can be graphed in an inverted U-shaped fashion, with people preferring more complex visual stimulation up until a certain optimal point, beyond which evaluations of the environment will decrease with further added complexity (Berlyne, 1971, 1974; S. Kaplan, 1995; Nadal et al., 2010). Overall, there has been relatively little empirical research conducted to evaluate human responses to different levels of organized complexity or to develop a body of evidence in relation to the human health impacts of this biophilic design principle.

Biophilic Design and Service Industry Environments

The design of the built environment in service industries is often considered an aspect of marketing. A term frequently used in this context is "atmospherics," which refers to the intentional manipulation of the environment to influence consumer emotions and behaviors (Bitner, 1992; Kotler, 1973; Namasivayam & Lin, 2008). Atmospherics in marketing seeks to promote an aesthetic response based on feelings of connectedness, belonging, and a sense of discovery (Csikszentmihalyi & Robinson, 1990). These goals are roughly parallel to the mentally restorative ART design components of extent, compatibility, and fascination, as discussed in the first section of this literature review. In service industries, the environmental design is primarily focused on achieving customer loyalty and encouraging spending behaviors, but it can also be understood as providing a restorative benefit for patrons of the business.

Bitner (1992) developed the concept of "servicescapes" to describe the physical features of consumer environments and the effects of these environments on people's cognitive responses. The environmental dimensions that Bitner included in the definition of servicescape were: ambient conditions (such as temperature, air quality, and noise), use of space (such as layout and furnishing), and symbols and artifacts (such as signage and style of décor). Bitner's terminology was adopted by other researchers, including Namasivayam and Lin (2008), who defined the servicescape as an environment "organized and delivered by service providers and experienced by consumers" (Namasivayam & Lin, 2008, p. 44). Rosenbaum (2009) and Rosenbaum and colleagues (2014) analyzed the potential for servicescapes to provide restorative benefits in relation to mental fatigue. These researchers found that arcades (Rosenbaum, 2009) and senior

centers (Rosenbaum et al., 2014) were commercially oriented environments that provided significant restorative benefits to their patrons.

In recent years, biophilic theory has begun to exert an influence on the design of servicescape environments. Purani and Kumar (2018) conducted the first research study that specifically examined the biophilic attributes of servicescapes in regard to their attention restoration benefits. In this study, Purani and Kumar asked the participants to examine images of different service contexts, including the lobby of a hospital, several different restaurants, a spa, and a bank lobby. Some of these environments incorporated biophilic design attributes, such as plants, natural light, and natural materials, while others were non-biophilic designs. The participants were asked to evaluate the service environments in regard to their restorative potential, their ability to provide pleasure and comfort, and their overall desirability. The environments incorporating biophilic design elements were rated more highly by the participants in all of these categories (Purani & Kumar, 2018). This study also found that employees working in the service environments with biophilic design features reported significantly higher levels of productivity and job satisfaction (Purani & Kumar, 2018). Rosenbaum, Ramírez, and Matos (2019) published another study same year exploring the retail environments as biophilic servicescapes. Rosenbaum, Ramírez, and Matos (2019) aimed to find the neurological responses of patrons of servicescapes. The study used videos of two similar lifestyle centers which one of them has green areas while the other one does not have any green areas (Rosenbaum, Ramírez, & Matos, 2019). Rosenbaum, Ramírez, and Matos (2019) measured the neural activity of the participants with electroencephalography. Results revealed that patrons who experienced the biophilic servicescapes are more interested in the environment and

setting, more involved and curious, more attentive and emotionally attached than the patrons who experienced the servicescape without biophilic design features (Rosenbaum, Ramírez, & Matos, 2019).

To the best of the current researcher's knowledge, there are not any previous studies that have examined human responses to specific biophilic design features in the context of hotel lobbies. This is a significant gap in the literature, since hotel lobbies are among the most frequently visited servicescapes in hotel settings, with a significant impact on the perceptions of guests and on the overall revenues of the hotel (Miller, 1995). Hotel lobbies are the places where guests' first and last impressions of the establishment are formed, and they serve as the primary areas for guests to relax, mingle, and engage with colleagues and friends (Collins, 2001; Miller 1995; Penner, Adams, & Rutes, 2013). In addition to the important role that they play for travelers, hotel lobbies are frequently open to members of the local community who are seeking a venue in which to relax, socialize, or hold events (Green, 2017).

Alfakhri and colleagues (2018) studied a variety of features that contributed to customers' evaluation of hotels, ranging from financial considerations and quality of service to aesthetic and emotional responses to the environment. Among the design elements that emerged in this study, patrons often stressed the importance of color, light, big windows, ease of wayfinding, comforting sounds, and the presence of plants and water. Many of these highly-rated environmental features could be understood as aspects of biophilic design. Browning and his colleagues (2012), and Green (2017) similarly found that biophilic design contributed to guests spending more time and money in hotel lobbies, lounges, retail, and restaurants. The observational study found that 36% of guests

of the biophilic hotels used the lobbies while it was only 25% in conventional hotel lobbies (Green, 2017). These studies have provided some general evidence that features associated with biophilic design may have important benefits for hotel patrons, employees, and owners, but more research is needed to improve the empirical quality of this evidence and to test the human benefits of specific design components.

Individual Differences in Human Responses to Biophilic Designs

When evaluating the human impacts of a biophilic design, it is important to note that previous researchers have reported individual and demographic differences in human responses to such designs. Kweon and colleagues (2008), for example, found that nature images in an office setting had a significant impact on reducing stress and anger for the study's male participants, but that there was no significant effect in reducing stress and anger among female participants. Conversely, Shibata and Suzuki (2004) found that incorporating indoor plants in an office setting helped to improve the task performance of female participants but did not have any significant effect for the task performance of male participants.

Some of these findings may be idiosyncrasies emerging from the limited data sets in these studies, but they could also possibly reflect real demographic differences in responses to natural environments and the ways in which evolved needs are prioritized, as suggested by Kellert (2018). Thus, it is important in any biophilic design study to include demographic variables, and to use caution in generalizing the results to broader populations. The current study considered the gender of participants as a potential moderator variable when analyzing the relationship between organized complexity and mental fatigue reduction.

CHAPTER 3: METHODS

Introduction

This chapter presents the study design and the empirical measures that were used to evaluate the effects of organized complexity on perceived attention restoration and environmental preferences in a hotel lobby setting. First, the variables and hypotheses of the study are described, along with the participant recruitment, measurement instruments, and data-collection procedures. The hotel lobby designs that were tested in the study are presented and discussed in the context of biophilic design theory, and the use of virtual environments as a research platform is explained and justified. Finally, the data-analysis methods that were used in the study are presented in detail.

Study Design

The study used a randomized experimental approach. Participants were randomly assigned to experience one of three hotel lobby designs using different conditions of complexity in the design through a virtual-reality (VR) platform. The study was based on a between-subjects design, meaning that each participant experienced and evaluated only one of the three virtual environments. The independent variable in the study was the level of organized complexity in the hotel lobby design (including three conditions: low organized complexity, medium organized complexity, and high organized complexity). The dependent variables were (a) the perceived degree of attention restoration and (b) self-reported environmental preferences. Moderator variables included the analysis were the gender of the participants, their level of mental fatigue at the start of the experiment,

their prior experience with virtual reality platforms, and their prior experience working or studying in design professions. The overall conceptual model of the study, *Theoretical Model of Perceived Restoration of Organized Complexity (PROC),* is shown in Figure 4.

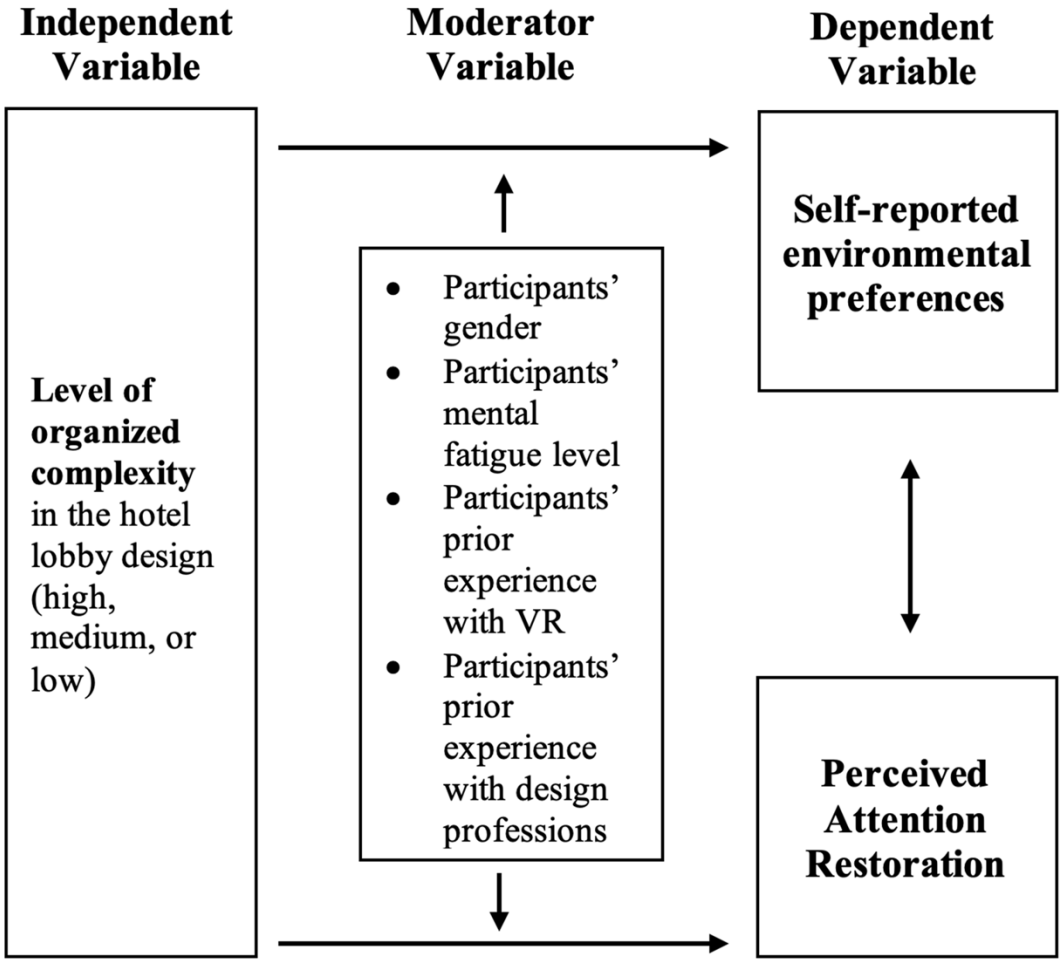

Figure 4. Conceptual model and variables used in the current study (Theoretical Model of Perceived Restoration of Organized Complexity (PROC)).

Research Questions and Hypotheses

Seven research questions and hypotheses were developed based on the literature review. Hypotheses 1 and 2 incorporated the prediction that participants' responses to organized complexity would follow an inverted U-shaped curve; in other words, that medium levels

of organized complexity in the hotel lobby design would be preferred over high or low levels of organized complexity. Hypothesis 3 predicted that participants who perceived greater restorative potential in the lobby design would also rate the design higher in their reported environmental preferences.

Based on previous research that indicated men gain greater emotionally restorative benefits from biophilic design compared to women (Kweon et al., 2008), Hypothesis 4 of the current study predicted a statistically significant difference between participants who identify as men and women. Since individuals who have greater mental fatigue levels may be more attuned to the restorative potential of an environment, Hypothesis 5 predicted that higher levels of mental fatigue would be associated with greater perceived restorative benefits. In addition, based on previous research indicating that adaptation to VR can improve users' comfort levels (Munafo, Diedrick, & Stoffregen, 2017), Hypothesis 6 of the current study predicted that participants who had previous experience with VR environments would report greater attention restoration benefits. Finally, Hypothesis 7 predicted that there would be a difference in perceived attention restoration benefits between the participants who had experience working or studying as designers vs. the participants who did not have design experience. The full list of research questions and hypotheses is as follows:

RQ1. Will the hotel lobby designs tested in this study have a greater perceived restorative potential if they integrate higher levels of organized complexity?

Hypothesis 1. Perceived restorative potential will be significantly greater in the hotel lobby design that uses medium levels of organized complexity, compared to the designs that use low or high levels of organized complexity.

RQ2. Will the hotel lobby designs tested in this study be rated more highly in self-reported user preferences if they integrate higher levels of organized complexity?

Hypothesis 2. Environmental preferences will significantly favor the hotel lobby design that uses medium levels of organized complexity, compared to the designs that use low or high levels of organized complexity.

RQ3. Will there be a relationship between the perceived restorative potential of the hotel lobby designs and their rating in self-reported user preferences?

Hypothesis 3. There will be a positive linear relationship between the perceived restorative potential of the hotel lobby designs and their rating in self-reported user preferences.

RQ4. Will there be a gender difference in the reported restorative potential of the hotel lobby designs?

Hypothesis 4. There will be a significant difference in perceived restorative potential between participants who identify as men vs. those who identify as women.

RQ5. Will participants' mental fatigue levels at the time of the experiment affect their perceptions of restorative potential in the hotel lobby designs?

Hypothesis 5. Perceived restorative potential will have a positive linear relationship with the participants' mental fatigue level at the time of the experiment.

RQ6. Will participants' prior experience with virtual reality affect their perceptions of restorative potential in the hotel lobby designs?

Hypothesis 6. Perceived restorative potential will be significantly greater for participants who have previous VR experience, compared to those who do not have previous VR experience.

RQ7. Will participant's prior experience studying or working in design professions affect their perceptions of restorative potential in the hotel lobby designs?

Hypothesis 7. There will be a significant difference in perceived restorative potential between participants who have prior experience studying or working in design vs. those who have no experience in design.

Participant Recruitment

The participants in this research were 91 adults who were located in the Minneapolis-Saint Paul Metropolitan area at the time of the study, and who had prior experience using hotels. The participants were recruited through a convenience sampling method. Prospective participants were contacted through e-mail and communication in person (Appendix B). Informed consent and demographic information were obtained at the time of the experiment, as described in the Procedures section below. Prior to the data collection, approval was obtained from the University of Minnesota Institutional Research Board to ensure the protection of human participants during the data collection process (Appendix C).

The participants were from diverse demographic backgrounds. Their ages ranged from 18 to 65, with a mean age of 28.38. A total of 36 (39.6%) participants self-identified

as male, and 55 (60.4%) self-identified as female. The participants were also asked to indicate if they worked or studied in design professions: a total of 20 (22.0%) worked or studied as designers, while 71 (78.0%) were non-designers. There were 47 (51.6%) participants who had previous experience with virtual reality, and 44 (48.4%) who did not have any prior experience with virtual reality.

Measurement Instruments

The instruments used in this study to evaluate the dependent and moderator variables were: (a) the Fatigue Assessment Scale (FAS) developed by De Vries, Michielsen, Van Heck, and Drent (2004); (b) the Perceived Restorativeness Scale (PRS) developed by Hartig, Kaiser, and Bowler (1997); and (c) a study-specific questionnaire created by the researcher.

The FAS is a brief, Likert-based assessment of overall perceived mental fatigue levels (Appendix D). It has been well-validated and used in a variety of medical studies. In the current research, the FAS was used to evaluate the participants' relative mental fatigue levels at the start of the experiment. The PRS is a Likert-based assessment of the restorative value that participants ascribe to an environment (Appendix E). The PRS was developed in the context of Attention Restoration Theory, and used questions related to the dimensions of "being away," "fascination," "extent," and "compatibility" (Kaplan & Kaplan, 1989), which are discussed in more detail in the literature review chapter above. In the current research, the PRS was used to obtain the participants' reactions to the hotel lobby designs in regard to their perceived restorative potential.

The study-specific questionnaire was created by the researcher to obtain data about self-reported environmental preferences, and to collect demographic information (Appendixes F and G). This instrument used a 5-point Likert scale, ranging from "Do Not Like It At All" to "Like It Very Much," to assess responses to the hotel lobby designs. It also asked participants to rate the complexity of the lobby designs, using a 5-point Likert scale from "Not Complex at All" to "Very Complex." The demographic data that was collected through this instrument included age, gender, participation in design professions, previous virtual experience, and frequency of hotel visits.

Lobby Designs and Scenarios

The independent variable in this study was the amount of organized complexity in the design of the hotel lobby. Three different lobby design conditions were used, labeled as "Low Complexity," "Medium Complexity," and "High Complexity." These hotel lobby models were created by the researcher, using the Sketch-Up 3D-modeling software program. The High Complexity lobby was created first, based on the literature review of applied organized complexity factors in design (Appendix H, Table H1). The other two designs, with Medium and Low levels of organized complexity, were created by reducing the level of detail in the High-complexity design. (Figures 5, 6, and 7). The distinctions between the different complexity conditions were in the micro- and meso-scale design features, including visual patterns, ornaments, spatial changes, and solid/void relationships (Ryan, 2015).

The spatial partitions in the hotel lobby design, as well as the ceiling height, were modeled to follow the golden ratio. An axis was created in the floor plan to provide a

pathway through the lobby for ease of wayfinding. This pathway was intended to create a sense of order while prompting curiosity and inviting hotel patrons to explore further into the space. The researcher designed varying heights of horizontal planes that came together into forms inspired by trees and canyons, which helped to create areas of prospect and refuge in the lobby. These horizontal planes were converted into walls, planters, ceilings, and seating units. In the High-complexity design (Variety x3, Figure 7), the height of each horizontal plane was set as ten inches, which created a high density of horizontal planes and thus a high degree of detail in the resulting environment. In the Medium-complexity design (Variety x2, Figure 6) the height of each horizontal plane was increased to twenty inches, and in the Low-complexity design (Variety x1, Figure 5) it was increased to thirty inches. In each case this reduced the number of horizontal planes and thus lowered the overall environmental detail in the lower-complexity designs. A natural color palette was chosen to enhance the biophilic quality of the lobby, as well as a carpet design that mimicked the natural element of grass growing between pavement stones. The density of the carpet patterns was adjusted in each of the three design variations to provide different complexity levels. Natural wood was used as a wall cladding to create geometric patterns, which also differed in complexity in each of the design variations.

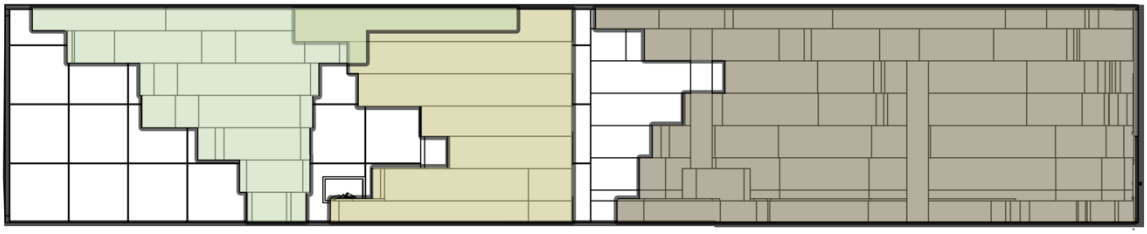

Figure 5. Schematic representation of information in the Low-Complexity design variation (Variety x1).

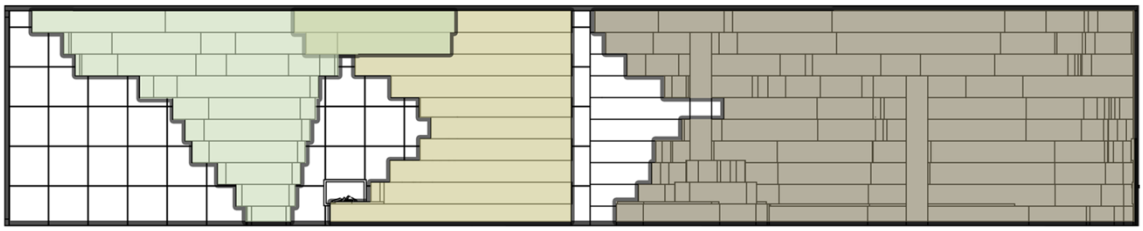

Figure 6. Schematic representation of information in the Medium-Complexity design variation (Variety x2).

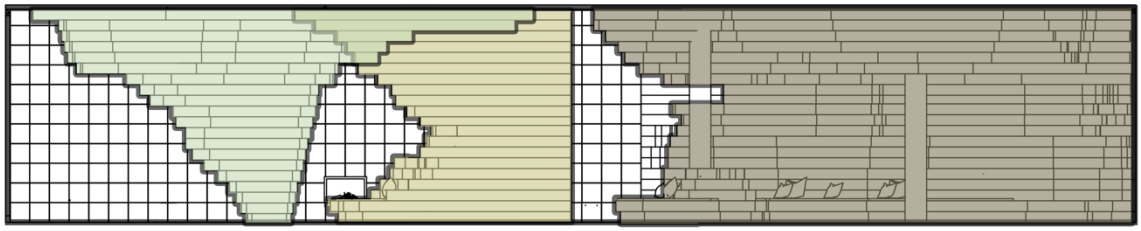

Figure 7. Schematic representation of information in the High-Complexity design variation (Variety x3).

The researcher conducted informal discussions with biophilic design experts from different disciplinary backgrounds (architecture, interior design, and behavioral research), to obtain feedback about the hotel lobby designs. The models were revised based on this expert advice. One of the most central responses from the design experts was to integrate additional natural elements, as opposed to just geometrical elements, in the designs (Elizabeth F. Calabrese, personal communication, February 27, 2019). To achieve the

successful application of biophilic design and organized complexity variation, the researcher identified areas of the lobby in which to apply direct connections with nature (plants, natural light, and a fireplace). These areas were then enhanced with additional elements—more plants, and a larger fireplace—in the higher-complexity designs. These changes were in addition to the increases in geometrical complexity (Figures 8, 9, 10, 11, and 12). Enscape™, a virtual-reality and real-time rendering program, was used to generate a photorealistic presentation of the lobby designs suitable for use with virtual reality goggles (Figures 10, 11, and 12).

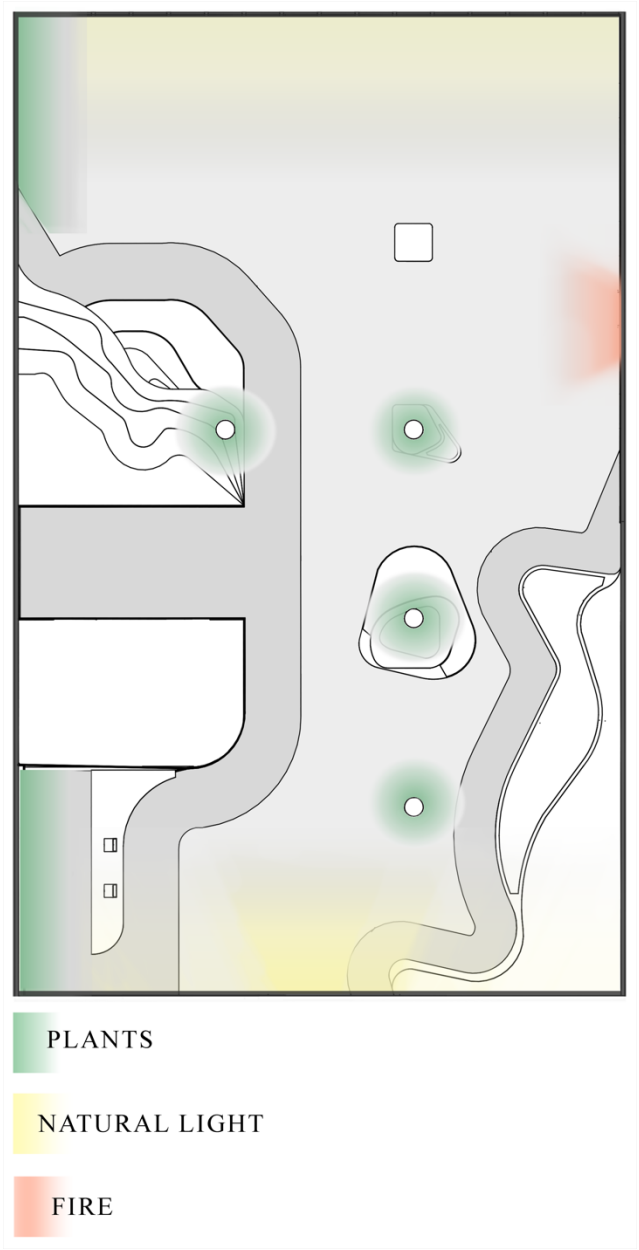

Figure 8. Areas of the lobby in which direct connections to nature were integrated. The level of natural detail in these areas was increased in the higher-complexity designs.

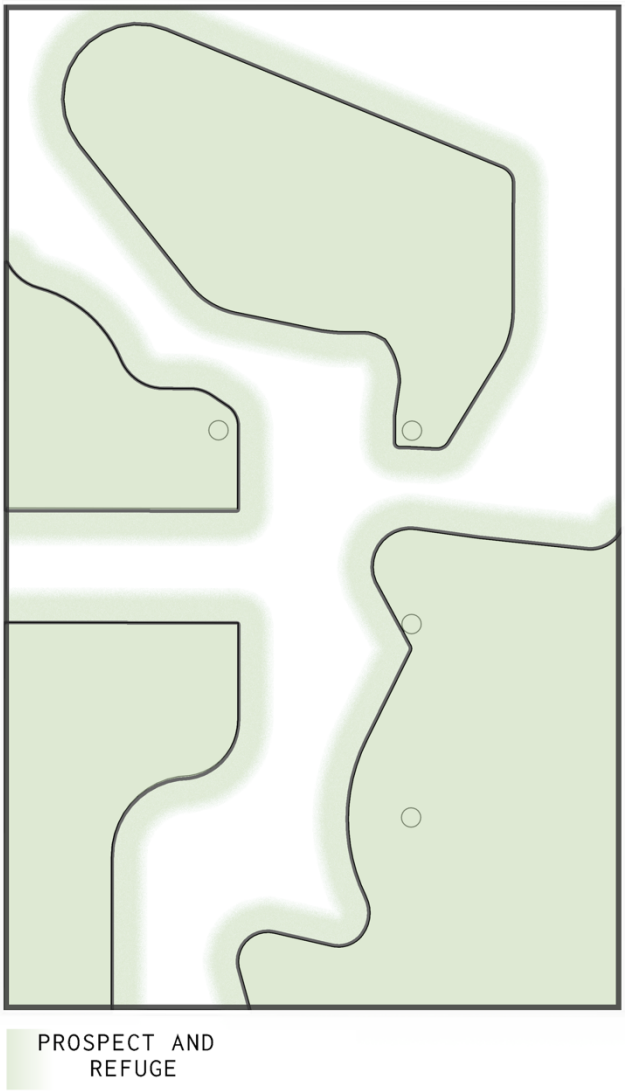

Figure 9. Sightlines related to Prospect and Refuge in the hotel lobby design. The level of refuge was increased in the higher-complexity designs.

Figure 10. Rendering of the Low-Complexity hotel lobby (Variety x1).

Figure 11. Rendering of the Medium-Complexity hotel lobby (Variety x2).

Figure 12. Rendering of the High-Complexity hotel lobby (Variety x3).

Previous studies on attention restoration have shown that offering participants a conceptual scenario involving mental fatigue can help them to better consider and evaluate the potential restorative value of an environment. Such scenarios generally involve asking the participants to imagine that they have been working on some kind of project for a long period of time. For the current study, we adapted a scenario that was originally devised by Staats, Kieviet, and Hartig (2003, p. 150). The scenario used by these previous researchers was changed slightly since it was originally oriented toward students, and the current study included a broader range of participants. The text the participants read for every scenario that was presented in the current study was as follows: *Lately, you have worked intensely. Now, at the end of an important submission, you really have had it. You have difficulty concentrating and are very irritable* (Staats, Kieviet, & Hartig, 2003).

Procedure of the Experiment

Data was collected between April 8, 2019 and April 30, 2019. Data was collected in room 495 of McNeal Hall at the University of Minnesota and at the 2019 IMPACT regional Midwest USGBC conference in Saint Paul, Minnesota. A clear space in which participants could freely walk was created in the middle of the room, defined by blue tape on the floor. Two HTC Vive base stations were placed on opposing corners of the defined floor space. These base stations help the computer system to define the area and to locate the associated VR goggles and hand-held controllers within that defined space. Participants were able to explore the virtual hotel lobby through body movements and hand gestures (Figure 13).

Figure 13. A study participant exploring the virtual hotel lobby using VR goggles and hand-held controllers.

The experiment was conducted with one participant at a time. Upon arriving for the experiment session, each participant first read and signed the consent form (Appendix I). The participants were also informed verbally that they could stop the experiment at any time and for any reason. Ensuring that participants feel comfortable stopping the experiment is vital for studies that incorporate virtual-reality tools, because some people can experience motion sickness or other ill effects while using this technology. After the consent process, the participants next filled out the FAS questionnaire, providing data about their mental fatigue level at the start of the experiment. They were then provided with the written experiment scenario, as discussed in the previous section. After reading the scenario, the participants donned the VR goggles and were allowed to freely explore the hotel lobby design that was randomly assigned to them (one of the three possible design options). Participants were given as much time as they desired to explore the virtual hotel lobby.

After each participant indicated that they were finished exploring the hotel lobby, the researcher read the questions from the PRS to the participants and obtained their verbal responses. The participants were still immersed in the virtual environment during this time, which allowed them to directly view the environment while answering the PRS questions about the lobby's perceived restorative potential. Finally, when the PRS questionnaire was complete, the participants removed the VR equipment. They were then asked to fill out the written, researcher-created questionnaire asking about their view of the lobby design's complexity and their rating of its quality. This final questionnaire also asked for demographic data about the participants.

Virtual Reality as a Research Platform

Particular attention needs to be given to the use of virtual reality as a research tool in this study design. The growing popularity of VR for both entertainment and professional purposes has led to drastic advances in this technology over the past few years. Today's immersive VR equipment is increasingly robust, effective, realistic, and inexpensive. Scholars in many different fields have discovered the potential of VR, and have applied it in a variety of research and teaching-related contexts. For example, the University of Minnesota College of Design faculty are working on a project, "VR Book Club," using VR as a tool to experience exhibitions of the Goldstein Museum of Design (GMD). The "VR Book Club" project aimed to provide low-income elderly residents of Episcopal Homes Senior Housing and Care Services with accessible solutions to discover the exhibitions of GMD (Narigon, 2018).

Most relevant to the current study, VR's immersive, three-dimensional environment can provide a vastly superior encounter with a design concept when compared to the traditional research method of exposing participants to images or flat-screen computer simulations in order to obtain their feedback about a design (Lindsey & McLain-Kark, 1998). Virtual reality allows users to experience an environment with their entire visual perceptual system, to move through it fluidly and at will, and in some cases to interact with it in a dynamic fashion. While this is not entirely equivalent to real-life immersion, it is far superior to looking at a static image of a design. At the same time, this approach allows researchers to obtain feedback about designs without the tremendous investment that would be required to physically construct the design in

reality. The use of virtual environments can allow for a very precise isolation and adjustment of design variables, in a way that would be extremely difficult, expensive, and time-consuming to perform in the actual world.

Thus, although caution must always be used when generalizing results from virtual to real environments, the use of VR can provide a valuable tool that is equal to or in some cases superior to long-established research techniques in the design field. In some cases it allows important studies to be conducted that would simply be impossible without the use of this technology. Researchers have found that human cognitive, emotional, and behavioral responses to virtual environments can be very similar to responses in identically designed real environments (Lindsey & McLain-Mark, 1998; Yin et al., 2018). In one of the recent studies, Yin and colleagues (2018) found that participants have similar physiological and cognitive response towards virtual and real biophilic indoor environments. Results of Yin and colleagues' (2018) study supports the validity of VR as an alternative research tool. Some of the research in the area of biophilic design even suggests that immersion in nature-oriented VR environments can provide some of the same health benefits and feelings of connection to nature as an actual real-world biophilic design (Downton, Jones, Zeunert, & Roös, 2017).

There are, however, some downsides to the use of VR. This technology generally does not include tactile, olfactory, or gustatory (taste) components, and it will never be able to fully recreate the level of detail and interrelationship that is present in an actual physical environment. Thus, the research results derived from VR must always be considered provisional when applied to real-world contexts. In addition, VR poses some

specific risks to research participants. Mild motion sickness is a commonly reported side-effect of virtual immersion, and in some cases this may develop into more significant nausea or dizziness. In very rare cases the visual displays of VR have incited seizures in individuals who suffer from epilepsy. Researchers and participants in VR-based studies need to be aware of these potential risks, and should be prepared to stop the experiment if any negative impacts are perceived. Heydarian and Becerik-Gerber (2016) found that experiences of visual strain, motion sickness, and generalized discomfort were correlated with the time of exposure to VR; after about 20 minutes of sustained immersion the prevalence of these symptoms began to increase significantly. Thus, researchers who make use of VR environments would be advised to end the experiment or provide significant breaks after 15 to 20 minutes of exposure. During the data collection of the current study researcher did not impose any time limit. Overall none of the participants spend more than 5 minutes to explore the hotel lobbies.

Data Analysis

Data obtained in the experiment were analyzed using the IBM SPSS (Statistical Package for the Social Sciences) program. The statistical techniques used to evaluate the study's hypotheses included one-way analysis of variance (ANOVA), independent samples t-tests, Pearson correlation, the Mann-Whitney *U* test, and Cronbach's Alpha.

One-way ANOVA is a commonly used statistical test that determines if the mean (average) responses from two or more independent groups are significantly different from each other (Howell, 2009). In the current study, one-way ANOVA was used to compare the responses given by three participant groups who each experienced a different hotel

lobby design. This test was used to evaluate potential differences in these three groups' perceived restoration (PRS) responses and, separately, in their self-reported environmental preferences. A one-way ANOVA test was also used to determine if there was a statistical difference between the participants' evaluation of the lobby designs' complexity level vs. the researcher-designated complexity levels.

Independent samples t-tests are similar to ANOVAs, but they are relatively simplified. This statistical test compares only two independent groups, and it works best when the sample sizes of the two groups are roughly equivalent (Ross & Willson, 2017). In the current study, an independent samples t-test was used to determine if there were significant differences in perceived restoration (PRS) between the participants who identified as men vs. those who identified is women. Another independent samples t-test was used to determine if there were significant differences in perceived restoration (PRS) between the participants who had previous VR experience vs. those who did not have any previous VR experience.

Pearson correlation is a statistical test that is used to measure the linear relationship between two variables (Kirch, 2008). The results of the correlation can range from +1 (total positive linear correlation) to 0 (no linear correlation) to -1 (total negative linear correlation). If the result is closer to +1 or -1 this indicates that the linear relationship is stronger, compared to a result that is closer to 0 (Kirch, 2008). In the current study, a Pearson correlation test was used to evaluate the relationship between the participants' self-reported environmental preferences and their perceived restoration scores (PRS). In addition, Pearson correlation was used to evaluate the relationship

between the moderating variable of mental fatigue level and the perceived restoration scores (PRS).

The Mann-Whitney *U* test is a non-parametric version of the t-test that is used as an alternative when the data doesn't meet the distribution requirements of standard t-tests (McKnight & Najab, 2010). Similar to t-tests, it is used to identify statistical differences in the responses of two independent groups. In the current study, a Mann-Whitney *U* test was conducted to determine if there were significant differences in perceived restoration (PRS) between the participants who had prior experience in design professions vs. those who were non-designers. Since the sample size for designers was relatively small ($n<30$), a Mann-Whitney U test was preferable to a standard t-test to evaluate this relationship.

Finally, Cronbach's Alpha is a statistical measurement of reliability, which indicates the internal consistency of a questionnaire's results. It can range from 0 to 1, with higher numbers indicating greater reliability. A Cronbach's Alpha of 0.70 or greater is generally considered acceptable, while 0.80 or greater is considered to be optimal. In the current study, Cronbach's Alpha was evaluated for the results of the FAS instrument and, separately, for the results of the PRS instrument. This test can help to confirm that the questionnaires are accurately measuring the intended variables, rather than just random noise.

CHAPTER 4: RESULTS AND DISCUSSION

Introduction

The first part of this chapter presents the findings of the statistical data analysis, along with their implications for the study's hypotheses. Then, the following discussion evaluates some of the larger ramifications of the findings in the context of the research questions, and compares these findings with the results of previous studies.

Findings

Organized Complexity and Perceived Attention Restoration

The primary focus of the study was to analyze the difference in perceived restorative potential between low-complexity, medium-complexity, and high-complexity designs in the context of a hotel lobby. The dependent variable of restorative potential was operationalized using the Perceived Restorativeness Scale (PRS) developed by Hartig, Kaiser, and Bowler (1997). Possible PRS scores range from 0 (low) to 96 (high).

The mean PRS rating was 77.27 (SD=11.501) for the low-complexity hotel lobby design; 70.61 (SD=13.647) for the medium-complexity design; and 74.20 (SD=12.458) for the high-complexity design. A one-way ANOVA test was conducted to statistically evaluate these results, with the finding of no statistically significant differences among these PRS scores (Appendix J, Tables J1 and J2). Therefore, the findings of the study do not provide support for Hypothesis 1. Perceived restorative potential was not significantly greater in the hotel lobby design that used medium levels of organized complexity (Figure 14).

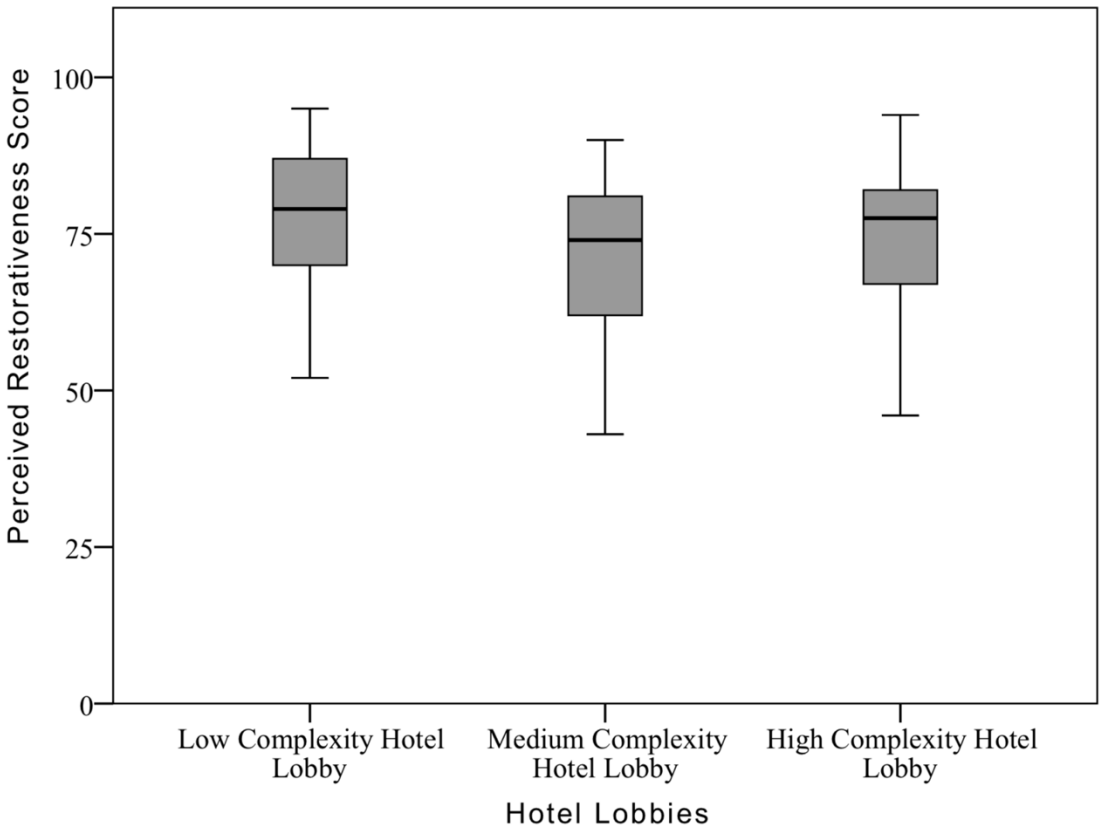

Figure 14. PRS scores for the three hotel lobby designs. An ANOVA test indicated no statistically significant differences in these scores.

Organized Complexity and Environmental Preferences

The dependent variable of self-reported environmental preferences was operationalized using a Likert-scale questionnaire developed by the researcher. Ratings on this scale ranged from 1 ("Do Not Like It At All") to 5 ("Like It Very Much"). The mean preference rating was 4.47 (SD=0.681) for the low-complexity hotel lobby design; 4.32 (SD=0.871) for the medium-complexity design; and 4.43 (SD=0.774) for the high-complexity design. A one-way ANOVA test was conducted to statistically evaluate these results, with the finding of no statistically significant differences among these environmental preference scores (Appendix J, Tables J3 and J4). Therefore, the findings

of the study do not provide support for Hypothesis 2. Self-reported environmental preference was not significantly greater in the hotel lobby design that used medium levels of organized complexity (Figure 15).

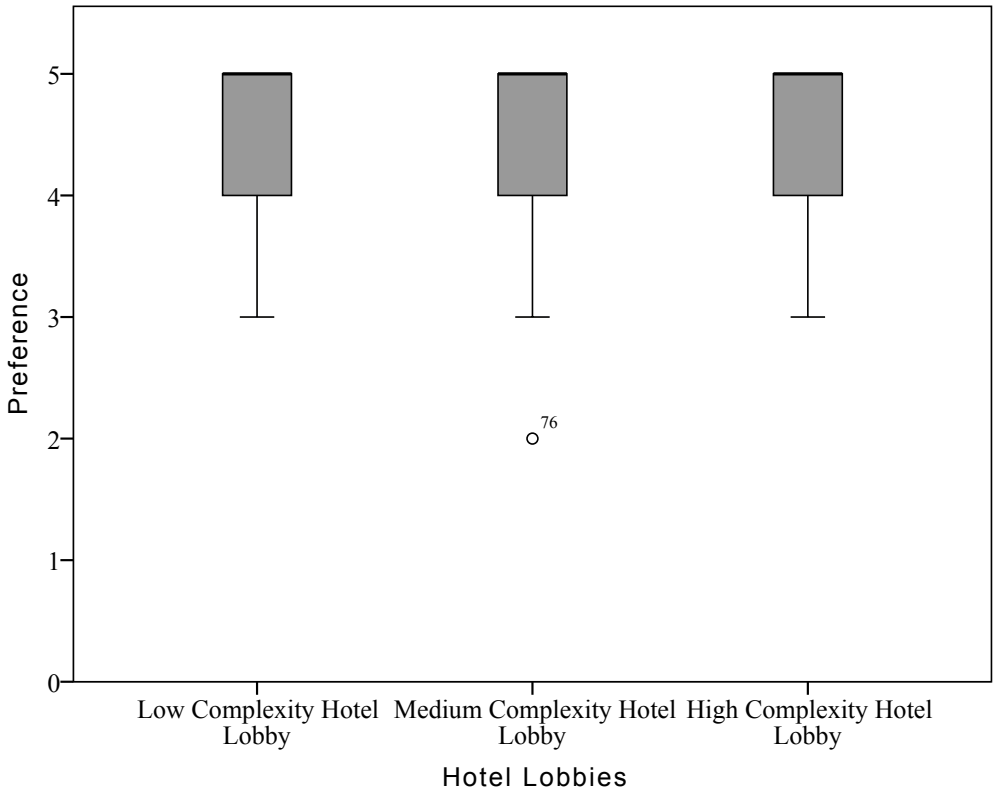

Figure 15. User preference scores for the three hotel lobby designs. An ANOVA test indicated no statistically significant differences in these scores.

Environmental Preferences and Perceived Attention Restoration

A Pearson correlation test was conducted to evaluate the relationship between self-reported environmental preferences and PRS scores. The results indicated that there was a strong linear relationship between these two variables. As the self-reported ratings of the hotel lobby design increased, the mean PRS scores also increased in a predictable

fashion (Appendix J, Tables J5 and J6). These results support Hypothesis 3. There was a positive linear relationship between the perceived restorative potential of the hotel lobby designs and their rating in self-reported user preferences (Figure 16).

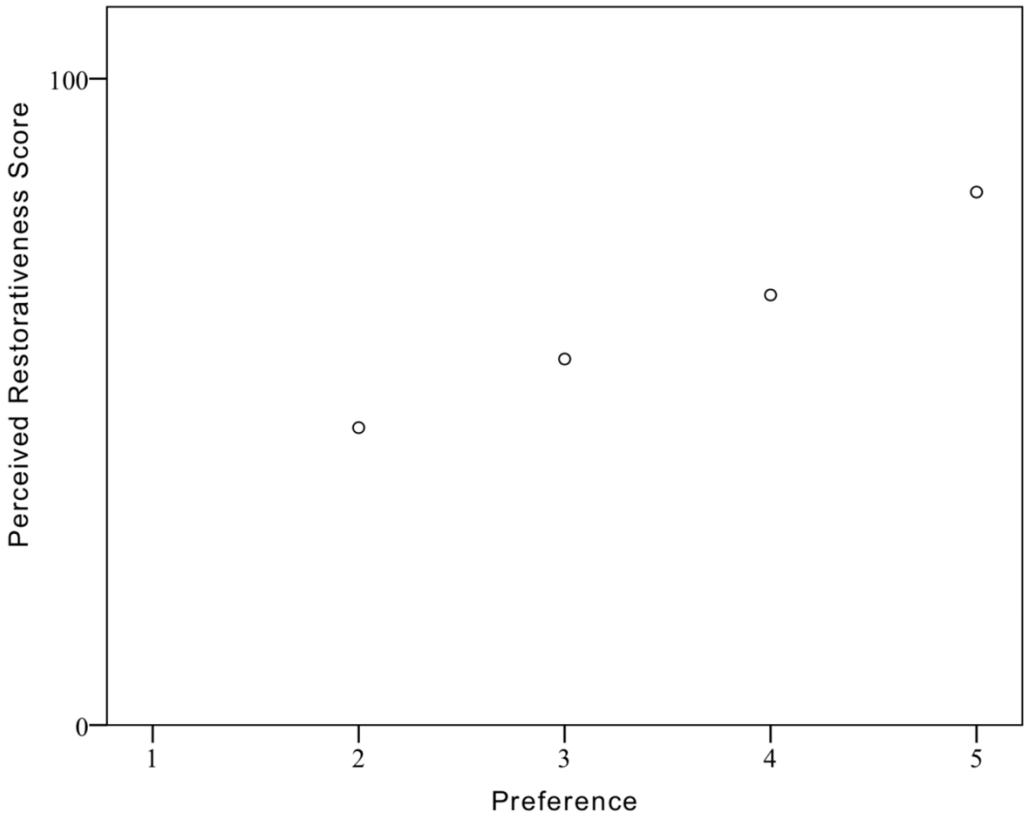

Figure 16. A Pearson correlation test confirmed that there was a positive linear relationship between user preference scores and PRS scores.

To further parse this finding, the four subcomponents of the PRS score, including "being Away," "fascination," "extent," and "compatibility," were also evaluated in relation to the user preference scores. Four separate Pearson's correlation analyses were conducted for this purpose. The results indicated that each of the separate components were also linearly related to user preferences (Table 2).

Table 2.

Pearson's Correlation Results for User Preference Scores vs. Each Subcomponent of the PRS Score

Subcomponent of the PRS Score	Correlation with Self-Reported Preferences	
Being Away	Pearson Correlation	.538**
	Sig. (2-tailed)	.000
	N	91
Fascination	Pearson Correlation	.715**
	Sig. (2-tailed)	.000
	N	91
Extent	Pearson Correlation	.408**
	Sig. (2-tailed)	.000
	N	91
Compatibility	Pearson Correlation	.762**
	Sig. (2-tailed)	.000
	N	91

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

Gender and Perceived Attention Restoration

The mean PRS score for female participants was 76.91 (SD= 11.04), and for male participants it was 69.53 (SD=13.96). An independent samples t-test was conducted to statistically evaluate these results, with the finding of no statistically significant difference between these PRS scores (Appendix J, Tables J7 and J8). Therefore, the findings of the study do not provide support for Hypothesis 4. Perceived restorative potential was not significantly different between participants who identify as men compared and those who identify as women (Figure 17).

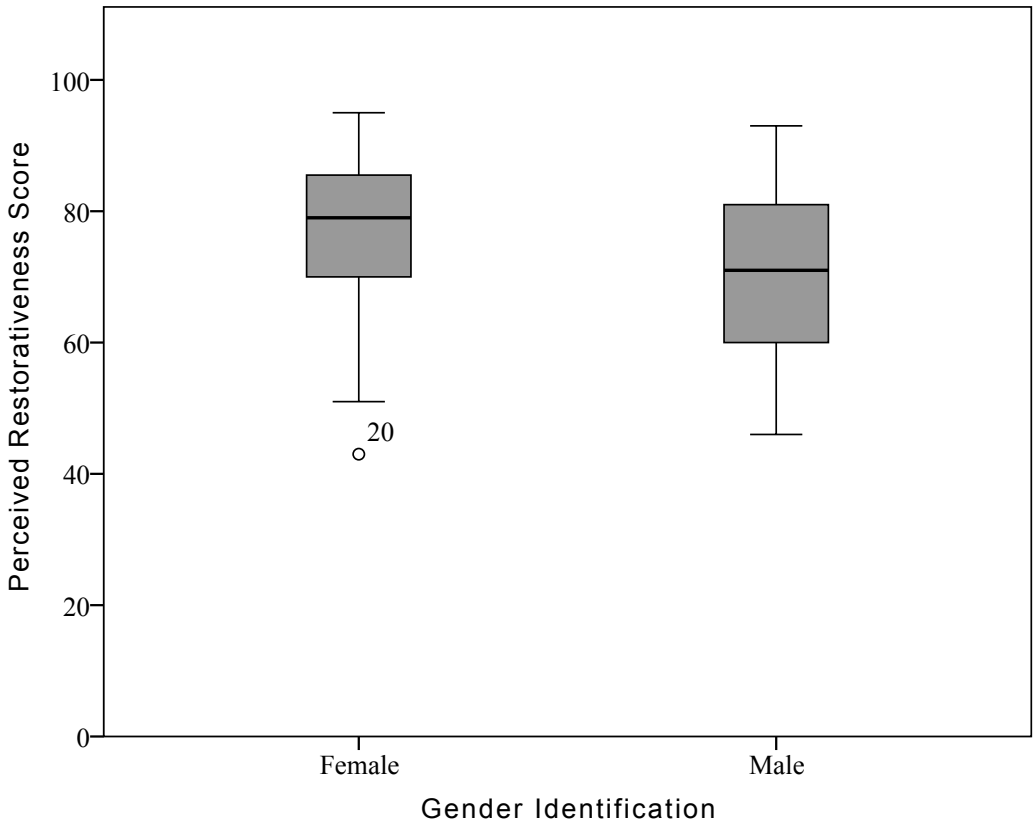

Figure 17. PRS scores for female and male participants. An independent samples t-test indicated no statistically significant differences in these scores.

Mental Fatigue Level and Perceived Attention Restoration

The moderating variable of mental fatigue level, measured at the start of the experiment, was operationalized using the Fatigue Assessment Scale (FAS) developed by De Vries, Michielsen, Van Heck, and Drent (2004). Possible FAS scores range from 10 (low) to 50 (high). A Pearson correlation test was conducted to evaluate the relationship between the participants' FAS scores and their PRS scores, in order to determine if mental fatigue level at the start of the experiment was related to the perceived attention restoration value of the hotel lobby designs. The results indicated that there was not a significant

correlation between these variables (Appendix J, Tables J9 and J10). Therefore, the findings of the study do not provide support for Hypothesis 5. Perceived restorative potential did not have a linear relationship with the participants' mental fatigue level (Figure 18).

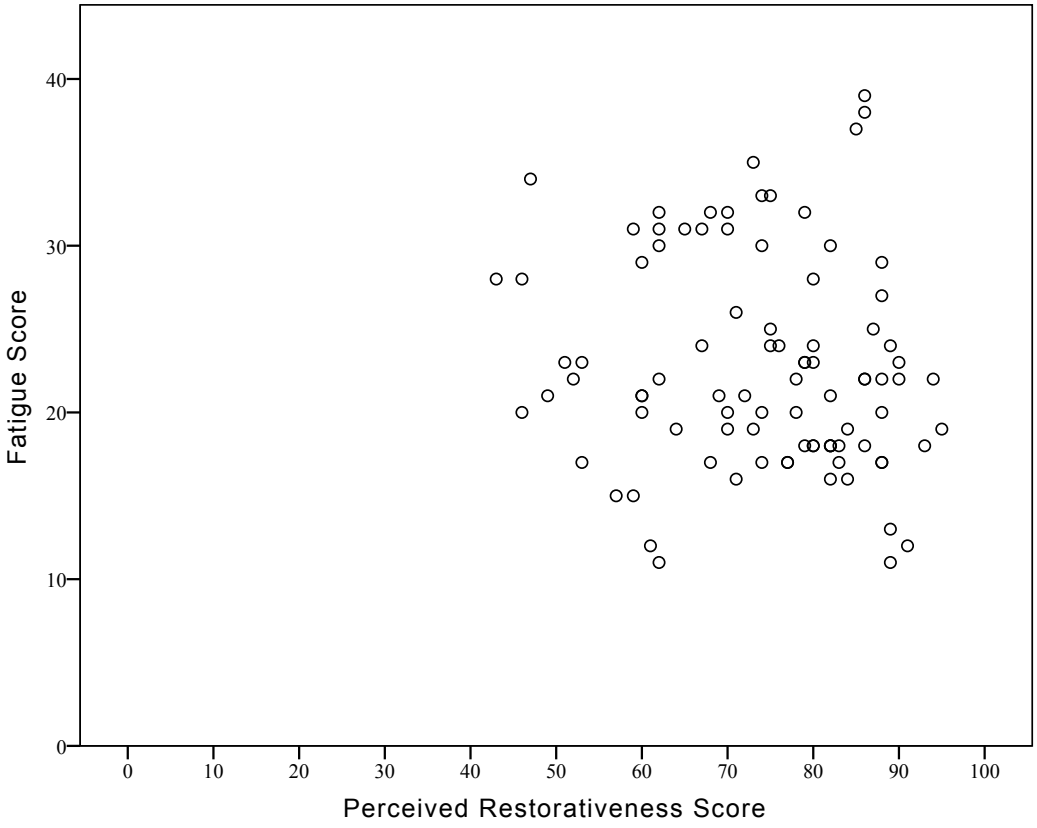

Figure 18. A Pearson correlation test confirmed that there was no linear relationship between FAS scores and PRS scores.

Previous VR Experience and Perceived Attention Restoration

The mean PRS score for participants who had previous experience with virtual-reality immersion was 74.22 (SD=11.85). For the participants who did not have previous VR experience it was 73.20 (SD=13.70). An independent samples t-test was conducted to statistically evaluate these results, with the finding of no statistically significant

difference between these PRS scores (Appendix J, Tables J11 and J12). Therefore, the findings of the study do not provide support for Hypothesis 6. Perceived restorative potential was not significantly greater for participants who had previous VR experience (Figure 19).

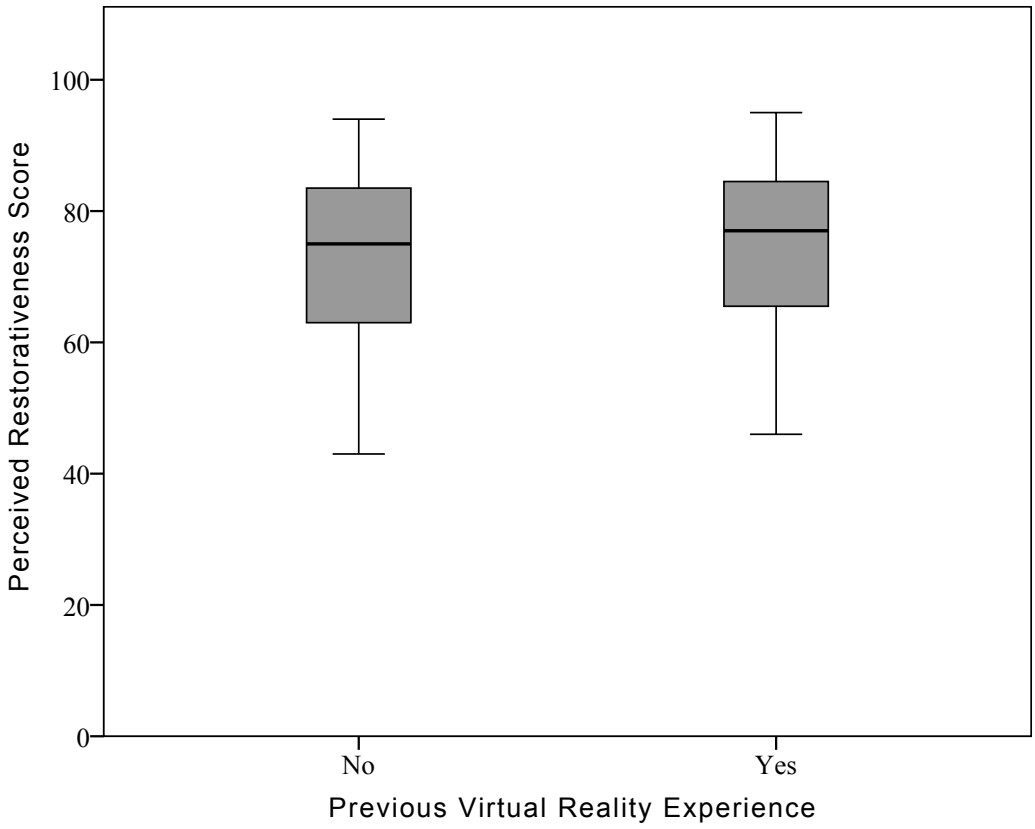

Figure 19. PRS scores for participants with previous VR experience and participants without previous VR experience. An independent samples t-test indicated no statistically significant differences in these scores.

Prior Experience in Design Fields and Perceived Attention Restoration

The mean PRS score for participants who had previous experience in design fields was 72.95 (SD=14.59). For the participants who did not have experience in design it was 74.28 (SD=12.26). Due to the small sample size of designers among the participants

(n=20, 22.0%), a standard t-test would not be a reliable method to evaluate these results. Instead, a Mann-Whitney *U* test was applied to this data. The results of the test indicated that there was no statistically significant difference between these PRS scores (Appendix J, Tables J13 and J14). These results do not support 7, which predicted that there would be a significant difference between designers and non-designers in regard to the hotel lobbies' perceived restorative potential.

Designated Complexity Levels vs. Perceived Complexity Levels

On the researcher-created questionnaire instrument, the participants were asked to rate the complexity of the hotel lobby environment to which they had been exposed (using a 5-point Likert scale from "Not Complex at All" to "Very Complex"). A one-way ANOVA test was conducted to determine if these participant ratings of complexity were significantly different from the way in which the researcher had categorized the three designs. The researcher's categorizations were compared against the mean (average) complexity rating of the participants for each lobby design. Unexpectedly, the ANOVA test found that there were statistically significant differences between the researcher's complexity categories and the participant's complexity ratings (Appendix J, Tables J15 and J16).

As a result of this finding, the researcher decided to investigate the relationship between perceived complexity and perceived restorative benefits (PRS). This was not an aspect of the original research design, but the collected data offered an opportunity to evaluate it as an emerging topic. A Pearson correlation test was used to understand if there is a significant correlation between perceived complexity and perceived restoration.

The results indicated that there was a weak, but significant, positive linear association between the perceived complexity of the hotel lobby designs and their perceived restorative potential (Appendix J, Table J17) (Figure 20). An additional Pearson correlation test was conducted to evaluate the relationship between perceived complexity and self-reported environmental preferences. This test also indicated a significant positive linear association (Appendix J, Table J18) (Figure 21).

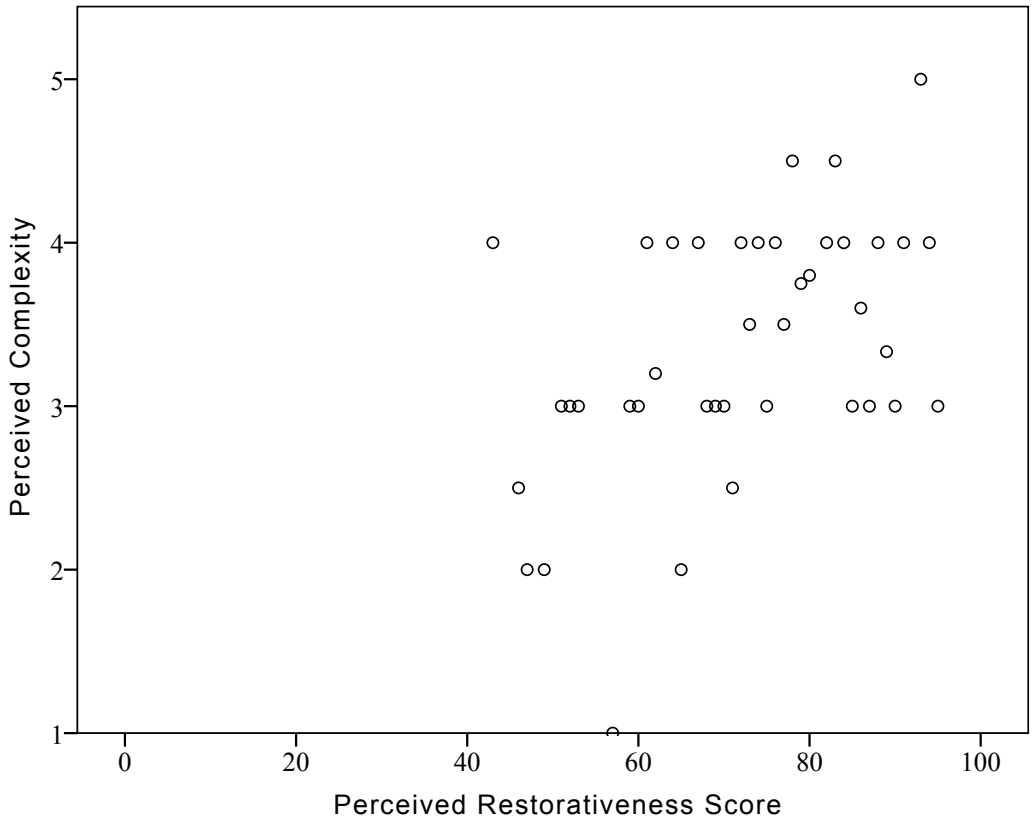

Figure 20. A Pearson correlation test confirmed that there was a positive linear relationship between the perceived complexity of the design and PRS scores.

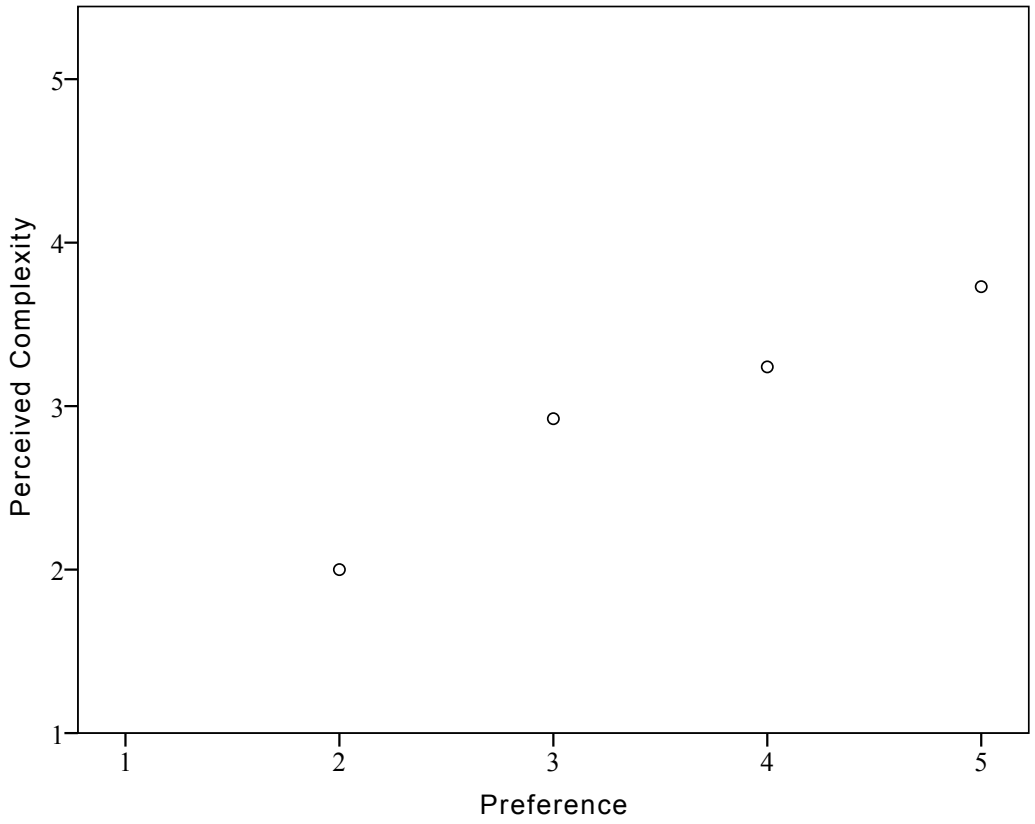

Figure 21. A Pearson correlation test confirmed that there was a positive linear relationship between the perceived complexity of the design and user preference scores.

Instrument Reliability

Reliability tests were carried out for the results of the PRS and FAS questionnaires. For the PRS, the Cronbach's Alpha rating was 0.90, and for the FAS it was 0.87. In both cases, all of the items on the questionnaires appeared to result in a decrease of the Cronbach's Alpha if they were deleted. These are very strong results and indicate that the PRS and FAS questionnaires had a very high internal consistency (Appendix J, Tables J19 and J20).

Discussion

Primary Findings

Although the theory of organized complexity is included in much of the biophilic design literature, there is very little previous empirical work that documents human effects and user preferences related to organized complexity as an implemented design strategy. In the current study, the researcher hypothesized that the participants' environmental preferences and perceptions of restorative potential related to organized complexity would follow an inverted U-shaped curve, with medium levels of complexity having the greatest perceived value. However, the results indicated no statistically significant relationship at all between the objective level of organized complexity in the hotel lobby designs and the participants' perceptions of restorative potential or overall environmental quality (Figures 14 and 15).

This situation changed when the researcher compared *self-reported perceptions of complexity* against perceived environmental benefits. Interestingly, in this evaluation there was a positive statistical relationship—when the participants perceived the lobby designs to have a higher level of complexity, they also rated those designs higher in terms of restorative benefits and overall preferability (Figures 20 and 21). The reasons for these findings are not entirely clear, but it may be that human responses to complexity in design are strongly subjective; in other words, these participant reactions and evaluations may need to be contextualized relative to each individual's personal background and previous experiences. We might speculate that each participant was reacting to the hotel lobby environment in comparison to his or her own personal baseline for expected

organized complexity, and that the evaluations of perceived benefits in the lobby designs were based on how the design deviated from these individual baselines. For a particular lobby design, participants with a low organized-complexity-baseline might perceive high complexity and high benefits—while in the same lobby design other participants with a higher organized-complexity-baseline might perceive lower levels of complexity and lower benefits.

Such an analysis would be commensurate with the positive findings of previous studies of complexity in design, since nearly all of this (limited) prior work used self-reported evaluations of perceived complexity rather than objective design characteristics as the independent variable (Berlyne, 1971, 1974). If this analysis is correct, then it would suggest that designers need to develop a strong awareness of their target audience's baseline environmental expectations, and thereby understand what levels of organized complexity are most effective for different individuals and demographic groups. However, more research would need to be carried out to verify if personal background is indeed a deciding factor in human responses to organized complexity, and to see if any demographic generalizations can be made.

The current study also found that there was a strong positive linear relationship between the participants' scores on the Perceived Restorativeness Scale (PRS) and their preference rankings for the lobby design on the researcher-created questionnaire (Figure 22). This finding was expected, and it is fairly unsurprising, since both of these survey instruments measured the perceived quality of the environment. This finding also agrees

with prior studies that have demonstrated a correlation between PRS scores and expressed environmental preferences (Green, 2017; Purani & Kumar, 2018).

Additional statistical analyses indicated that the participant scores on each sub-element of the PRS — "being away," "fascination," "extent," and "compatibility"—were also positively correlated to the user-preference evaluations (Table 2). The strongest relationship was for the "compatibility" score, which measures how familiar the design feels in the context of a respondent's personal and cultural background (Hartig, Kaiser, & Bowler, 1997; R. Kaplan & Kaplan, 1989). These PRS sub-component results therefore also support the conclusion that subjective preferences and personal background ("compatibility") is a central factor in the participants' reactions to the hotel lobby designs.

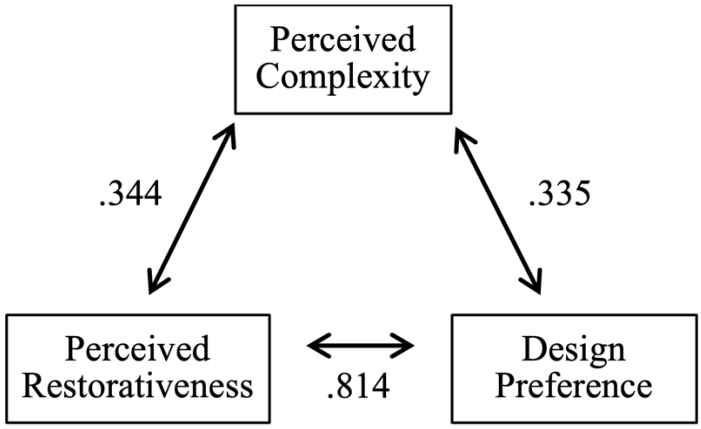

Figure 22. Pearson correlation coefficients showing the relationships between perceived complexity, perceived restorativeness (PRS), and design preferences. The correlation between the two measurements of environmental quality (PRS and design preference) is very strong at r=0.814. The correlations between each of these measurements and perceived design complexity have a relatively weak effect size (but are still statistically significant).

Moderator Variables

The data analysis examined several demographic factors as potential moderator variables to determine if they were related to the participants' scores on the Perceived Restorativeness Scale (PRS). The first of these factors was gender. Previous studies have indicated that there may be gender differences in human responses to biophilic design; however, these prior research results are limited and somewhat contradictory. For example, Kweon and colleagues (2008) found that images of natural scenery had a soothing effect on office employees who identified as men, but had no significant effect on those who identified as women. Conversely, Shibata and Suzuki (2004) reported that the addition of indoor plants in an office environment improved women's task-performance, but had no similar effect on men's task-performance.

In an attempt to contribute to this complex literature, the current study investigated the participants' gender as a potential moderator variable for the perceived restorative benefits of organized complexity in a hotel lobby design. While the participants who identified as women reported (on average) slightly higher perceptions of environmental restorativeness compared to men on the PRS instrument, these gender differences were not large enough to be statistically significant (Figure 16). Therefore, the study findings do not provide any conclusive evidence about gender differences in human responses to organized complexity. In future studies researchers may want to consider gender *in combination with* other demographic variables (ethnicity, nationality, age, income level, urban/rural background, etc.) to provide a more nuanced exploration of

how these personal background factors may affect human responses to various biophilic design strategies.

Another potential moderator variable that was examined in the current study was the participants' prior experience with virtual-reality environments. Munafo and colleagues (2017) found that the frequent use of VR technology had an acclimatization effect, with regular users expressing a greater sense of comfort during VR immersion. Therefore, in the current study the researcher tested to see if prior VR experience was related to greater perceived restorativeness as the participants explored the hotel lobby designs using this technology. The results did not indicate a statistically significant relationship between the participants' prior VR use and their PRS scores.

Similarly, the researcher analyzed prior experience in design fields as a potential moderator variable, to determine if such an experience might affect the way in which the participants responded to the hotel lobby designs. The findings indicated no statistically significant relationship between design experience and PRS scores (though it should be noted that the small sample size of designers in the study required the use of a non-parametric statistical test, which is less powerful than a standard t-test, and thus less likely to find a positive result). Finally, the researcher also analyzed mental fatigue levels at the time of the experiment as a possible moderator variable. These results, based on correlating participants' PRS scores with their scores on the Fatigue Assessment Scale (FAS), again yielded no statistically significant findings.

Overall, then, none of the potential moderator variables that were evaluated in this study could be shown to have a significant effect. It is entirely possible, however, that

some combination of these or other demographic variables could still be found in future work to mediate human responses to organized complexity. Since the participants' individual perceptions of complexity levels in the environment, and the "compatibility" of the environment with the participants' personal backgrounds, emerged in the study as the most significant variables, it is logical to consider that more in-depth research on various demographic features could potentially provide meaningful insights. Age, ethnicity/race, education level, income level, rural/urban backgrounds, personal experiences with nature, and various other important individual factors were not considered in the current research. It is likely that a better understanding of human responses to implementations of organized complexity could be identified through a more extensive and careful intersectional analysis of such demographic features.

CHAPTER 5: CONCLUSION AND BROADER IMPLICATIONS

This research study focused on the biophilic design strategy of "organized complexity" and its relationship to perceived attention restoration and user preferences in a hotel lobby setting. The literature review revealed a notable lack of prior empirical evidence about implementations of organized complexity in design and the resulting human outcomes. Although biophilic design is becoming increasingly influential in hotels and other service environments, and many aspects of this design approach have been previously shown to contribute to human health and well-being, studies that focus specifically on the organized complexity strategy in biophilic design have been sparse and extremely limited in their methods. To help fill this gap and provide more evidence about human responses to organized complexity, the current study sought to answer the following research questions:

RQ1. Will the hotel lobby designs tested in this study have a greater perceived restorative potential if they integrate higher levels of organized complexity?

RQ2. Will the hotel lobby designs tested in this study be rated more highly in self-reported user preferences if they integrate higher levels of organized complexity?

RQ3. Will there be a relationship between the perceived restorative potential of the hotel lobby designs and their rating in self-reported user preferences?

RQ4. Will there be a gender difference in the reported restorative potential of the hotel lobby designs?

RQ5. Will participants' mental fatigue levels at the time of the experiment affect their perceptions of restorative potential in the hotel lobby designs?

RQ6. Will participants' prior experience with virtual reality affect their perceptions of restorative potential in the hotel lobby designs?

RQ7. Will participant's prior experience studying or working in design professions affect their perceptions of restorative potential in the hotel lobby designs?

A convenience sampling method was used to recruit 91 participants, who were randomly assigned to one of three different design conditions: low-complexity, medium-complexity, or high-complexity, based on the objective level of organized information present in the environment. The implementation of organized complexity in these designs was based on established techniques in the biophilic design literature, and the designs were finalized based on feedback from five expert professionals with extensive experience in biophilic design. Each study participant engaged with one of the three lobby designs using a virtual-reality (VR) presentation system, and was asked to complete various survey instruments that measured responses to and evaluations of the environment.

The results of the study did not indicate any statistically significant relationship between the objective levels of organized complexity in the hotel lobby designs and the participants' responses to those designs (Research Questions 1 and 2). Interestingly, however, when the objective level of complexity in this analysis was replaced by self-reported levels of perceived complexity, there was a positive statistical correlation with both perceived restorativeness and user preferences. In other words, when the participants

rated the environments as more complex, they also responded more positively to those designs. The significance of this result cannot be entirely elucidated without further study, but it seems likely that different participants may have different subjective baselines for expected or "normal" design complexity. This would explain why they did not respond in a consistent fashion to the different objective complexity levels, while at the same time expressing preferences that were positively correlated with their subjective evaluations of the design complexity. More research will need to be carried out to determine if this interpretation can be confirmed.

The study results also indicated that participants' scores on the Perceived Restorativeness instrument (PRS) were strongly positively correlated with their preference ratings for the designs (on a Likert scale ranging from "Do Not Like It At All" to "Like It Very Much"). While this correlation does not prove that higher perceived restorativeness caused higher preference ratings, it does support the view that these two types of positive reactions to the environment tend to co-occur (Research Question 3). In addition, the PRS scores can be broken down into different sub-components. Of all the sub-components, the factor of "compatibility"—measuring how familiar the design feels in the context of a respondent's personal and cultural background—was most strongly correlated to the preference ratings. This correlation provides further evidence that each participant's reaction to organized complexity in design may depend strongly on his or her personal background, expectations, and sense of familiarity.

Several demographic variables were analyzed to determine if they were significantly related to participants' PRS scores. The researcher evaluated gender, prior

VR experience, prior experience in design fields, and mental fatigue level at the time of the experiment. None of these variables proved to be statistically significant in the current study. However, there are many other personal and demographic variables that could be investigated in this regard, such as participants' age, ethnicity/race, education level, income level, rural/urban backgrounds, personal experiences with nature, and so forth. Comparing these demographic variables in an intersectional sense, for example analyzing the responses of urban women vs. rural women, could potentially yield further insights about the factors that influence personal responses to organized complexity and other components of biophilic design.

Broader Implications

There are several important implications of this study for biophilic design. First and foremost, the literature review and current study findings indicate that our understanding of certain design strategies or elements that are included in biophilic design theory may need to be further developed and placed on stronger empirical footing before we can implement these design strategies with confidence. There is a fairly solid basis of evidence for some biophilic design practices, particularly those related to direct connections to nature (natural views, natural light, immersion in ecologically vibrant environments, etc.). For other, more indirect biophilic design strategies such as organized complexity, however, the evidence about human benefits and optimal design implementations is less robust.

The current study showed that higher levels of *perceived complexity* were weakly (but significantly) correlated with more positive responses to a hotel lobby design. This

indicates that the topic of organized complexity merits consideration and continued inclusion in biophilic design practices. As a design strategy, organized complexity can be particularly useful to support mental restoration and human well-being in settings where direct connections with nature are not feasible to implement. At the same time, however, the current lack of robust research findings means that a much better understanding is needed about the human impacts of organized complexity and how to implement this design strategy in a way that provides maximum benefits to intended users. The finding that *perceived complexity* of the design was more significant than objective measurements of information-richness, and the finding that "compatibility" with a participant's personal and cultural background was strongly correlated to the design ratings, suggest that responses to indirect biophilic design strategies such as organized complexity may be highly dependent on demographic factors.

The positive correlation between perceived design complexity and environmental preferences in this study does suggest that applications of this design strategy in hotel lobby contexts can make the environment more attractive to potential customers—assuming an implementation that is correctly tailored to the needs of the intended hotel users. This finding is consistent with prior research that has shown people prefer to spend more time in biophilic hotel lobbies than in conventional hotel lobbies (Green, 2017). There is ample evidence to suggest that biophilic design in general can help hotels to increase their revenue and popularity, while also providing meaningful value for customers and employees. The findings in this study also suggest, however, that these

designs can be most successful if they are carefully adapted to the pre-existing preferences and cultural expectations of the intended hotel users.

Limitations

The use of a convenience sampling method in selecting the participants for this study means that the findings may not be representative of the population as a whole. In addition, all of the participants were located in the Minneapolis–Saint Paul metropolitan area, so particular caution must be used in generalizing the results to other geographical regions, especially internationally. The population sample of 91 individuals was large enough to conduct statistical analyses, but it would have been preferable to include a greater number of participants. Small sample sizes and convenience sampling increases the likelihood of inaccurate findings and false discoveries.

Other important limitations of the study are related to its between-subjects design. This means that each participant experienced and evaluated only one of the three virtual environments. Using this approach allowed the researcher to eliminate any familiarity effects, which would have been a concern if each participant had responded to multiple designs one after the other. However, familiarity effects could have also been mitigated by presenting multiple designs in a random order. The use of a between-subjects study design creates a higher likelihood of introducing confounding variables—for example, if the random assignments unintentionally led one participant group (i.e., one design condition) to have a higher average income level than another participant group. In addition, the study did not include a non-Biophilic-design condition; and it did not allow an opportunity to collect participant baseline data, which could have been accomplished

by exposing each participant to the same non-biophilic design. Finally, the researcher did not collect data to compare the VR results against participant reactions to non-VR environments.

Recommendations for Future Research

One of the most notable results of the current study was the difference that emerged between objective levels of information complexity vs. perceived complexity. Future researchers may want to focus on this issue, to see if the result will be replicated and if it is, what personal/demographic factors may contribute to an individual's baseline perception of "normal" levels of design complexity. A better understanding of this topic could allow designers to develop more sophisticated methods of implementing organized complexity, so that it is suited to the perceptions and expectations of different user demographics. Such a study might integrate a much greater attention to demographic variables (with an accompanying increase in sample size). It might include a non-biophilic design variation, and it might be conducted using a within-subjects study design, thus allowing for the collection of baseline and comparative data for each participant.

Another topic that the current study did not examine is the extent of order/patterns in the environment (for the current study, all designs had the same amount of order, but different levels of information complexity). It would be interesting to conduct a study in which the amount of information in the environment was held constant, but different design conditions imposed increasing amounts of order on this information. This would provide additional insights into the effective implementation of organized complexity and

help designers to better understand this biophilic strategy and its human effects. Similar concerns about collecting robust demographic data and individual baseline responses would also apply to such a study.

Finally, more work needs to be done to evaluate other human responses to biophilic design attribute organized complexity (beyond perceived restorativeness), and to expand this knowledge into other settings (beyond hotel lobbies). Researchers may be interested in examining the relationship of organized complexity to factors such as job performance, emotional affect, and long-term health. Some studies in this category would need to be based on ongoing longitudinal studies, real-world immersion in biophilic vs. non-biophilic designs. Additional settings in which organized complexity could be evaluated are quite numerous, ranging from office workplaces, to healthcare environments, to exterior building facades and urban landscapes.

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APPENDICES

APPENDIX A

Table A1.

Ways to integrate biophilia into built environment

Heerwagen & Gregory (2008)	**Hildebrand (2008)**	**Browning, Ryan, & Clancy (2014)**	
Sensory Richness	Complex Order	**Nature in the Space**	Visual Connection with Nature.
Serendipity	Prospect		Non-Visual Connection with Nature.
Variations on a theme	Refuge		Non-Rhythmic Sensory Stimuli.
Resilience	Enticement		Thermal & Airflow Variability.
Sense of freeness	Peril		Presence of Water.
Prospect and Refuge			Dynamic & Diffuse Light.
			Connection with Natural Systems.
		Natural Analogues natural	Biomorphic Forms & Patterns.
			Material Connection with Nature.
			Complexity & Order.
		Nature of the Space nature	Prospect.
			Refuge.
			Mystery.
			Risk/Peril.

APPENDIX B

Recruitment Email

Hello,

I'm Naz Bilgic. I am an Interior Design Graduate student at the University of Minnesota. I am conducting research examining the effects of organized complexity, an attribute of biophilic design, on the restorative potential of hotel lobbies. I am using virtual reality on my research to provide my participants an immersive experience when they are evaluating hotel lobbies.

Research is estimated to take no more than 30 minutes in total. Participants will experience virtual hotel lobbies and answer questionnaires evaluating attention restoration. The research will be conducted in McNeall Hall, Room 495 in Saint Paul Campus of the University of Minnesota. If you want to have more information about the research or you want to participate in this research and help me with my research, please feel free to contact me: bilgi008@umn.edu

Thank you,
Naz Bilgic

Interior Designer | M.S. Student
Interior Design | College of Design
University of Minnesota.

APPENDIX C

IRB Approval

Naz Bilgic <bilgi008@umn.edu>

STUDY00005626 has been approved

1 message

ethosirb@umn.edu <ethosirb@umn.edu> Fri, Feb 22, 2019 at 11:09 AM
Reply-To: ethosirb@umn.edu
To: bilgi008@umn.edu

Template:IRB_T_Post-Review_Approved

Notification of Approval

To:	Naz Bilgic
Link:	STUDY00005626
P.I.:	Genell Ebbini
Title:	Bilgic, N - Restorative Potential of Hotel Lobbies: A Symbiotic Examination of Biophilic Design Through Complexity and Order, and Attention Restoration Theory
Description:	This submission has been approved. You can access the correspondence letter using the following link: Correspondence_for_STUDY00005626 (1).pdf(0.01) To review additional details, click the link above to access the project workspace.

APPENDIX D

Fatigue Assessment Scale (FAS)

The following 10 statements refer to how you lately feel. For each statement you can choose one out of five answer categories, varying from never to always.

	Never (1)	Sometimes (2)	Regularly (3)	Often (4)	Always (5)
I am bothered by fatigue	○	○	○	○	○
I get tired very quickly	○	○	○	○	○
I don't do much during the day	○	○	○	○	○
I have enough energy for everyday life	○	○	○	○	○
Physically, I feel exhausted	○	○	○	○	○
I have problems to start things	○	○	○	○	○
I have problems to think clearly	○	○	○	○	○
I feel no desire to do anything	○	○	○	○	○
Mentally, I feel exhausted	○	○	○	○	○
When I am doing something, I can concentrate quite well	○	○	○	○	○

APPENDIX E

Perceived Restorativeness Scale (PRS)

	Not at all (0)	(1)	(2)	(3)	(4)	(5)	Completely (6)
It is an escape experience	○	○	○	○	○	○	○
Spending time here gives me a good break from my day-to-day routine	○	○	○	○	○	○	○
The setting has fascinating qualities.	○	○	○	○	○	○	○
My attention is drawn to many interesting things	○	○	○	○	○	○	○
I would like to get to know this place better	○	○	○	○	○	○	○
There is much to explore and discover here	○	○	○	○	○	○	○
I would like to spend more time looking at the surroundings	○	○	○	○	○	○	○
There is too much going on	○	○	○	○	○	○	○
It is a confusing place	○	○	○	○	○	○	○
There is a great deal of distraction	○	○	○	○	○	○	○
It is chaotic here	○	○	○	○	○	○	○
I can do things I like here	○	○	○	○	○	○	○
I have a sense that I belong here	○	○	○	○	○	○	○
I have a sense of oneness with this setting	○	○	○	○	○	○	○
Being here suits my personality	○	○	○	○	○	○	○
I could find ways to enjoy myself in a place like this	○	○	○	○	○	○	○

APPENDIX F

Perceived Complexity and Preference Questions

Please answer the following questions thinking about the hotel lobby you just saw.

"Complexity signifies a setting rich in detail and diversity" (Kellert, 2018, p.91).

Not complex at all	○ ○ ○ ○ ○	Very Complex
Don't like it at all	○ ○ ○ ○ ○	Like It Very Much

APPENDIX G

General Questions

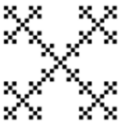
General Questions

Age	
Gender Identification	
Profession	
Frequency of Hotel visits (How many times you visit hotels per year including visits for amenity usage)	
Duration of Hotel stay (How many days you approximately stay in every visit?)	
Do you have previous virtual reality experience? (Yes/No)	
If you have previous virtual reality experience, what type of experience it is? (e.g. : N/A, Games, Another Study, Design, etc.)	

APPENDIX H

Table H1.

Strategies from Literature to Achieve Organized Complexity

Where	Organized Complexity Manipulation Method	How	Low Level of Iteration	Medium Level of Iteration	High Level of Iteration	Result
Floor Plan	Golden Ratio, Fractals (Salingaros, 2010; Ramzy, 2015)	Using partitions, creating sub spaces, floor material changes	Variety x1	Variety x2	Variety x3	Organized Complexity
Interior Design Element	Number of Elements (Berlyne, 1974; Feldman, 1997; Pieters, Wedel, & Zhang, 2007)	Furniture, accessories, different patterns, colors	Variety x1	Variety x2	Variety x3	Complexity
	Variety of Elements (Berlyne, 1974; Feldman, 1997; Pieters, Wedel, & Zhang, 2007)	Furniture, accessories, different patterns, colors	Variety x1	Variety x2	Variety x3	Complexity
	Fractals (Salingaros, 2010, 2012)	Patterns, artwork, partition				Organized Complexity
	Scale (Salingaros, 2010; Ramzy, 2015)	Different height	Variety x1	Variety x2	Variety x3	Universal Scaling

APPENDIX I

Consent Form

Consent Form

Title of Research Study: Restorative Potential of Hotel Lobbies: A Symbiotic Examination of Biophilic Design Through Complexity and Order, and Attention Restoration Theory. HRP-582 – CONSENT FORM - 06252018

Investigator Team Contact Information: Genell W Ebbini

For questions about research appointments, the research study, research results, or other concerns, call the study team at:

Investigator Name: Genell W Ebbini Investigator Departmental Affiliation: DHA Phone Number: 624-5318 Email Address: gebbini@umn.edu	Student Investigator Name (if applicable): Naz Bilgic Phone Number: 612-624-4797 Email Address: bilgi008@umn.edu Study Staff (if applicable): N/A Phone Number: Email Address:

Key Information About This Research Study

The following is a short summary to help you decide whether or not to be a part of this research study. More detailed information is listed later on in this form.

What is research?

- The goal of research is to learn new things in order to help people in the future. Investigators learn things by following the same plan with a number of participants, so they do not usually make changes to the plan for individual research participants. You, as an individual, may or may not be helped by volunteering for a research study.

Why am I being invited to take part in this research study?

We are asking you to take part in this research study because you are the part of researcher's target population which is Minneapolis – Saint Paul Metro Area Residents who are 18 years old or older.

What should I know about a research study?

- Someone will explain this research study to you.
- Whether or not you take part is up to you.
- You can choose not to take part.
- You can agree to take part and later change your mind.
- Your decision will not be held against you.
- You can ask all the questions you want before you decide.

Consent Form

Why is this research being done?

1. In this study, the researcher is going to examine the optimal application of order and complexity, one of the Biophilic Design attributes, through evidence-based design. The goal of the study is to measure the Restorative Potential of hotel lobbies.
2. The aim of this study is to fill the gap in the literature by assessing if there is an impact on the restoration of attention perceived by the users due to the use of order and complexity attribute of Biophilic Design in hotel lobbies.
3. Findings of this study will contribute to the larger body of knowledge in hospitality design; in particular, hotel lobbies. The significance of the study provides a conceptual framework of 'best practices' in designing restorative experiences.

How long will the research last?

The researcher expects that the participation time for each individual will be approximately 30 minutes in total. Surveys will require approximately 15 minutes and exploration of virtual hotel lobbies will take another 15 minutes in total.

What will I need to do to participate?

Participants will read the consent form and sign it before starting the. After the consent form participants are going to answer the Fatigue Assessment Scale. Fatigue Assessment Scale is a questionnaire to assess the current mental fatigue of people. Then participants will read the scenario created by the researcher with the help of the theory to illustrate the mental fatigue. Participants will explore one of the randomly assigned hotel lobby settings using virtual reality goggles. When they state that they are ready and explored enough the researcher will verbally ask the participant questions of the Perceived Restorativeness Scale. The same data collection process will be done three times in the same order for the participant to assess all different hotel lobby settings with different order and complexity levels. After participants are done with the third assigned hotel lobby setting, they will answer the last questionnaire asking them about their preference of these hotel lobby settings and some demographic information.

More detailed information about the study procedures can be found under "What happens if I say yes, I want to be in this research?"

Is there any way that being in this study could be bad for me?

Participants may experience visual discomfort and/or motion sickness during the process of using virtual reality goggles. The physical discomfort that participants may experience can be normally encountered in daily lives of the participants.

What happens if I do not want to be in this research?

There are no known alternatives, other than deciding not to participate in this research study.

Detailed Information About This Research Study

The following is more detailed information about this study in addition to the information listed above.

How many people will be studied?

We expect between 30 to 40 people will be in this research study in the entire study nationally (USA).

What happens if I say "*Yes, I want to be in this research*"?

- You will be contacted by the researcher through email.
- You will come to Room 495, McNeal Hall, the University of Minnesota at the time you scheduled with researcher.
- The researcher will go through the consent form with you. This consent form is for you to understand the process and your rights as a participant of this study. This will take approximately 5 minutes.
- After the consent process you will answer a survey assessing your mental fatigue. This will take approximately 3 minutes.
- You will experience the first virtual hotel lobby and answer the Perceived Restorativeness Scale questions for the first hotel lobby that the researcher asks to you while you're immersed to the virtual hotel lobby. This will take approximately 5 minutes.
- You will experience second virtual hotel lobby and answer the Perceived Restorativeness Scale questions for second hotel lobby that researcher asks to you while you're immersed to the virtual hotel lobby. This will take approximately 5 minutes.
- You will experience third virtual hotel lobby and answer the Perceived Restorativeness Scale questions for third hotel lobby that researcher asks to you while you're immersed to the virtual hotel lobby. This will take approximately 5 minutes.
- Lastly, you will answer one more questionnaire about your preference and demographic information. This will take approximately 5 minutes.
- During the process of participation, you will only interact with the researcher (Naz Bilgic).
- The research will be completed at the end of Spring 2019 semester of the University of Minnesota.

What happens if I say "Yes", but I change my mind later?

You can leave the research study at any time and no one will be upset by your decision.

If you decide to leave the research study, contact the investigator so that the investigator. The investigator will delete participants' information, questionnaire answers from procedures.

What are the risks of being in this study? Is there any way being in this study could be bad for me? (Detailed Risks)

Participants of this study may experience minimal physical discomfort. The physical discomfort that participants may experience can be normally encountered in daily lives of the participants.

Participants may experience visual discomfort, motion sickness, and/or fatigue on their neck or back during the process of using virtual reality goggles. These minimal physical risk and prevention techniques are listed below:

Visual Discomfort	Researcher will introduce experiences gradually by limiting the time the user is exposed to them. Researcher will limit the overall time a user spends on the virtual reality system.
Motion Sickness	Researcher will introduce experiences gradually by limiting the time the user is exposed to them. Researcher will observe the user's reactions whilst they are experiencing and encourage them to discuss their experience during and afterwards.
Weight of the headset	Introduce experiences gradually by limiting the time the user is exposed to them. Limit the overall time a user spends on the virtual reality system.
Infection control	Risks will be minimized by cleaning headset and controllers with antibacterial wipes.

Will it cost me anything to participate in this research study?
Taking part in this research study will not lead to any costs to you.

What happens to the information collected for the research?
Efforts will be made to limit the use and disclosure of your personal information, including research study and medical records, to people who have a need to review this information. We cannot promise complete confidentiality. Organizations that may inspect and copy your information include the Institutional Review Board (IRB), the committee that provides ethical and regulatory oversight of research, and other representatives of this institution, including those that have responsibilities for monitoring or ensuring compliance.

Whom do I contact if I have questions, concerns or feedback about my experience?
This research has been reviewed and approved by an IRB within the Human Research Protections Program (HRPP). To share feedback privately with the HRPP about your research experience, call the Research Participants' Advocate Line at 612-625-1650 or go to https://research.umn.edu/units/hrpp/research-participants/questions-concerns. You are encouraged to contact the HRPP if:

- Your questions, concerns, or complaints are not being answered by the research team.
- You cannot reach the research team.
- You want to talk to someone besides the research team.
- You have questions about your rights as a research participant.
- You want to get information or provide input about this research.

Will I have a chance to provide feedback after the study is over?
The HRPP may ask you to complete a survey that asks about your experience as a research

participant. You do not have to complete the survey if you do not want to. If you do choose to complete the survey, your responses will be anonymous.

If you are not asked to complete a survey, but you would like to share feedback, please contact the study team or the HRPP. See the "Investigator Contact Information" of this form for study team contact information and "Whom do I contact if I have questions, concerns or feedback about my experience?" of this form for HRPP contact information.

Can I be removed from the research?

If a participant experiences motion sickness and states this sickness or the investigator thinks that participant is experiencing motion sickness because of the virtual reality goggles, investigator will stop the study and withdraw the participant from the study.

What happens if I am injured while participating in this research?

This research doesn't involve the potential for injury.

Your signature documents your permission to take part in this research. You will be provided a copy of this signed document.

_____ _____

Signature of Participant Date

_____

Printed Name of Participant

_____ _____

Signature of Person Obtaining Consent Date

_____

Printed Name of Person Obtaining Consent

APPENDIX J

Table J1.

Descriptive Statistic Results of PRS Based on Different Complexity Hotel Lobbies

	N	Mean	Std. Deviation
Low Complexity Hotel Lobby	30	77.27	11.501
Medium Complexity Hotel Lobby	31	70.61	13.647
High Complexity Hotel Lobby	30	74.20	12.458

Table J2.

One Way ANOVA Results for PRS Based on Different Complexity Hotel Lobbies

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	677	2	338	2.14	.124
Within Groups	13924	88	158		
Total	14601	90			

Table J3.

Descriptive Statistic Results of Preference Based on Different Complexity Hotel Lobbies

	N	Mean	Std. Deviation
Low Complexity Hotel Lobby	30	4.47	.681
Medium Complexity Hotel Lobby	31	4.32	.871
High Complexity Hotel Lobby	30	4.43	.774

Table J4.

One Way ANOVA Results for Preference Based on Different Complexity Hotel Lobbies

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.349	2	.174	.286	.752
Within Groups	53.608	88	.609		
Total	53.956	90			

Table J5.

Descriptive Statistic Results of PRS Scores and Preference

	N	Mean	Std. Deviation
PRS Score	91	73.99	12.737
Preference	91	4.41	.774

Table J6.

Pearson Correlation Results for PRS Score and Preference

		PRS Score	Preference
PRS Score	Pearson Correlation	1	.814**
	Sig. (2-tailed)		.000
	N	91	91
Preference	Pearson Correlation	.814**	1
	Sig. (2-tailed)	.000	
	N	91	91

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

Table J7.

Descriptive Statistic Results Based on Gender

	Gender Identification	N	Mean	Std. Deviation
PRS Score	Female	55	76.91	11.047
	Male	36	69.53	13.964

Table J8.

Independent Samples t-test Results Based on Gender

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
PRS Score	Equal variances assumed	4.626	.034	2.804	89	.006
	Equal variances not assumed			2.671	62.728	.010

Table J9.

Descriptive Results of FAS and PRS

	N	Mean	Std. Deviation
FAS Score	91	22.82	6.411
PRS Score	91	73.99	12.737

Table J10.

Pearson Correlation Results for FAS and PRS Scores

		FAS Score	PRS Score
FAS Score	Pearson Correlation	1	-.137
	Sig. (2-tailed)		.197
	N	91	91
PRS Score	Pearson Correlation	-.137	1
	Sig. (2-tailed)	.197	
	N	91	91

Table J11.

Descriptive Statistic Results for PRS Scores Based on Previous VR Experience

	Previous VR experience	N	Mean	Std. Deviation
PRS Score	No	44	73.20	13.709
	Yes	47	74.72	11.857

Table J12.

Independent Samples t-test for PRS Scores Based on Previous VR Experience

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
PRS Score	Equal variances assumed	1.113	.294	-.566	89	.573
	Equal variances not assumed			-.564	85.239	.575

Table J13.

Descriptive Statistic Results of PRS Scores Based on Profession

	Profession	N	Mean	Std. Deviation	Median
PRS Score	Designer	20	72.95	14.584	71.5
	Non-Designer	71	74.28	12.266	77

Table J14.

Non-Parametric Mann-Whitney U Test Results for PRS Scores Based on Different Professions

	Perceived Restorativeness Score
Mann-Whitney U	689.000
Wilcoxon W	899.000
Z	-.201
Asymp. Sig. (2-tailed)	.840

a. Grouping Variable: Design Experience

Table J15.

Descriptive Statistic Results of Perceived Complexity

	N	Mean	Std. Deviation
Low Complexity Hotel Lobby	30	3.90	.803
Medium Complexity Hotel Lobby	31	2.97	1.080
High Complexity Hotel Lobby	30	3.53	.973

Table J16.

One-Way ANOVA Test Results for Perceived Complexity

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	13.481	2	6.740	7.311	.001
Within Groups	81.134	88	.922		

Table J17.

Correlation Results of PRS Scores and Perceived Complexity Ratings

		Perceived Complexity	PRS Score
Perceived Complexity	Pearson Correlation	1	.344**
	Sig. (2-tailed)		.001
	N	91	91
PRS Score	Pearson Correlation	.344**	1
	Sig. (2-tailed)	.001	
	N	91	91

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

Table J18.

Correlation Results of Preference and Perceived Complexity Ratings

		Preference	Perceived Complexity
Preference	Pearson Correlation	1	.335**
	Sig. (2-tailed)		.001
	N	91	91
Perceived Complexity	Pearson Correlation	.335**	1
	Sig. (2-tailed)	.001	
	N	91	91

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

Table J19.

Cronbach's Alpha Results for PRS

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.896	.900	16

Table J20.

Cronbach's Alpha Results for FAS

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.870	.869	10