A Study on Improving the Experience of Space Tourists Through Biophilic Design

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ABSTRACT

With private space companies seeking to send tourists into space in the near future, meeting the needs and demands of future space tourists will become a primary concern. The human factors of space tourism are investigated in tandem with the effects of biophilia. Thus, this dissertation is a study on improving the experience of space tourists through biophilic design. A combination of primary and secondary research methods are carried out; the former consists of literature reviews and case studies, while interviews and surveys were conducted for the latter. Interviews were conducted with individuals who had their freedom of movements curtailed due to the COVID-19 pandemic in 2020. Their experiences of living in a confined environment for an extended period of time would be similar to those of future space tourists. After analysing the results of the research, it is determined that the potential customers of space tourism are compatible with biophilic designs. In addition, these biophilic elements would have to be multisensory in nature to address the monotony faced by space tourists. Furthermore, it is shown that science fiction shapes the perception of space tourism. The forms of these biophilic designs should be informed by science fiction in order to reduce the gap between expectations and reality. Last but not least, space tourism has the potential to reduce alienation between humans and the biodiversity of Earth. This can be achieved through careful design and prioritization of the Earth-viewing experience, thereby maximizing the positive effects of “the overview effect.”

Introduction

Background

In the 21st century, the 'Space Race' has been reignited by the efforts of national space programs and private companies, with NASA aiming to send humans to Mars in the 2030s (Bickerton). Concurrently, private companies such as SpaceX and Boeing are planning to fly tourists into orbit. According to Northern Sky Research, suborbital and orbital tourism would have a market size of $2.8 billion and $610 million by 2028 respectively (Sheetz). These trends and rates of development suggest that space tourism will become a legitimate prospect for the mass market in the near future.

The act of going into space pushes both the technological and psychological limits of mankind. During the 1980s, head of Soviet space medicine Oleg Gazenko, "concluded that the limitations of living in space are not medical, but psychological" (qtd. in Harrison 32). Despite being in space for leisure and for shorter periods of time as compared to career astronauts, space tourists will face greater challenges as they may not be as mentally prepared as their professional counterparts. Living in a confined spacecraft may also lead to side effects such as sensory deprivation and boredom (Cohen 9). Additionally, the physical distance of the man-made spacecraft environment disconnects them from the natural environment of Earth.

According to Wilson's biophilia hypothesis, this mismatch between environments will reflect humans’ emotional state and amplify any existing psychological stresses (Wilson 110). He explained that humans have an innate

preference and connection with elements of nature, due to the environment in which our ancestors had evolved (109). This hypothesis is often applied to designing for the built environment. Biophilic design does not simply mean inserting nature into built environments, but rather it means viewing humans as biological animals as a part of a larger interconnected ecological system, where biophilic elements are integrated to improve health and productivity (Kellert 17). Thus, biophilic design could be applied to tackle the potential psychological issues faced by space tourists.

However, the sole reliance on meeting the psychological needs of space tourists would not be sufficient in sustaining demand. The space tourism industry can only flourish when customer expectations are met. This sentiment was shared by Jane Reifert, President of Incredible Adventures, who commented that gaps between customer expectations and reality would lead to huge disappointments (qtd. in David). Such expectations of space travel and by extension, space tourism, are shaped by the visions of people depicted through science fiction (Westfahl 196). Within these science fiction movies, instances of biophilic elements have appeared to serve as visual metaphors for positivity. These would provide hints on whether the act of incorporating biophilic elements into space tourism is compatible with the expectations of the masses.

Research Objectives

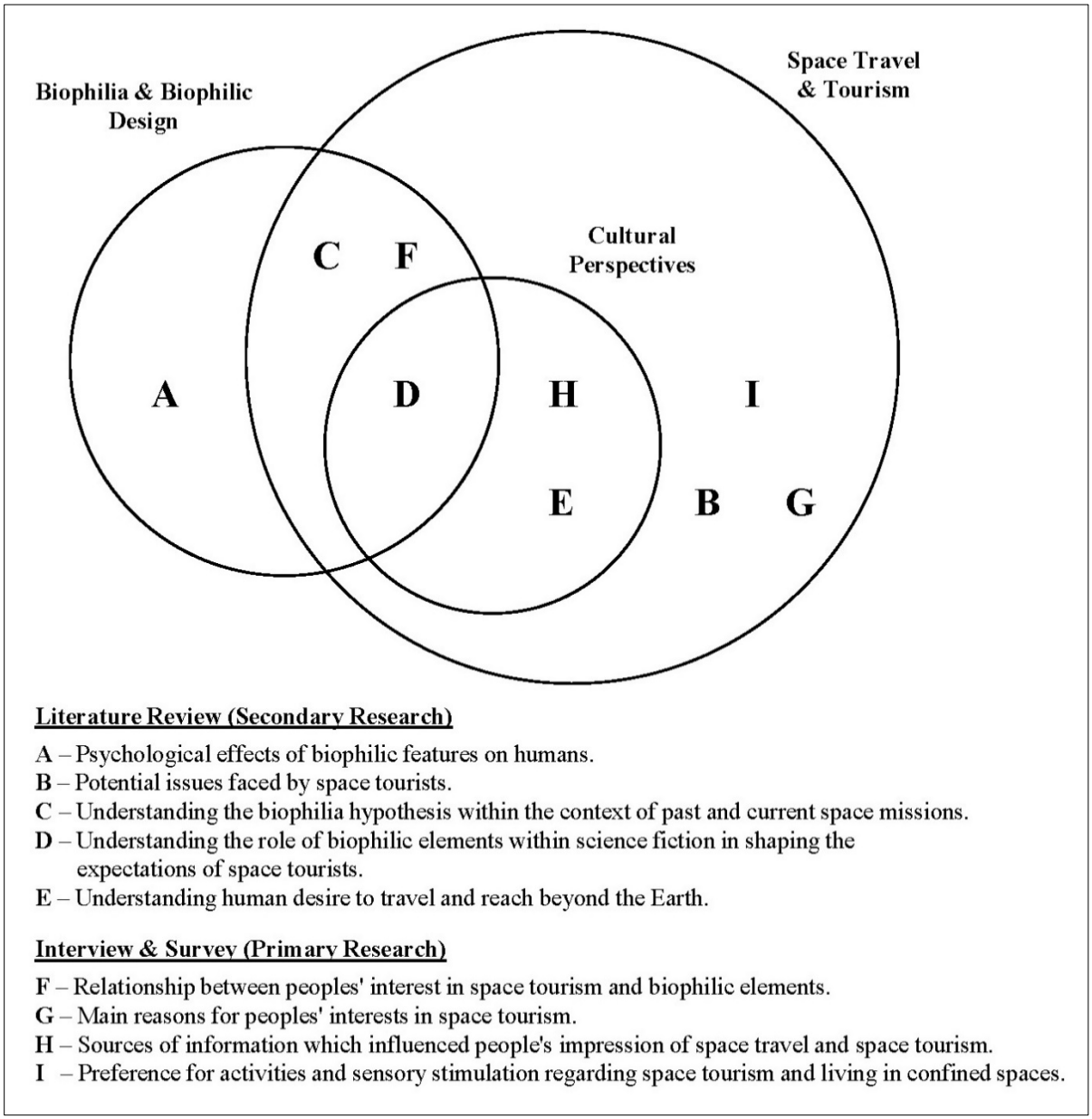

Fig. 1. Structure and content of dissertation.

This dissertation is a study aimed at improving the experience of space tourists through biophilic design. Information would be collected through a combination of primary and secondary research methods. The former would consist of interviews and surveys while the latter, a literature review. In order to assist in understanding this dissertation, a diagram (Fig. 1) has been created to visualize the structure and content. From here, the individual aims of both research methods can thus be categorized into the three main components of this topic; biophilia & biophilic design, space travel & tourism, and cultural perspectives.

Before any attempts to apply biophilic designs to improve the tourists' experiences, both the positive and negative effects needs to be investigated. This would mainly be done through experiments by Roger Ulrich and Charles Montgomery, along with Kaplans' Attention Restoration Theory. Through the primary research, preferences towards

space tourism and biophilic elements would be enquired. Secondly, as humans would be involved in space tourism, there is a need to understand the potential issues faced by tourists. This would be augmented with the primary research, by learning about the concerns of potential customers. Thirdly, the contexts of biophilia and biophilic design researches are mainly based on Earth. Evidences drawn from past and current space missions would be needed to prove that these researches would still be applicable in the context of space. This can only be achieved through secondary research, which would revolve around Frank White's "overview effect" and the biophilic tendencies of astronauts. Last but not least, space tourism is an industry that can only exist if there are potential customers. It would be important to understand the perspectives and expectations they have about space travel and space tourism, and if biophilia is compatible. One approach is through science fiction, a medium in which space travel is often brought up and communicated to the masses. The prevalence and role of biophilia in these mediums would thus be analysed. The other approach would be done through the primary research, where the preferences of the participants with regards to space tourism would be asked directly.

Literature Review

Psychological Effects of Biophilic Features on Humans

The first section of this literature review will explore the effects of biophilic features on humans, with a focus on psychological impacts. These features have a direct impact on emotions, which in turn translates to health benefits. These would be highlighted in Roger Ulrich's study and the Kaplans' Attention Restoration Theory. Lastly, the need for a variety of biophilic features would also be explored.

Jana Söderlund notes that a common theme amongst biophilic design writers is the mismatch between urban environments and the natural environment in which humans have evolved in. They believe that modern cities are not designed to support the mental health and well-being of its inhabitants, as humans have yet to adapt physiologically to these sterile and technological environments (Söderlund 15). In another research by Frances Ming Kuo and William Sullivan on said environments, they too noted that barren courtyards in social housings evoked negative emotions and "left people feeling more raw and aggressive". The presence of greenery in another courtyard had instead attracted people in to spend time and socialize (Montgomery 113).

Biophilic designs have a significant impact on human's recovery processes. Roger Ulrich did a study on recovering patients within a hospital, where some patients had views of a brick wall, while others had views of nature. Patients with the first view experienced slower recovery times and required stronger painkillers than those in the second. Their moods were affected too with greater dissatisfaction regarding their quality of care, which were expressed through more frequent complaints (Kellert 10).

These restorative effects have also been brought up by the Kaplans' Attention Restoration Theory. When humans are near nature, they experience pleasure and satisfaction due to its aesthetic qualities, which leads to restoration from mental fatigue. Restorativeness can be categorized into two sides; the pragmatic and spiritual. The pragmatic side refers to the health benefits, both mental and physical. The spiritual side refers to the sensation of feeling "at one" and sense of tranquility, which often occurs in natural environments. The combination of both sides would affect mental fatigue, attentiveness and clarity of judgments (Kaplan 196). This is supported in a study conducted by Judith Heerwagen in office complexes. She had concluded that biophilic features such as interior vegetation, natural lighting and sitting places amongst nature increased workers' well-being. The workers had experienced significant gains in attendance, productivity, motivation and overall emotional satisfaction after these biophilic features were added (Kellert 11).

Although the presence of greenery elicits positive emotions and leads to restorative benefits, monotony of greenery could be detrimental. In an analogue named Mars 500, an international crew isolated themselves in a simu-

lated mission to Mars for 520 days with a greenhouse as part of their facilities. According to their individual preferences, some chose to grow plants with large red flowers while others grew plants for salad greens (Ushakov 111). Participants who were isolated at another experiment, the EDEN-ISS greenhouse project in Antarctica, had similar experiences. The availability of fresh food and natural colours to observe were unanimously cited as the main reasons of having a positive impact on their well-being. Despite so, the crew had requested for more variety of plants and herbs, as the greenhouse was dominated by leafy greens (Schlacht 801). This preference of red flowers and variety of plants could be a response to the monotonous environment and sensory deprivation in isolation.

This section allows us to understand the importance of having biophilic features by highlighting the benefits brought by them, which ranges from emotional to health benefits. Moreover, any biophilic features incorporated would have to be of a variety to break the monotony of the isolated environment.

Potential Issues Faced by Space Tourists

Before attempting to apply biophilic designs, it is important to understand the needs of the target users. This section of the literature review aims to understand the potential issues faced by space tourists. Due to the scope of this dissertation, it would focus more on the psychological aspects than the physiological aspects of space travel. This section would cover the well-being of tourists and the passive and mono-sensory nature of space tourism.

Laing and Crouch have considered space tourism as an extension of adventure tourism. The authors suggested that methods to optimize the space tourism experience could be similar to adventure tourism, guided by Csikszentmihalyi's concept of "flow", where there is a "complete involvement of the actor with his activity". "Flow" results in intense enjoyment and pleasure, which can be achieved when the participant's skill level and challenge posed by the activity balances out (Laing 17).

However, the passivity of space tourism could be a barrier in achieving "flow." The complexity and technical nature of spaceflight prevents tourists from participating in its operations. Thus, the spacecraft and voyage lies in the hands of professional astronauts and operational support networks. Unlike the experiences of early adventurers where qualities and skillset are needed to survive the harsh environments on Earth, space tourists are simply passengers who observe the journey without having any responsibilities (Cohen 9). A low participant skill level combined with little to no challenges would prevent them from achieving Csikszentmihalyi's concept of "flow", which would potentially result in a poor tourist experience.

While conventional tourism increasingly emphasizes multisensory experiences, space tourism would be mainly restricted to the ocular sense. Tourists are unable to interact with space itself through smell or sounds due to the lack of air, and are only able to observe their environment through sight. However, "internal senses" such as the vestibular, known as the sense of balance, now plays a major role in their weightlessness experience (Cohen 10). The furnishings of a space hotel would likely be limited by the high cost of transporting materials into space. This would result in a utilitarian and cramped interior, while offering limited facilities (Liang 19). Spending most of their time within a confined environment with a lack of sensory engagement may lead to boredom on the tourist's part.

This environment of a spacecraft is similar to Wilson's description of a lunar habitat; one that is sealed with air and decorations. These environments are artificially created by us and our thoughts, and unlike nature, they would be limited in complexity. This lowered complexity leads to a lack of stimulation and engagement of our senses. Since he hypothesized that the human mind is directly linked to the state of the environment, he argued that these environments would limit the growth and degrade the minds of inhabitants. This would drive people to insanity, unless they have a “strong character and a clearly defined goal” (Wilson 115). Although the duration of stay of space tourists would be shorter than that of lunar inhabitants described by him, these concerns could still potentially have a negative impact on the overall experience, albeit less severe.

This section of the literature review serves as a desk research on user needs. These would be useful as a guide to develop solutions to counter the potential issues faced by space tourists during the trip though design.

Understanding the Biophilia Hypothesis Within the Context of Past and Current Space Missions

The previous sections of the literature review have covered both the effects of biophilia and needs of space tourists separately. The context of the former is on Earth, while the latter, in space. This section will instead aim to understand biophilia within the context of space through past and current space missions, and through the phenomenon known as "the overview effect."

The main idea of the biophilia hypothesis is that the preferences of humans are innate and linked to nature, due to the natural environment in which our ancestors had evolved in (Wilson 109). Humans have a natural attachment towards savannah-like landscapes and will attempt to recreate them in various ways. In the ninth to twelfth century, Japanese gardens had Asiatic pine arranged with spaces between them, and their height and crown shape were pruned to resemble the African acacias (111). This attachment towards natural elements is also present in space. The Soviet space program's Group for Psychological Support provided postcards and projected slides of landscapes onto screens in the interior of the Salyut-6 space station. This provided a window-like view of Earth while in orbit. While videos of television programs were provided, the cosmonauts found those depicting natural landscapes and scenery of their homeland more appealing than recordings of theatre or movies (Coss 2).

Astronauts have recounted emotional experiences when viewing and photographing Earth while in space. Cosmonauts of the Salyut space stations had reportedly enjoyed looking out of the windows for long periods of time, which replaced watching films as a form of relaxation (Coss 2). Quoting Space Shuttle astronaut Kathryn D. Sullivan, "I'm happy to report that no amount of prior study or training can fully prepare anybody for the awe and wonder this inspires." Similarly, NASA-Mir astronaut Jerry Linenger was also particularly emotional when he photographed his hometown of Michigan on his own accord (Robinson 81). The author describes the positive emotions derived from these activities as salutogenesis (80).

Frank White have coined this phenomenon "the overview effect." It refers to the profound impact on viewers upon looking at Earth from space. He asserts that this effect is not unique to space and as such, these experiences would also be prevalent when people view landscapes from high altitudes, like mountain peaks (Yaden 2). This effect may also trigger "self-transcendent" experiences, which are generally positive and are described as temporary feelings of unity. It reduces self-salience while increasing the feelings of connection with others which in the context of space, refers to the emotional connection with the entire Earth and its inhabitants (5). This effect could be related to Wilson's biophilia hypothesis. Other than the innate preferences towards nature, Wilson argued that humans have a gravitation towards places with topographic relief due to their ability to provide ancient humans with vantage points (Wilson 110).

Biophilia in space goes beyond the ocular sense. When astronaut Linenger received a fruit sent from Earth, he described it as "a gift and aroma of the Earth". This reflected the importance of olfactory stimulation, which in this case served as a medium for astronauts to connect with Earth. Furthermore, the importance of the auditory sense was brought up by the Salyut cosmonauts, who had a preference for listening to earthbound noises while in orbit. Combining various sensory stimulations could create an atmosphere that resembles Earth, thereby providing better experiences for astronauts (Ahmadi 9).

Even while the astronauts were physically away from Earth, they still desire the means to reconnect with Earth and her natural landscapes through multisensory elements. Earth viewing activities engaged the ocular sense, video recordings of Earth's landscapes engaged the auditory, while fresh produce delivered to astronauts engaged the olfactory sense. Although these sensory stimulations are less complex than what was recommended in the biophilia hypothesis (Wilson 115), the astronauts' preferences towards these activities are sufficient to support his hypothesis on human's innate preference to nature.

This section shows that the link between humans and nature is still present even when they leave the Earth. Through this, the biophilia hypothesis is proven to be relevant even when in space, thus implying that the benefits in which biophilic design brings would still be applicable for space tourists. Moreover, it provides examples and evidences on how biophilic interventions can take up various forms to trigger different senses, thereby creating a desirable

multisensory stimulation. Thus, this section would pave the way for us to apply biophilic design to improve the experiences of our target users.

Understanding the Role of Biophilic Elements Within Science Fiction in Shaping the Expectations of Space Tourists

This section of the literature review will aim to understand the role of science fiction in shaping the expectations of space tourists. This would be done through understanding the idealization of space and learning about the portrayal of biophilic elements within science fiction movies.

Science fiction is a medium for people to express their own versions of reality. Gary Westfahl argues that it is a way for people to return to an idealized past. When writers imagine the future of humans in space, they rarely envision new human lifestyles or attitudes. Instead, they imagine space travel as a return to the "rugged individualism" of the past, similar to the American West of old (Westfahl 196). The Apollo 13 film of 1995 is another example. Although it intended to portray the actual incident which happened in 1970, it had interpreted reality differently. The sense of community amongst the characters was amplified through ideological values such as teamwork, duty and friendship, which were depicted in the scenes. However, historical contexts of cultural or political dissent during the 1970s such as the civil rights movement, women's liberation and the Vietnam War were omitted. This presented an idealized form of America, flawless and focused on space exploration without any conflicts (Llinares 168). Thus, science fiction plays an important role in enabling people to reimagine and set expectations of the future of humans in space, even if they often refer back to a past which they prefer.

Fig**. 2.** Scene in Elysium (Blomkamp).

Fig**. 3.** Scene in Passengers (Tyldum).

Biophilic elements have been used in science fiction movies as visual metaphors for positive contexts. In the 2013 movie Elysium set in 2154, people on Earth are living in poverty, while the rich and powerful have migrated to an artificial space colony in orbit around Earth, named Elysium. The colony is known to be technologically advanced with the ability to cure all diseases, but they have withheld these services from people on Earth. The dwellings and environment on Earth was depicted as a sandy and derelict slum devoid of nature, while grass and trees filled the landscapes of Elysium (Blomkamp) as seen in Fig. 2. In this movie, the scenery of Earth, an undesirable place to live in, contrasted with that of the space colony, which was described as a paradise. This was done through the introduction of biophilic elements. In another 2016 movie, Passengers, biophilic elements were also introduced. The movie was set on a sleeper ship, whose goal was to transport hibernating colonists to a new planet. The story revolves around a pair of protagonists who had been unwillingly woken up 90 years too early on the ship, but eventually decide to live their lives out together instead of re-hibernating. It was narrated that they lived their lives happily from then on. Their eventual living environment was visually depicted (Fig. 3) as a garden with trees, sounds of nature and a wooden hut (Tyldum). The association between living a satisfied life and being in a biophilic environment was drawn in this movie, by the narrative and the visuals. Both of these movies are thus similar in that they had used biophilic elements as visual metaphors for positive contexts.

Westfahl and Llinares have shown that science fiction movies play a role in allowing people to envision what the future of space could be. Conversely, analyzing science fiction would allow us to gain an understanding of the imaginations and expectations of people. The usage of biophilic elements in science fiction movies shows that such elements would elicit positive emotions even within a futuristic context, and therefore the incorporation of these elements within space tourism would not be inappropriate.

Understanding Human Desire to Travel and Reach Beyond the Earth

The final section of this literature review tries to understand the human desire to travel and reach beyond the Earth. The reason could be due to a combination of astrofuturism and alienation, which eventually leads to an increased interest in space tourism.

Fig**. 4.** Opening sequence for Valerian and the City of a Thousand Planets (Besson).

Astrofuturism plays a part in rationalizing human's desire to explore outer space. This term was coined by literary scholar De Witt Douglas Kilgore, who described it as a widely shared belief that the future would take place in outer space, and would include encounters with alien life-forms (Geppert 599). Astrofuturism was portrayed in the opening sequence of the 2017 movie Valerian and the City of a Thousand Planets, as shown in Fig. 4. It depicts the historical meeting between astronauts from the United States and cosmonauts from the Soviet Union of 1975 in space. This scene was followed by a fictitious meeting with Chinese astronauts in 2020, and with other countries later on. A century later in 2150, they were joined by aliens from other planets (Besson). The timeline and alien encounters of this movie serves as a visual example of astrofuturism, which is a belief that the future would involve space travel and alien species.

Astrofuturism promotes the development of space travel, which could cause the Earth to be neglected. In this case, space would then serve as an escape from Earth's problems. Futurist Alvin Toffler predicts a society with a "throw away" culture, where people would discard the old. This, when applied to space travel, refers to discarding and neglecting the Earth. It may become a reality when technology develops to a point where new solutions to Earth's dwindling resources, such as energy and materials, can be found and used in space. Conversely, environmental advocates believed that money spent on space travel could be diverted to solving Earth's problems (McCurdy 306). The plot of George Clooney's movie, The Midnight Sky, depicts this aspect of astrofuturism. In 2049, a series of man-made radioactive disasters rendered Earth uninhabitable. However years before the disaster, humans had spent resources to send out missions investigating potentially habitable worlds. The movie ends with two humans leaving Earth towards a newly discovered habitable world, giving humanity a second start (Clooney). When humanity is guided by a belief in astrofuturism, their focus would be shifted towards space travel which may eventually lead to a neglect towards Earth’s problems.

Due to the belief in astrofuturism, the urge to reach out to alien life-forms is widespread amongst humans. This could be caused by the alienation between humans and the biodiversity of Earth. Being a cultural phenomenon, it is described as a sense of cosmic loneliness present since the ancient times. This can be seen through the public and media’s fascination with stories or news about alien life. One NASA scientist remarked that extra-terrestrial life "re-

mains the most emotionally and ideologically charged issue associated with astronomy." Despite having Earth, humans still feel alone, and thus yearn to reach beyond it. Alienation between humans and the wild biodiversity of Earth could be the cause of this phenomenon (Acampora 146).

Erik Cohen believes that people's interest in space tourism is a response to this alienation. Quoting Weber, he describes future space tourists as "disenchanted" who may be leading unhappy and alienated lives. In space, they are removed from reality and any kind of social structure, away from their unsatisfactory lives. The unique location of space offers an opportunity to not only escape, but also re-enchant their lives with "a sense of awe and mystery." Space becomes a zone of "liminality", a point for individuals to transition from one stage to another. Thus, they view space tourism as a method of curing their conditions of disenchantment and alienation (Cohen 234).

This section demonstrates that both astrofuturism and alienation plays an important role in driving human desire for space travel and space tourism. It informs us about people's motivations for space tourism, which would in turn inform their needs and expectations. Moreover, there are two potential implications. Firstly if space tourism were to be positioned as a way to escape the Earth, it could further alienate people from the biodiversity of their home, Earth. Secondly, the fact that potential customers of space tourism are alienated from Earth's biodiversity could imply that they may not respond to the benefits of biophilic designs. If so, incorporating biophilic elements into space tourism may not improve their experiences.

Case Studies

Rotofarm

Fig**. 5.** Rotofarm hydroponic system (Rotofarm).

Rotofarm (Fig. 5) is a device capable of growing vegetables through hydroponics, targeted at urban dwellers with limited indoor space. It consists of a constantly rotating cylindrical shell and farm bed, with lights mounted in the central axis. The lights mimics the colour emission of sunlight to provide optimal indoor plant growths. Other than the need of replenishing the water reservoir every few days, it is a fully automatic growing system (Rotofarm). It makes the indoor farming experience more convenient, while serving as an avenue to bring greenery and simulated sunlight into the urban environment. These biophilic elements are multi-sensory. The rotation, light and greenery engages the ocular sense, while the act of harvesting engages the sense of touch. Lastly, cooking and eating the vegetables would too engage the sense of smell and taste. This product shows the potential of incorporating biophilic elements beyond the usual passive decorations. They can be applied in a functional and engaging way, not only through a single product, but also throughout the process of using the product. This example proves the possibility of

biophilic multi-sensory engagement without the need of modifying the environment, which is limited for a spacecraft. Thus, the concept behind this product could be adapted to provide sensory stimulation for space tourists beyond the ocular sense.

Thorncrown Chapel

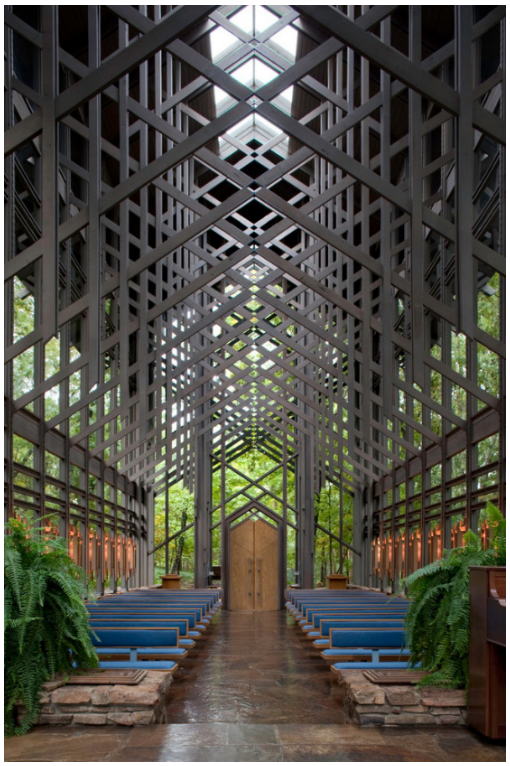

Fig**. 6.** Interior of Thorncrown Chapel (Galloway).

Thorncrown Chapel (Fig. 6) was designed by Euine Fay Jones in 1980 and built in an Arkansas forest. It has been considered as one of the best American buildings since then. The construction process was part of the design; manpower and materials were sourced locally, and the assembly left little site impact in the forest. Pine wood trusses created an illusion of a "forest within a forest", while central glass windows provided natural skylight (Galloway). Combined with the vertical columns, the quality of skylight from these windows mimics those of a forest. The popularity of this building lies in its sensitivity to both biophilic principles and its locality. Although the contexts around this building differs significantly from that of the focus of this dissertation, it allows us to understand that true biophilic design is not about a single element, but a series of individual designs put together. This combination of elements generates a multi-sensory experience, which can be an opportunity to improve the space tourism experience. Natural materials and the control of sunlight could be applied within a spacecraft for tourists to stimulate senses of sight and touch. Moreover, the sunlight and views of nature would also provide emotional and health benefits, as investigated in the literature review.

Primary Research

Methods

It is not possible to secure contacts with space tourists or astronauts due to the lack of connections and support for the primary research. The futuristic and speculative timeline of the space tourism market will dictate the age group of this research. This market may only start to become significant after year 2028 (Sheetz), with the timeline stretching even further for it to become a mass market phenomenon. For the purpose of this research, the year for mass market viability would be set to 2051. Dennis Tito, a space tourist who was 61 years old when he travelled to space (Slade), would be used as a reference for the upper age limit. Thus, the target group for this research would then be restricted to ages below 30.

Interview

Personal interviews have been chosen due to its ability to provide in depth data, by allowing the interviewer to probe into motivations and feelings. This data is also immediate and complete (Collins), making it suitable as a guide for the design of the second research method.

As the format of the interview is semi-structured, the order in which these questions would be asked is dependent on the interview process. Questions are sorted by segments. The first segment aims to discover the interviewees' thoughts about space tourism, their impression of space travel in general, and their sources of influence regarding these topics. The second segment aims to discover the interviewee's ideal confined space, and to find out their preferences for biophilic elements. As the terms "biophilic" or "biophilia" might be foreign to interviewees, they would not be mentioned to minimize miscommunications. This would be interweaved with questions relating to their experiences during the Circuit Breaker measures of 2020, which restricted gatherings and non-essential activities. They were enacted to control the spread of COVID-19 (“Circuit Breaker Extension”).

The third segment would replace some of the questions in the second segment, and would only be applicable for interviewees who had undergone Stay-Home Notice (SHN) or Quarantine. For individuals serving their Stay-Home Notice, they are not allowed to leave their assigned place of residence for a certain duration. The experiences of interviewees pose a unique opportunity to understand people who have lived within a confined space, physically detached from the environment and without the freedom of movement. Although involuntarily and based on Earth, parts of this experience would be similar to those experienced by space tourists.

Interviews were conducted with four individuals; Rehan, Jyn Hern, Samantha and Elaine. They had been selected as suitable interviewees due to their varied experiences with living in confined spaces and having their freedom of movements curtailed due to the COVID-19 pandemic in 2020. Additionally, they were all interested in space tourism and are their 20s, which falls within the appropriate age range. Rehan experienced the Circuit Breaker and Work-from-home arrangements in Singapore. Jyn Hern experienced a 10-day CDC quarantine in the United States with a few housemates. Samantha experienced a 14-day Stay-Home Notice alone in Singapore. Finally, Elaine experienced a self-imposed quarantine alone in Hong Kong during the first wave, and also a 7-day Stay-Home Notice in Singapore.

Survey

Surveys are useful in providing data within a narrow scope of questioning, across a large population (Purdue University). Conducting the interviews prior to this had helped to design better options for the multiple choice answers of the survey. Google Forms was used and disseminated through school-related chat groups, in line with the target group of the interviews; respondents below 30 years old.

Multiple choice questions reduces the time required to complete the survey and ensures that the responses are easily quantifiable. The survey starts off with a demographics question to filter out respondents of different age groups. Dichotomous questions were then used to learn of their interest in space tourism and preferences for indoor greenery. To gain a deeper understanding of the respondent's reasons for their interests and concerns with regards to space tourism, ranking questions were used. Lastly, images were used to enquire about their preferences for window views.

The survey generated a total of 48 responses. Of these, 1 of responses were omitted as they did not fall within the age range of the target group. 3 of those who were not interested in space tourism were also filtered out from the findings. The remaining 44 responses were then analysed.

Findings

Interview

Expectations of Space Tourism Would be Shaped by Movies

It was apparent in a few interviews that their impressions and expectations of space tourism were shaped by movies. Rehan had described going on such a trip as fulfilling his "'Interstellar dreams". He was intrigued by the space and universe exploration aspect of the 2014 movie of the same name, Interstellar. For him, this movie could have served as a source of motivation or inspiration to embark on a trip to space.

Both Jyn Hern and Elaine's impression of space travel and tourism came from movies. Jyn Hern noted the limited coverage in science fiction movies, stating that "For me when I see space travel in movies, it's not so much tourism but they are out there to do something, resource mining and something, not so much leisure." Meanwhile, Elaine expressed interest in planting crops in space, which she mentioned that she picked it up from movies. Quoting her, "you always see in movies how the astronauts live in space, and how they, how they can plant stuff out there."

From the responses of the interviewees, movies had helped them to imagine what kind of activities they would like to do and experience in space. Thus, one can infer that movies do serve as an important source of information for potential customers of by shaping their impressions and expectations of space tourism.

Monotony of Activities Would Lead to Negative Experiences

From the interviews, it can be understood that the monotony of activities within a confined space would lead to negative experiences.

Both Samantha and Jyn Hern notes that the novelty of unique environments would wear out after a short period of time. Quoting Samantha, "At first in the first few days you will be excited, you can live in a hotel and chill, have the facilities like TV, bathtub, and nice bed and stuff, but along the way, sometimes you will think that, wah you cannot do anything." Although there were plenty of things available to her, the unchanged environment would eventually lead to boredom. Similarly, Jyn Hern felt that although he is excited to experience weightlessness, he might be bored of it once he was accustomed to it.

For Samantha and Elaine, they felt that the boredom and loneliness would not set in if there are sufficient activities to occupy them. When asked to imagine living in an environment like the International Space Station, Samantha responded that she would be able to cope in the short term due to the amount of electronics and compartments for her to discover and be occupied with. Likewise, Elaine had occupied herself with hobbies and things to do when she was confined to her apartment, to ward off loneliness.

Samantha had further reinforced the negativity brought by monotony by recounting her favourite moments during the SHN. "The routine, when you stay there all day like wake up, then eat, then stuff. But then suddenly where there's

someone like enter the room giving something, then it's something that's attractive. Oh, I got something, and it's a new thing. Then it's kind of change the habits or the rituals." The act of delivering something to her disrupted the monotonous and negative daily routine.

These personal anecdotes shows that if monotony exists within space tourism, it would not be a positive or enjoyable experience.

Need for Connections with Multisensory Elements from Natural Landscapes

The interviewees have highlighted their need for connections with multisensory elements from natural landscapes. Rehan mentioned his preference for scented candles over indoor potted plants. He felt that the latter would only be useful as a decoration for photo taking. This preference could be due to the multisensory aspect of the candle, which combines the visuals of the flame with the smell of the melting wax.

Both Samantha and Elaine described the importance of fresh air. They felt that the indoors was unbearable after some time due to the air. Quoting Elaine when asked about her visits to the park, "To breathe in some fresh air because it is spacious. Hong Kong right everywhere is very cramped. So the only place where there is like actual space, and where people aren't like walking to and fro is like the park lor, the park is slightly bigger, and I feel more spacious. So I feel a lot better there."

Both of them preferred having window views of natural landscapes, in contrast with the views they had during their confined lifestyles, which were facing buildings. Samantha preferred a beach view "because its natural, you can see the sea, the sand, the trees, and people running around." Elaine described her window views as "very claustrophobic" as the buildings had blocked off any views of the sky. To her, being able to see the sky and birds flying around allows her to feel a sense of spaciousness. In addition to this, both Rehan and Jyn Hern had also voiced out their preference for views of sunset and sunrise views respectively.

From these responses, one can infer that although views of natural landscapes is important, there still needs to be some form of multisensory elements present. These could be the presence of life in the form of people and birds, or also the movement of the air and sun.

Survey

Seeing the Earth from a New Perspective as the Main Reason for Interest in Space Tourism

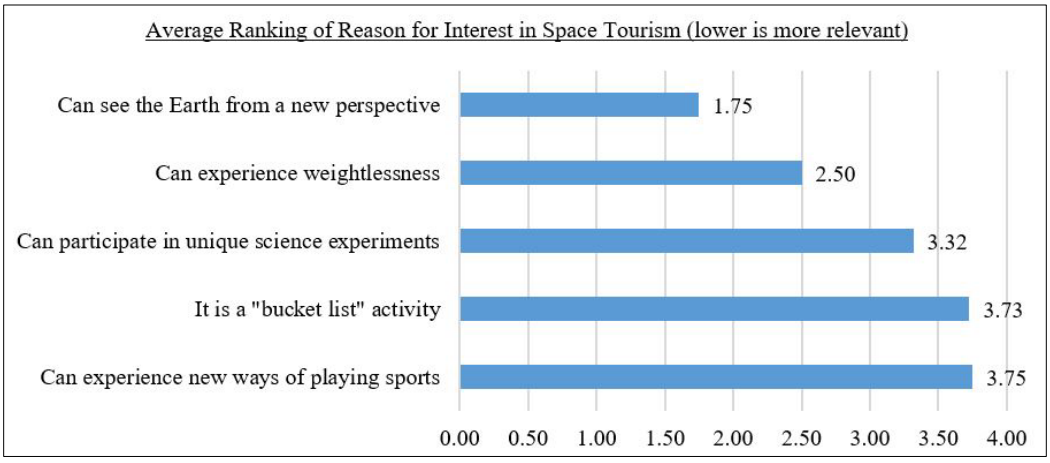

Fig. 7. Average ranking of reason for interest in space tourism.

The main reason for the respondents' interests in space tourism is the opportunity to see the Earth from a new perspective, with an average ranking of 1.75 as shown in Fig. 7. Following it is the chance to experience weightlessness, with an average ranking of 2.50.

Lack of Fresh Air as the Top Concern Regarding Space Tourism

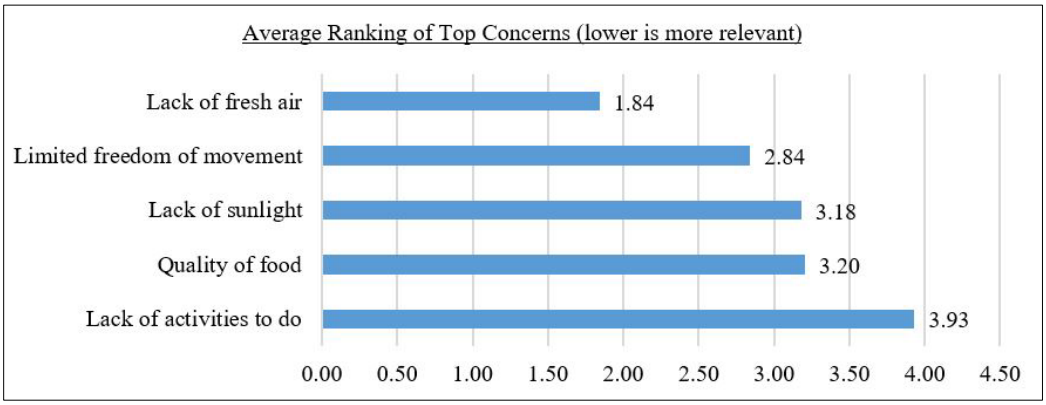

Fig. 8. Average ranking of top concerns.

In Fig. 8, the lack of fresh air leads the rankings of top concerns by a significant margin, with an average ranking of 1.84. Slightly more than half of the respondents, 23, had chosen it as their top concern. As the lack of fresh air is a biophilic element, it demonstrates the plausibility that biophilic design interventions could be the key in tackling the bulk of the concerns raised by future space tourists.

Movies are the Main Source of Information in Shaping the Impressions of Space Tourism and Space Travel

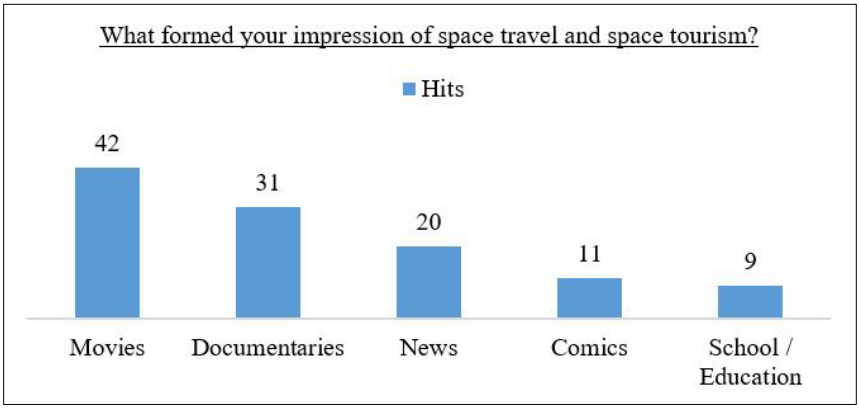

Fig. 9. Sources which formed the respondents' impression of space travel and space tourism.

Fig. 9 shows that main sources which influenced the respondents' impression of space travel and space tourism were movies, followed by documentaries. Out of 44 responses, 42 had included movies, corresponding to 95.5%. This shows the universality of movies in shaping perceptions of space tourism.

Respondents Who are Interested in Space Tourism Have a Preference for Biophilic Elements

Table 1: Cross tabulation of Q10, Q11 & Q13.

Count of Q13: What kind of window views would you prefer the LEAST?		Q13: What kind of window views would you prefer the LEAST?					
Q10: Would your ideal home contain in-door greenery?	Q11: What material would you prefer for indoor furniture?	View 1	View 2	View 3	View 4	View 5	Grand Total
No	Stone (Marble & Granite)	0.0%	0.0%	2.3%	0.0%	0.0%	2.3%
	Wood	0.0%	2.3%	0.0%	2.3%	2.3%	6.8%
Yes	Glass	0.0%	2.3%	4.5%	0.0%	0.0%	6.8%
	Stone (Marble & Granite)	0.0%	9.1%	0.0%	6.8%	2.3%	18.2%
	Wood	6.8%	38.6%	4.5%	6.8%	9.1%	65.9%
Grand Total		6.8%	52.3%	11.4%	15.9%	13.6%	100.0%

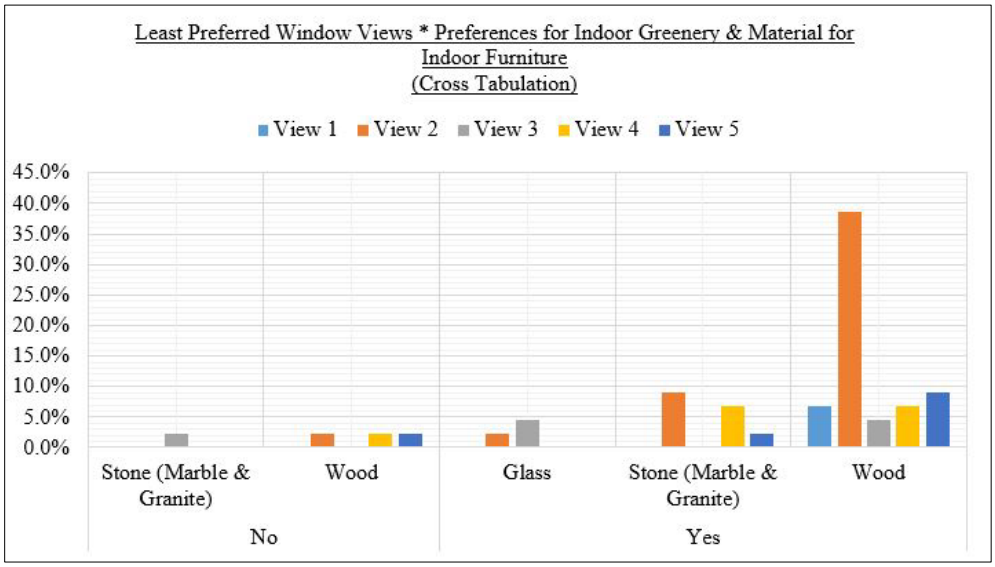

Fig. 10. Cross tabulation chart.

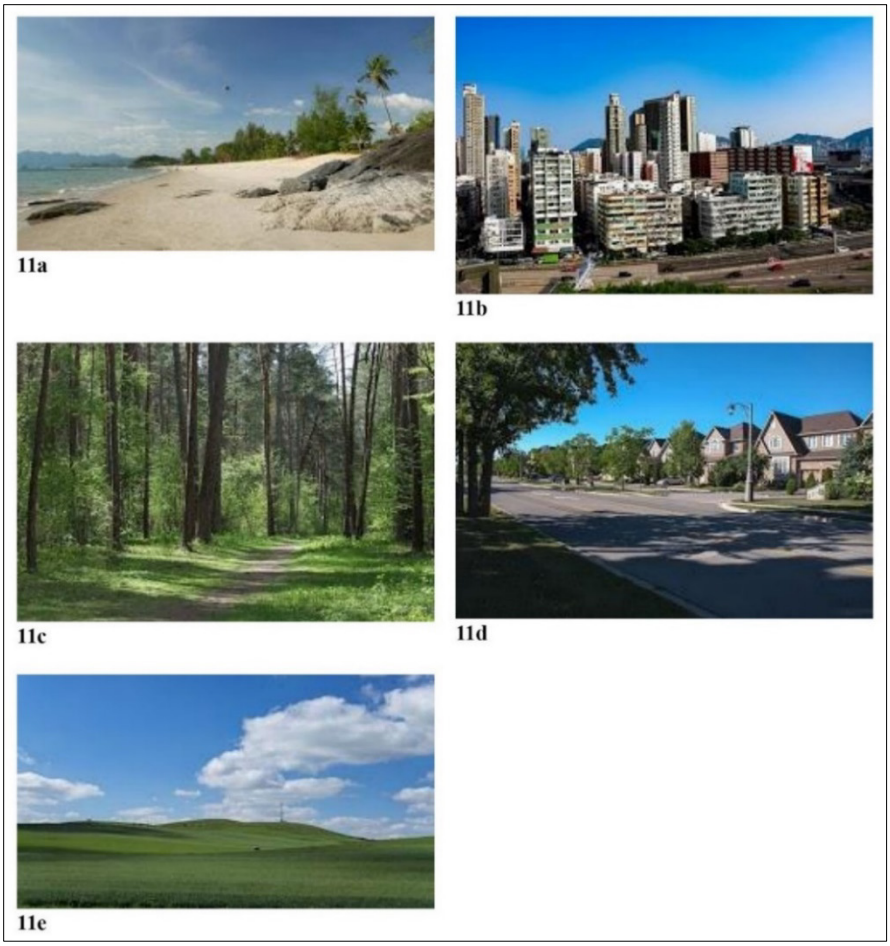

Fig. 11. Images of Views 1-5 shown in the survey. 11a: View 1, depicts a beach (NickLubushko). 11b: View 2, depicts an urban city (Blazejosh). 11c: View 3, depicts a forest (Ruslan_Kadyrov), 11d: View 4, depicts a suburb (Fahal), 11e: View 5, depicts a prairie (James_Peng).

The preference for biophilic elements had been broken down into multiple questions, which necessitates the use of a cross tabulation. The least preferred window views was cross tabulated with the preference for indoor greenery and material for indoor furniture, and the results are displayed in Fig. 10 and Fig. 11.

90.9% of filtered respondents preferred indoor greenery. 52.3% of respondents least preferred View 2, which depicted views of a city. When combined, a total of 38.6% had least preferred View 2, preferred indoor greenery and wood for their indoor furniture. This indicates that respondents who are interested in space tourism have a preference for biophilic elements, which paves the way for biophilic design to be applied to improve the experiences of future space tourists.

Analysis, Interpretations and Recommendations

Potential Customers of Space Tourism are Compatible With Biophilic Designs

The research have proven that potential customers of space tourism are compatible with biophilic designs. This was investigated by learning from the experiences of astronauts in the secondary research, and by understanding the rela

tionship between interests in space tourism and biophilic elements through the primary research.The third part of the literature review showed that even when humans go into space, they still exhibit a yearning for Earth. Astronauts had enjoyed Earth viewing (Robinson 81) and interacting with objects from Earth (Ahmadi 9). If the link between humans and Earth can still exist despite the distance, biophilia and biophilic design would thus be applicable in space.

In the fifth part of the literature review, Erik Cohen believes that the interest in space tourism is a response to the alienation between themselves and the biodiversity of Earth (Acampora 146). Due to this alienation, it can be implied that there lies a risk that these people may not be compatible or respond to the benefits afforded by biophilic elements, thus rendering biophilic designs irrelevant in improving their space tourism experiences.

However, the results from the primary research emerges in contrast to Erik Cohen's beliefs and concerns. The survey shows that respondents who are interested in space tourism do have a preference for biophilic design. Nearly all of the respondents, 90.9%, had preferred indoor greenery, while more than half of them, 52.3%, had expressed that their least preferred window views was one of a city. This city view is an urban environment devoid of nature and greenery, which would not be chosen as the least preferred if the respondents did not have biophilic tendencies. In addition, interviewees who were interested in space tourism had expressed preferences for multisensory biophilic elements. They had preferred window views with natural environments and brought up the importance of having fresh air.

The primary researches establishes the fact that people interested in space tourism, who are potential customers, do have a preference and are compatible with biophilic elements. Combined with the literature review which proved that biophilia is still relevant in space, would pave the way for biophilic designs to be implemented to improve the space tourism experience.

Science Fiction Movies Shapes Perceptions of Space Tourism

Both the primary and secondary research shows that science fiction movies have the ability to shape perceptions of space tourism.

The fourth section of the literature review had explored the importance of science fiction in enabling people to set expectations of the future and space, by allowing them to express their own versions of reality. In some versions, space travel was imagined as a return to the "rugged individualism" of America's past (Westfahl 196). Biophilic elements were also used to depict ideal environments (Blomkamp) or positive contexts (Tyldum), such as in the movies Elysium and Passengers respectively. Although these may not be representative all science fiction movies, the primary research showed that individual movies do make a lasting impression on the interviewees and respondents.
In the primary research, 95.5% of survey respondents who are interested in space tourism had indicated movies as their sources of information. Data gathered from the interviews reflects a similar finding. One interviewee described space tourism as a way to fulfil his "Interstellar dreams", a phrase he created after being inspired by the movie of the same name. Another interviewee was interested in experiencing the same activities being portrayed in movies, such as planting crops in space.

Thus, it is clear that science fiction movies play an important role in shaping the perceptions that potential space tourists have with regards to space tourism. Based on these findings, one recommendation for implementing biophilic designs is to use movies as a reference. If biophilic elements are brought from the movies into the real world, it might be well received due to both the familiarity and positive connotations they represented. As such, the gap between customer expectations and reality (David) could then be bridged, reducing disappointments.

Importance of Multisensory Biophilic Design in Tackling Monotony

This research highlighted the importance of having multisensory biophilic design elements in tackling monotony.

Monotony is a potential issue with space tourism, as shown through the researches. In the first literature review, isolated participants in research facilities had either requested for more variety of plants (Schlacht 801), or had preferred growing plants with red flowers (Ushakov 111). This could be a response to the visually monotonous indoor environment which they had lived in. This is corroborated by the interviewees during the primary research albeit in a different form; the monotony of activities. They responded that varied or non-routine activities had helped keep boredom away during their time in quarantine.

In the second section of the literature review, Erik Cohen states that the passengers do not have responsibilities and are unable to interact with the environment of space due to the complex nature of spaceflight. They can only observe and sightsee, which involves only the ocular sense (Cohen 10). The responses of the interviewees from the primary research reinforces the fact that a mono-sensory environment is inappropriate for extended isolation. They mentioned the need for fresh air and walks in the park in order to cope better when in quarantine, in addition to views of nature and skies. The lack of fresh air was also cited as the top concern by the survey respondents. These results thus underscores the importance of multisensory biophilic elements.

Therefore due to the mono-sensory environment of space tourism, multi-sensory biophilic elements can be implemented to improve the experiences of space tourists. These could be applied to alleviate the visual monotony of the interior. However, more research has to be done to see if such biophilic elements could be used to tackle the issue of monotonous activities.

Space Tourism as a Way to Reduce Alienation Between Humans and the Biodiversity of Earth

Space tourism could be a way to reduce alienation between humans and the biodiversity of Earth, if biophilic designs are applied appropriately.

In the fifth section of the literature review, Astrofuturism was described as a belief that drives people towards a future in space, with a possibility of neglecting Earth (McCurdy 306). Meanwhile, Erik Cohen believes that people's interest in space tourism stems from them being alienated from Earth and nature (Cohen 234). These in combination may result in space tourism being viewed as an avenue to escape Earth.

However, space tourism also allows people to view Earth from a new perspective. They will then experience "the overview effect", a term created by Frank White to describe the life-changing impact the activity has on people who viewed Earth from space (Yaden 2). Viewers may experience increased feelings of unity and an enhanced emotional connection to Earth and all life on it (5). In addition, the survey had shown that the majority of respondents were most interested in seeing Earth from a new perspective as compared to other activities. This implies that most tourists might look forward and spend the most time by the windows overlooking the Earth, thereby experiencing "the overview effect" in its entirety.

Thus, space tourism should not be marketed as an escape from Earth, but rather an opportunity to view Earth from a new perspective and an experience to reconnect emotionally with the biodiversity of Earth. One approach to achieve this is to ensure that biophilic design elements do not take the centre stage, lest it draws attention away from the windows overlooking the Earth. Once the space tourists are given the opportunity to fully focus on viewing the Earth, they then can reap the benefits from "the overview effect" and be less alienated from the life on Earth.

Conclusion

In conclusion, results gained from this dissertation would be important in understanding how to improve the experiences of space tourists through biophilic design. Five sections of literature review were included for the secondary research while an interview and survey was completed for the primary research. In order to have a better understanding of the topic, individual aims of the research methods were categorized; biophilia & biophilia design, space travel & tourism, and cultural perspectives.

Research guided by these categories and topics resulted in four key findings. The first is an indication that potential customers of space tourism would be compatible with biophilic design and its positive effects. Secondly, perceptions of space tourism would be shaped by science fiction movies. Thirdly, biophilic design must be multisensory to address monotony. Lastly, space tourism can be used as a method to reconnect humans with the biodiversity of Earth, to reduce alienation.

The space tourism market is on track to develop into a multi-billion dollar industry in the near future (Sheetz). Improving the experiences of space tourists and reducing the gap between reality and customer expectations (David) would be vital for anyone aiming to capitalize on this trend. Thus, this dissertation has demonstrated the possibility of using biophilic design as a method to improve the experiences of space tourists.

References

Acampora, Ralph. "Biophilia: Alienation and Solidarity." *Between the Species*, vol. 22, no. 1, 2018, pp. 136–157., digitalcommons.calpoly.edu/cgi/viewcontent.cgi?article=2170&context=bts. Accessed 24 Jan. 2021.

Ahmadi, Mosleh. "The Experience of Movement in Orbital Space Architecture: A Narrative of Weightlessness." *Cogent Arts & Humanities*, vol. 7, no. 1, 2020, doi:10.1080/23311983.2020.1787722.

Besson, Luc, director. *Valerian and the City of a Thousand Planets*. EuropaCorp Distribution, 2017.

Bickerton, James. "China Announces Plans for Manned Moon Base as New Space Race Surges Forward." *Express.co.uk*, Express.co.uk, 22 Aug. 2020, www.express.co.uk/news/science/1326029/Space-news-China-manned-Moon-base-lunar-south-pole-Chang.

Blazejosh. "Hongkong view city cityscape." *Pixabay*, 15 Sept. 2019, https://pixabay.com/photos/hongkong-view-city-cityscape-4478110/.

Blomkamp, Neill, director. *Elysium*. Sony Pictures Releasing, 2013.

"Circuit Breaker Extension and Tighter Measures: What You Need to Know." *Gov.sg*, Singapore Government, 21 Apr. 2020, www.gov.sg/article/circuit-breaker-extension-and-tighter-measures-what-you-need-to-know.

Clooney, George, director. *The Midnight Sky*. Netflix, 2020.

Cohen, Erik, and Sam Spector. *Space Tourism: The Elusive Dream*, 1st ed., vol. 25, Emerald Publishing Limited, Bingley, 2019.

Collins, Hilary. *Creative Research. The Theory and Practice of Research for the Creative Industries*. Lausanne, AVA, 2010. pp. 134-137

Coss, Richard G., et al. *Functional decor in the International Space Station: Body orientation cues and picture perception.* NASA, 1989, https://ntrs.nasa.gov/citations/19900004615.

David, Leonard. *Space Tourism: Keeping The Customer Satisfied*, Space.com, 2005, www.space.com/1234-space-tourism-keeping-customer-satisfied.html.

Fahal, Fayez. “Suburbs.” *Exponents*, 1 Apr. 2020, https://exponentsmag.org/wp-content/uploads/2020/04/suburbs.jpg.

Galloway, Andrew. “AD Classics: Thorncrown Chapel / E. Fay Jones.” *Archdaily*, 2018, https://www.archdaily.com/533664/ad-classics-thorncrown-chapel-e-fay-jones.

Geppert, Alexander C. T. “Flights of Fancy: Outer Space and the European Imagination, 1923–1969.” *Societal Impact of Spaceflight*, edited by Steven J. Dick and Roger D. Launius, National Aeronautics and Space Administration, Office of External Relations, History Division, Washington, DC, 2007, pp. 585–599.

Harrison, Albert A., et al. “Behavioral Health” *Psychology of Space Exploration: Contemporary Research in Historical Perspective*, National Aeronautics and Space Administration, 2011, pp. 17–46.

James_Peng. “Grassland blue sky white cloud.” *Pixabay*, 26 Jul. 2018, https://pixabay.com/photos/grassland-blue-sky-white-cloud-3585385/.

Kaplan, Rachel, and Stephen Kaplan. *The Experience of Nature: A Psychological Perspective*. Cambridge University Press, 1989.

Kellert, Stephen R. *Nature by Design: The Practice of Biophilic Design.* Yale University Press, 2018.

Laing, Jennifer, and Geoffrey I. Crouch. “Vacationing in Space: Tourism Seeks ‘New Skies.’” *New Horizons in Tourism Strange Experiences and Stranger Practices*, edited by T.V Singh, CABI, 2005, pp. 11–26.

Llinares, Dario. “Idealized Heroes of ‘Retrotopia’: History, Identity and the Postmodern in Apollo 13.” *The Sociological Review*, vol. 57, no. 1_suppl, 2009, pp. 164–177., doi:10.1111/j.1467-954x.2009.01823.x.

McCurdy, Howard E. *Space and the American Imagination.* Smithsonian Institution Press, 1997.

Montgomery, Charles. *Happy City.* Penguin Books, 2013, pp. 108-149.

NickLubushko. “Cenang Beach view, Langkawi.” *Wikimedia*, 1 Mar. 2015, https://commons.wikimedia.org/wiki/File:Cenang_Beach_view,_Langkawi.jpg.

Robinson, Julie A., et al. “Patterns in Crew-Initiated Photography of Earth from the ISS—Is Earth Observation a Salutogenic Experience?” *Psychology of Space Exploration: Contemporary Research in Historical Perspective*, National Aeronautics and Space Administration, 2011, pp. 79–101.

“Rotofarm” *Rotofarm - Bace*, 2019, bace.co/rotofarm.

Ruslan_Kadyrov. “Forest trees green forest landscape.” *Pixabay*, 14 May 2017, https://pixabay.com/photos/forest-trees-green-forest-landscape-2320356/.

Schlacht, Irene Lia, et al. “Impact of Plants in Isolation: The EDEN-ISS Human Factors Investigation in Antarctica.” *Advances in Human Factors of Transportation Advances in Intelligent Systems and Computing*, 2019, pp. 794–806., doi:10.1007/978-3-030-20503-4_71.

Sheetz, Michael. “How SpaceX, Virgin Galactic, Blue Origin and others compete in the growing space tourism market.” *Cnbc.com*, Cnbc.com, 26 Sep 2020, https://www.cnbc.com/2020/09/26/space-tourism-how-spacex-virgin-galactic-blue-origin-axiom-compete.html.

Slade, Jim, and Willow Lawson. “World's First 'Space Tourist' Lifts Off.” *ABC News*, 7 Jan. 2006, abcnews.go.com/Technology/story?id=98612&page=1. Accessed 27 Nov. 2020.

Söderlund, Jana. “The Rationale for Biophilic Design.” *The Emergence of Biophilic Design.* Springer International Publishing, Switzerland, 2019, pp. 13–33.

Tyldum, Morten, director. *Passengers*. Sony Pictures Releasing, 2016.

Ushakov, Igor’ Borisovich, et al. “Main Findings of Psychophysiological Studies in the Mars 500 Experiment.” *Herald of the Russian Academy of Sciences*, vol. 84, no. 2, 2014, pp. 106–114., doi:10.1134/s1019331614020063.

“What Is Primary Research and How Do I Get Started?” *Purdue Online Writing Lab*, Purdue University, owl.purdue.edu/owl/research_and_citation/conducting_research/conducting_primary_research/index.html.

Westfahl, Gary. “The Case against Space.” *Science Fiction Studies*, vol. 24, no. 2, July 1997, pp. 193–206., doi:https://www.jstor.org/stable/4240602.

Wilson, Edward O. Biophilia. Harvard University Press, 1986, pp. 103-118. *ProQuest*, http://ebookcentral.proquest.com/lib/singaporenatlib-ebooks/detail.action?docID=3300337.

Yaden, David B., et al. “The Overview Effect: Awe and Self-Transcendent Experience in Space Flight.” *Psychology of Consciousness: Theory, Research, and Practice*, vol. 3, no. 1, 2016, pp. 1–11., doi:10.1037/cns0000086.