Health and well-being: The experience of nature inside

Reconnecting people with nature by removing the barriers between the natural and built environment

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Being outside inside: *building outside the box*

Preface

The vision of BOI Consultancy is to reconnect people with nature by removing the barriers between the natural and built environment. Our goal is to let people live together with nature instead of living apart from it. Our aim is to spread the story about healthy, innovative and nature-inclusive buildings by providing sound academic research combined with creativity. BOI consultancy consists of seven enthusiastic and motivated students with a passion for nature and its integration within practical applications. All members of BOI Consultancy come from different backgrounds such as urban environmental management, nutrition and health, biology, forest and nature conservation and plant breeding. Combining this diverse knowledge makes BOI Consultancy a multi-disciplined and diverse consultancy firm.

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1. Executive summary

The Natural Pavilion exemplifies a future where buildings are based on a collaboration between nature and design. The Natural Pavilion, located at the Floriade Exposition 2022 in Almere, is currently used as a proof of concept designed and created by De Noordereng Group, assisted by among others Oosterhoff Group B.V. The potential implementation of the natural design elements of this project to other areas in society is enormous and could contribute to creating urban environments that are sustainable and beneficial to both the planet and humans. However, there is a knowledge gap on the exact impact of the Natural Pavilion on its users. This project aimed to investigate the effect of the natural design elements in the Natural Pavilion on the user experience, wellbeing and physical health of the visitors using questionnaires, interviews, sensor data and literature. Overall, the implemented natural design elements were experienced as positive, they led to an improved wellbeing and contributed to a healthy indoor climate. Based on these findings, an advice for future implementation of these natural design elements in elderly care institutions has been formulated. Generally, most natural design elements in the Natural Pavilion will cause a visual experience positively affecting wellbeing in elderly care institutions. However, several design elements need to be reconsidered regarding practical concerns, such as ventilation requirements and temperature regulation.

2. Introduction

Nowadays, a majority of the people spends most time of the days inside buildings (Mengmeng, Li, Hou, Guo, & Fu, 2022). In addition to this, the implementation of natural elements in buildings are generally not considered as top priority (Bessoudo, 2018). Currently, trends have focused more on environmentally sustainable design and construction, however a majority of the buildings is still lacking any connection with nature (Bessoudo, 2018). One of the negative outcomes related to the extensive time spent indoors in these conventional buildings is the sick-building syndrome (SBS) (Redlich, Sparer, & Cullen, 1997). SBS is the process in which people can suffer mentally or physically from spending too much time in a low-quality indoor environment. Symptoms of the SBS include headaches, fatigue and respiratory irritative issues, all caused by exposure to low levels of chemical, physical and biological hazards. This can lead to premature deaths, cardiovascular diseases and asthma (Allen et al., 2015). Therefore, it is vital to investigate the effect of the indoor climate of the building on its users (Prochorskaite & Maliene, 2013). Using natural design elements, such as indoor air quality, natural materials, and natural shapes have proven to reduce the effects of SBS (Al horr et al., 2016; Morsy & Emam, 2019).

Oosterhoff is a consultancy and engineering company that develops and realises innovative concepts, products and knowledge regarding the built environment. Together with several other firms, they assisted De Noordereng Groep in designing the Natural Pavilion (Figure 1) located at the Floriade Exposition in Almere. The Floriade offers a platform for new building designs that support green and sustainable cities. New ideas for implementing nature in urban environments are brought to the public with the goal of inspiring citizens to adopt a healthier lifestyle (Floriade, 2022). The Natural Pavilion functions as an example for exploring sustainable building and construction possibilities. Aesthetic and functional design come together in a futuristic building that connects the inside world with the outside. The design includes several natural design elements to simulate the natural outdoor environment inside. In this research, natural design elements are defined as elements of the building that connect the indoor environment with outdoor environment. Natural design elements in the Natural Pavilion include technical innovations, such as automatically opening windows, large windows in the outside walls, vertical and horizontal shaders for temperature and light control, natural materials, such as wood, straw, mycelium, plants, and sounds from nature.

Figure 1. Schematic overview of the Natural Pavilion (Natural Paviljoen, n.d.)

Whilst a lot is known and measurable on how this building effects the environment, it is not yet clear to Oosterhoff how the visitors experience it and what impact it has. Oosterhoff has commissioned BOI Consultancy to investigate the effect of the natural design elements in The Natural Pavilion regarding user experience, wellbeing and physical health. The aim of this project is to investigate the impact of the Natural Pavilion in mitigating the SBS. Based on these findings, an advice about the transferability of natural design elements in elderly care institutions has been written as this is what Oosterhoff aims to do in the future.

This report starts with the overall advice on the transferability of natural design elements in elderly care institutions. This section is then followed by an explanation of the research questions in chapter 4 and a detailed description of the applicated research methods per subquestion in chapter 5. This chapter also entails an outline of the findings and conclusion in every subquestion. In chapter 6 a summary of all the findings is given. Finally, the discussion in chapter 7 addresses the most important limitations of the research and suggestions for future research.

3. Advice

The following chapter explains the overall advice from BOI Consultancy. The advice is oriented towards implementation in the elderly care sector.

3.1 Elderly care

Occupants of elderly care homes spend a lot of time inside buildings. Natural design elements can have positive effects on health and productivity for both residents and employees (Merrill, Hyatt, Aldana, & Kinnersley, 2011). Judging from our findings, there are some design elements that were perceived consciously by all age groups and elements that were noticed less by the elderly age group. What is deemed healthy or beneficial is also dependant on age. Below are recommendations on implementation in elderly care for each natural design element investigated in the Natural Pavilion. This was done by relating our practical findings to literature research. A limitation is, however, that in

literature, older adults are not often investigated, or only in relation to the outdoor effects of nature (Qiu, Chen, & Gao, 2021; Wen, Albert, & Von Haaren, 2018).

3.2 Natural design elements

In the Natural Pavilion, most of the elements noticed were the same across all ages but a small discrepancy was that elderly people (here defined as 65 or) reported noticing shade as opposed to the below 65 age group which noticed smell, plants and ventilation.

3.2.1 Plants

Smelling of natural plant odours results in improvement in self-rated calmness, alertness and mood (Weber & Heuberger, 2008). This effect is independent of age (Glass & Heuberger, 2016). Research in general has shown that a multisensory experience of plants has a very positive effect on elderly people. Various colours, fragrances and texture combinations in flowers can have physiological and psychological effects on these elderly people. We advise therefore to create zones where there is an abundance of these influences. These zones can be located in or just outside of the complex (Lu et al., 2021). From the point of view of BOI consultancy, it is better to create differentiating zones compared to applying colourful and fragrant plants everywhere, for practicality and costs concerns.

There is evidence that the physical act of gardening is beneficial for physiological and mental relaxation of elderly (Hassan, Qibing, & Tao, 2018). From studies done in the healthcare sector, it's known that gardens and nature can heighten satisfaction with the healthcare provider, for both the patients, their family but also the hospital staff, who face great a great deal of workload (R. Ulrich, 2002). It is advised to create zones with actual and abundant nature. People can in these zones savour nature which has a beneficiary effect (Gritzka, MacIntyre, Dörfel, Baker-Blanc, & Calogiuri, 2020). Zonation can also deal with personal preferences for environmental circumstances within a building.

3.2.2 Materials

Overall, the materials were mentioned plentiful across the board. Especially wood has been proven to have regenerative effects in a care setting. It has appealing aesthetics and structures, high contact comfort, pleasant smell, possibility to regulate air humidity, volatile organic compound emission and acoustic well-being (Verma, Cronhjort, & Kuittinen, 2016). We do advice to take into account cleaning and care. Especially because wood in contact with humans does get dirty. When the wood is dirty the antimicrobial effect is reduced (Kotradyova et al., 2019). Therefore, we advise to protect the wood that is in contact with humans. The wood that is not in contact with humans can be left unprotected to serve its benefits. We do suggest increased education for architects and interior designers about the benefits of wood in hospital spaces. That should include education about implementation of more practical and usable use of natural materials. Wood positively touches upon the different sensory experiences of seeing, smelling, touching and hearing. For that reason, we advise to extend the user experience to include more touching if natural elements. Practical concerns among elderly are the maintaining and cleaning of the natural materials. The relief of the natural materials may attract more dust which can affect health and air quality. Whether this is the case has to be concluded from further research.

3.2.3 Humidity

In an elderly health care setting, it is necessary to refrain from sudden changes in humidity or temperature, as this can have adverse health effects on elderly people (H.-W. Wu, Kumar, Yu, & Cao, 2022). However, we do believe in a varied inside environment. One could suggest creating zones that

differ in humidity, but more research is needed for this. The humidity in the Natural Pavilion is on the high side. We therefore advise extensive monitoring to prevent the development of harmful mite and fungi and prevent damage to the wood.

3.2.4 Natural ventilation

Implementing (natural) ventilation is of high importance. It influences both physical health and mental well-being. It could therefore be worthwhile to advance with the current natural ventilation system in the Natural Pavilion. In literature, elderly people have shown a preference for cooling via Natural Ventilation (Y. Wu et al., 2019).

3.2.5 Personal control

People spoken to in the Natural Pavilion displayed a preference for personal control over ventilation, temperature and light. It may be helpful to implement this alongside natural design elements in these areas.

3.2.6 Light

Indoor light requirements for elderly are higher than those for young people. The natural lighting system in place in the Natural Pavilion can meet these requirements however more needs to be investigated about meeting requirements of different room functions. In literature where health care patients benefit positively from a light environment (Rasmussen, Mathiasen, Lygum, & Sigbrand, 2021). An issue that came up with the natural lighting system present is that the shaders disrupted views, whilst another issue found in literature was that privacy is an important in determining whether paediatric hospital patients use a window overlooking a garden or not (Sherman, Varni, Ulrich, & Malcarne, 2005). For these reasons it may be necessary to investigate both private but less disruptive shading mechanisms in order for the natural lighting system to reach its full potential of transferability to the elderly care sector.

3.2.7 Costs

We advise to use an adapted design strategy to give more attention to the effect that the building will have on the mental and physical health of its user. The costs may rise but this is however justified/outweighed by the benefits natural design elements inside will bring (Prochorskaite & Maliene, 2013).

4. Integrative purpose and research questions

4.1 Integrative purpose

The purpose of this project is to find the effects of natural design elements in buildings on mental and physical health and find which of these elements are most effective. The Natural Pavilion at the Floriade is a case study and potential implementations in elderly care institutions are explored. A visualization of the integrative purpose can be found in **Fout! Verwijzingsbron niet gevonden.Fout! Verwijzingsbron niet gevonden.**2.

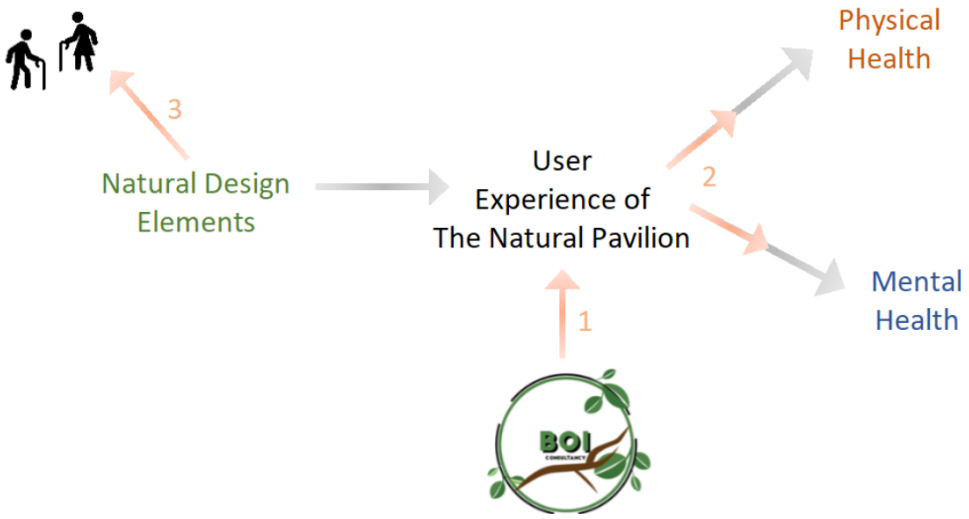


Figure 2. Visualization of the approach: orange arrows indicate the role of BOI consultancy to evaluate user experience (1) as a tool to establish links between design elements and physical/mental health (2) and to write a final advice (3)

In the context of the problem, the following research questions have been formulated:

"What is the user experience of people visiting the Natural Pavilion and how is this linked to physical and mental wellbeing?"

The following sub-questions support this general research question:

- **SQ1:** What are the most prominent natural design elements in user experiences from the Natural Pavilion?
- **SQ2:** How do people experience the effects of the natural design elements in the Natural Pavilion?
- **SQ3:** What physical health effects can be deducted from the user experience of natural design elements?
- **SQ4:** What effects on wellbeing can be deducted from the user experience of natural design elements?

5. Research methods, findings and conclusion

The following chapter is divided per sub research question. For each sub research question, the goal, research methodology, data analysis, findings and conclusions are described.

The sub questions complimented each other in the research. The outcome of sub question one was used as input for the social science set-up of sub question two. The outcome of sub question two was explained by the outcomes of sub questions three and four. Therefore, methods and findings are both presented in this chapter. The activities and outcomes for each sub question are shown inFigure 3. **Fout! Verwijzingsbron niet gevonden.**

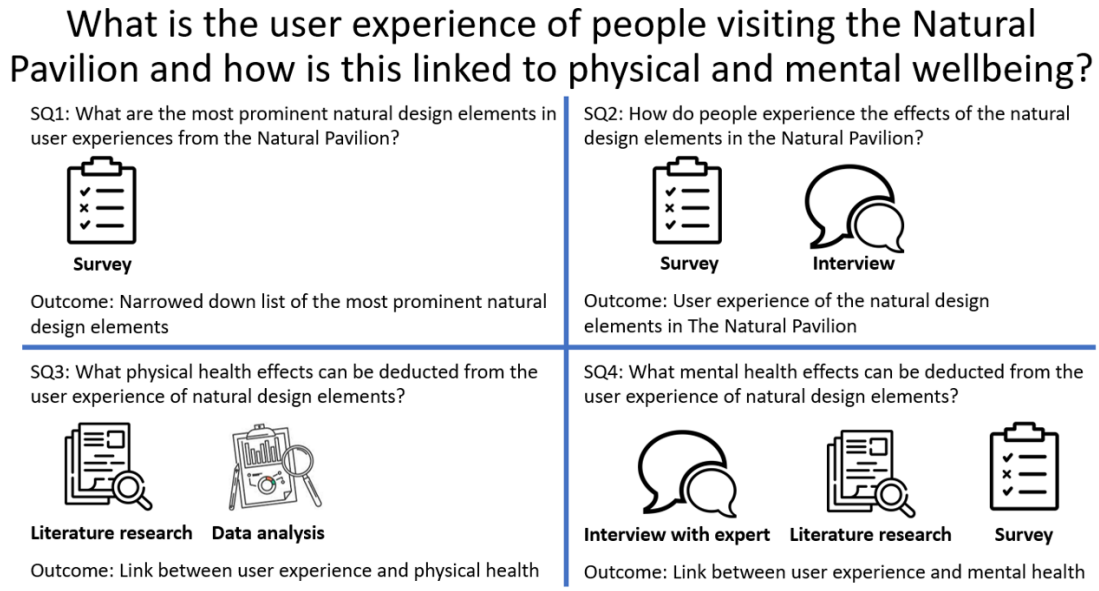


Figure 3 Overview of the activities. Activities per research question.

5.1. Sub question 1: What are the most prominent natural design elements in user experiences from the Natural Pavilion?

The aim of SQ1 was to explore what elements in the Natural Pavilion are most impactful to the visitors. First, a list of natural design elements has been created based on existing documents provided by Oosterhoff Group B.V. as well as what the BOI consultancy team noticed upon an exploratory visit to the Natural Pavilion. This list was used to analyse the results of a 5 Seconds Test (5ST). This list was also used as a basis for conducting a self-report Likert scale test on impact. The combined results of these two tests were used to create a final list of the most impactful natural elements to visitors in the Natural Pavilion. This list is then used further in SQ2, as explained in subsection 5.2.

5.1.1 5 Seconds Test

Methodology

In order to determine a focused list of natural elements on which to determine impact, a list was obtained from Oosterhoff of the natural elements present in the Natural Pavilion:

- Controlled natural ventilation
- Use of daylight
- Use of shading
- Natural climate control (no heating or cooling)
- Plants growing in the building

For ease of compiling these elements into a survey, and because there were not many plants present inside the building, this list was edited to:

- Ventilation
- Light
- Temperature
- Plants

Further elements (below in **bold**) were added to the list based on what we as a team noticed during our first exploratory visit to the Natural Pavilion. The final list of elements on which impact would be examined was:

- Ventilation
- Light
- Shade
- Temperature
- Plants
- **Smell**
- **Colour**
- **Sound**

When measuring 'impact', this research focused on both implicit and explicit impact. Implicit impressions are formed unintentionally and subconsciously whilst explicit impression is about a person's spontaneous deductions and evaluation (Okten, 2018). Since implicit impressions are more linked to the memory of a person, memory tests are often conducted research methods. To measure the implicit impression of design elements in the Natural Pavilion, an adapted version of the 5ST was performed on visitors after they had left the Natural Pavilion (Gronier, 2016). In the original 5ST, participants view an image for five seconds and recall what they remember from it (Gronier, 2016). As the aim was to gather information on more than just visual impact, an image would not have been appropriate. Furthermore, it is impossible to stipulate a five second limit on the visitors experience since entering and visiting the building takes longer than five seconds. For this reason, a modified version of the 5ST was used. Instead of limiting the visitor's time in the building, the visitor's response time was limited.

It was necessary to think of how meaningful responses from participants could be gained now that the 5ST was adapted. Response time can be used in many studies to determine and limit non-effortful responses (Soland, Kuhfeld, & Rios, 2021). Some sources suggest that time limitations can cause participants to answer more accurately (Kyllonen & Zu, 2016). More specifically, it has been shown that for memory tests, time deadlines have resulted in increased efficiency (where efficiency is defined by both speed and accuracy) (Malmberg, Lehman, Annis, Criss, & Shiffrin, 2014). The exact time constraint stipulated for this specific test still had to be determined. Because the 5ST is an example of

a speeded task where the focus is on participants reporting back on items that are simple enough so the participant always knows the "correct" answer, it is possible to account for participant processing speed by computing mean response time participants use to give answers (Kyllonen & Zu, 2016).
For this reason, a pilot trial was conducted to determine how long it takes to recall at least five elements present in The Natural Pavilion. This pilot trial was conducted on group members, which were granted an initial time of 30 seconds. The pilot trial was then extended to 22 visitors of the Natural Pavilion for whom the time was finalised at 30 seconds. Besides adjusting the time limit of the 5ST, the proposed question given in the test was also adjusted. The question asked in the pilot trial was: *"What do you remember about your visit to the Natural Pavilion?".* As the Natural Pavilion also hosts expositions, people also mentioned elements from the exposition they visited. These answers were not useful for answering the research question as they did not say anything about the building itself. The adjusted question was therefore: *"From when you were in the building, what from the natural elements of the building do you remember seeing/hearing/smelling and feeling not including the expositions?".*

Another finding of the pilot trial was that a lot of Dutch and German people were visiting the Floriade and the Natural Pavilion. For that reason, the 5ST and the other English research methods were translated into Dutch and German. For a complete overview of the test, see appendix 1.1. In order to explore several implicit and explicit impressions from visitors and have enough time to analyse the data, the aim was to conduct 40 tests and have an equal number of participants above and including the age of 65 (65+) and below the age of 65 (65-). The threshold was set at 65, as this was the retirement age until 2013, and people from that age group might have developed opinions about their future homes.

The test was conducted on Thursday June 2nd 2022 from mid-morning to mid-day. The weather was sunny with clear skies, wind speed of seven km/h, and maximum temperatures of 19°C. Visitors that were exiting after spending some time in the Natural Pavilion were approached by a duo of researchers just outside of the building. Visitors were invited to partake in the 5ST after a short introduction to the interviewers and the project. When they agreed to participate, they were given a short verbal explanation of the adapted 5ST. After asking the question, one interviewer watched the time, while the other took notes of the responses. After the interview, the participant's age was asked and noted. If participants answered the question in a group, the ages of all contributors were noted.

Data Analysis

Data analysis was done in Excel. During the analysis of the tests, the impact of each element was determined based on frequency of appearance of the related code. The code form (see **Fout! Verwijzingsbron niet gevonden.**) shows how the coding of responses was performed. The criteria for each code are conceptualised based on own interpretation after going through the 5ST interviews. The criteria were added to the code form that has been used as a tool for coding the data according to each element (Bryman, 2016). The three most frequently mentioned categories were chosen to be the most impactful.

Table 1. Code form with criteria and code to categorize the data of the 5ST according to the elements

Element	Code	Criteria
Ventilation	V	open, space, high, air, breathing, fresh air, claustrophobic, stuffy, closed space, surrounded, draft, empty
Light	L	windows, glass, sun, light, bright, brilliant, sunshine, clear,
Shade	SH	shade, dark, shadow, inability to see
Temperature	T	cold, warm, comfortable temperature, temperature, freezing, hot, refreshing
Plants	P	plants, nature, greenery, flowers, garden, growing, farming
Smell	S	smell, scent, aroma
Colour	C	(any colour mentioned)
Sound	SO	sound, soft, loud, stifled, dampened, acoustic, muffled, echo, deafening, talking, voices, footstep/walking sounds, birds
Natural Materials	M	wood, straw, floor, reeds, bamboo, materials, timber, walls, seed floor, coconut, cork, plywood, bark, isolation material
Flexibility/ Versatility	F	modular, many layers, variety, different, flexible, versatile,

Findings

In total there were 66 surveys conducted of which 22 belonged to the pilot trial. 18 of the participants were aged 65+ and the remaining 48 were aged 65-.The results of the 5ST are that the elements which had the biggest implicit impact were **materials, plants, smell** and **ventilation**. The results differed slightly per age category. In both cases materials and plants were mentioned most often. In the 65+ category all other elements were only mentioned once or not at all whilst the 65- category also mentioned smell and ventilation nine and six times, respectively.

5.1.2 Self - report Likert test

Methodology

Explicit impression can be understood with “self-report tests” such as evaluations and ratings (Okten, 2018). To measure the explicit impression of visitors, a self-report tests was conducted. Several existing self-report tests have been adjusted to investigate landscape experiences of individuals (Karmanov, 2009). Based on this, visitors in the Natural Pavilion were asked for their level of agreement on the statement “The listed element in The Natural Pavilion stood out.” Per natural design element defined in the list above using a commonly used Likert scale of 5 optional responses ranging from “completely disagree” to “completely agree” and including an option “neutral”(Joshi, Kale, Chandel, & Pal, 2015). Another additional question was included where respondents could fill in what element or topic they thought was missing in the survey (see appendix 1.2). The aim was to conduct 40 tests and have an equal number of participants aged 65+ and 65- (participants could fill out their age on the survey). If older visitors have a different perception of natural design elements compared to younger visitors, this might have consequences for the use of data obtained from the younger age group for application of the findings in elderly care buildings. Surveys were done on the ground floor and the second floor, (also the upper floor), and were marked accordingly. Differences in perception of natural design elements between floors could indicate variability of the effects of these elements per floor. The different floors were not designed to show these differences, however, their occurrence could not be excluded. The test was conducted for 2 hours from mid-day to mid-afternoon on Thursday June 2nd 2022. The weather was sunny with clear skies and temperatures of 18 °C.

Data Analysis

In total 43 self-report tests were conducted on 16 people aged 65+ and 28 people aged 65-. Likert scale data was analysed (Bhandari, 2020), whereby most frequent response or "mode" was determined for each element in the list. Elements were deemed the most impactful when participants responded with "completely agree" or "agree" to the statement. Elements were understood to be less impactful when participants responded with "neutral". Elements were considered not impactful when participants responded with "disagree" or "completely disagree". The 3 most impactful elements were therefore chosen based on the highest frequency in the "agree" and "completely agree" categories.

Findings

According to the self-report tests performed inside the building, overall **temperature** and **light** were the most explicitly impactful natural elements. **Ventilation** was also frequently marked with "completely agree" as well as mentioned in the 5ST described above. The difference in opinion between participants aged above 65 and below 65 was minimal. The elements to which participants "completely agreed" and "agreed" most were temperature and light in both age groups. Differences arose when people aged below 65 noticed plants and colour more whilst those aged above 65 noticed shade. In total, 27 surveys were conducted on the ground floor and 16 on the second floor. There were small discrepancies between different floors. Light and temperature still played a leading role in impact on both floors with temperature being especially noticed on the ground floor. Additional to this, on the ground floor people noticed smell whilst on the second-floor plants were reported as impactful. The answers to the self-report Likert test can be found in Table 2. The overall level of agreement and the distribution over the categories is shown.

Table 2. Answers to self-report Likert test. Question "Did we miss anything?" is excluded from this table. All = total number of responses, GF = Ground floor, 2F = Second floor.

	Completely disagree			*Disagree*			*Neutral*			*Agree*			*Completely agree*		
	All	65+;65-	GF; 2F	All	65+;65-	GF; 2F	All	65+;65-	GF; 2F	All	65+;65-	GF; 2F	All	65+;65-	GF; 2F
Venti-lation	2	0;2	2;0	2	1;1	1;1	6	1;5	3;3	21	9; 12	14;7	12	4;8	7;5
Light	2	0;2	2;0	1	0;1	1;0	2	0;2	2;0	24	10;14	15;9	14	5;9	7;7
Shade	1	0;1	1;0	6	2;4	4;2	11	6;5	8;3	16	4;12	9;7	9	3;6	5;4
Temp-erature	1	0;1	1;0	1	1;0	1;0	3	2;1	3;0	21	5;16	10;11	17	7;10	12;5
Plants	1	0;1	1;0	9	1;8	9;0	13	5;8	9;4	10	4;6	5;5	10	5;5	3;7
Smell	2	0;2	2;0	4	0;4	3;1	11	4;7	6;5	17	8;9	13;4	9	3;6	3;6
Colour	0	0;0	0;0	6	1;5	6;0	14	3;11	8;6	17	8;9	11;6	6	3;3	2;4
Sound	1	0;1	1;0	6	2;4	6;0	16	7;9	9;7	18	5;13	10;8	2	1;1	1;1

Conclusion

The final list of most impactful elements at the Natural Pavilion was deemed: **materials, plants, smell, ventilation, light, temperature**. There was very little overlap in elements which were most explicitly impactful or most implicitly impactful, namely only ventilation was noticed as both. The differences between participants aged 65+ and 65- were minimal as the top 3 most elements were the same for both categories and both tests. Differences which did occur were mostly due to the 65- category noticing elements which the 65+ category did not. These elements were plants, smell, colour and ventilation. Only in one instance did the 65+ group notice something which the 65- age group did not; this was shade. Because it was not possible to get a high number of participants with an equal representation of age, and because the results of the different age groups did not have major differences in response, it was decided that the responses should be combined.

5.2. Sub question 2: How do people experience the effects of the natural design elements in the Natural Pavilion?

After creating the final list of the most impactful elements in SQ1, the aim of SQ2 was to explore how and why people experience the specific natural design elements of the Natural Pavilion. This question was answered using a survey and by conducting several qualitative interviews.

5.2.1 Survey

The goal of the survey is to find about how visitors experience the most impactful natural design elements in the Natural Pavilion.

Methodology

The survey was designed according to the Likert scale, which was used earlier in sub question one. in order to determine more in-depth viewpoint from visitors on elements named in SQ1 (Joshi et al., 2015). The main design themes from Oosterhoff were taken as a starting point, namely natural ventilation, natural climate control, optimal use of daylight and plants. Next to these four categories, the theme “materials” was added, based on the outcome of SQ1. Per category, 3 to 5 statements were formulated. A reoccurring statement per category was ‘I would enjoy living in a house with [*natural design element*] to make a first estimation of the applicability of the outcomes. Finally, this process led to 22 statements relating to the natural design elements in the Natural Pavilion (see appendix 2.1). These statements vary in their wording and phrasing, in order to actively keep the respondent’s attention to the survey. Next to the statements, the age of the participants was asked. Surveys were translated from English into Dutch and German by native Dutch speakers, the German translation was subsequently checked by a native German speaker.

Participants were asked to fill in their opinions while the researching team remained nearby in order to be available for questions. Participants were either Dutch, German or English speaking and had to have been in the Natural Pavilion for at least ten minutes. The participants were approached usually when they left the building or came back down from the stairs, to ensure that they met the time requirement. A number of 40 participants was aimed for, as that number could be reached within our time availability and was expected to reflect different opinions of the visitors. On Thursday 9th of June 2022, between 10:30 and 12:30, 40 participants filled out the survey. This took place inside of the

Natural Pavilion, on both the ground floor as well as on the second floor. The weather at this time was 18 °C, mostly sunny and the wind speed was 20 km/h.

Data analysis

Using Excel, responses to each of the 22 statements was standardized, so that it represented a percentage of the total answers to that particular statement. Next, graphs (per statement, and all combined) were made to visualize the levels of agreement. A potential difference in opinion between floors or age groups was researched by a distinction between the surveys that were filled out on the ground floor and second floor and age categories. In accordance with SQ1, the age categories were defined as 65 years and older (65+) and younger than 65 (65-). Differences between age groups would indicate that the applicability of a certain natural design element would be different for elderly care buildings than for buildings for a broader audience. One participant did not fill in their age, this survey was categorized as 65- based on the participant's appearance. A distinction between age groups on the second floor could not be made because out of ten participants, only a single person belonged to the age category 65+.

The number of responses for the statements varied between 20 and 41 because statements were either filled in twice, statements were forgotten to respond to, or statements were lost in translation. For statements that were responded to twice, the average response was taken if the responses were opposite. Both responses were used in data analysis if one of both answers was 'neutral'. The statements that were accidently lost during the translation from English to Dutch and from English to German were 'I enjoy seeing plants inside of buildings I use.' In the Dutch survey, which was responded to 20 times, and 'I would enjoy living in a house with growing plants in the building.' In the German survey which was responded to 27 times. Nevertheless, the standardisation of the responses allowed the use of all statements in data analysis.

Findings

In total 40 visitors participated in the survey, of which 30 on the ground floor and 10 on the 2nd floor. 14 participants were 65+, 26 participants were 65-. The only significant difference between the two age categories was regarding the statement "I did not miss plants on the inside". The 65+ age category mostly agreed, whereas the 65- category disagreed (see **Fout! Verwijzingsbron niet gevonden.** and 5). For all other statements, there was no difference in opinion between older and younger than 65 years old participants (appendix 2.3). Overall, visitors would enjoy living in a house with wind-dependent ventilation. The air quality was deemed as not stuffy with enough fresh air, and the humidity was perceived as not too high. Visitors would also enjoy living in a house that is mainly lit by daylight coming in through large windows, and according to visitors, it was not too bright or dark inside, and neither was there too much sunlight inside. The visitor's opinion about living in a house with shaders varied between neutral and agree, although the general opinion stated that the shaders did not disrupt the outside view. Visitors also indicated that they would enjoy living in a house that uses natural climate control and experienced the temperature of the Natural Pavilion as comfortable. There was a difference between age groups on the statement "I did not miss plants on the inside". Most visitors older than 65 agreed while most younger visitors disagreed. Most visitors enjoyed seeing plants inside buildings they use and agreed that the indoor gardens provided enough ambience in the building. Besides they would enjoy living in a house with plants growing in the building. Visitors generally would enjoy living in a house mainly built from wood, and they agreed that the use of wood made them want to touch it. It was agreed to that the use of glass created an open space and visitors would enjoy living in a house with big windows. Most visitors reacted neutral or positive on using a floor made of seeds in their own house No differences were detected between floors. For all

statements except the one mentioned before, there was no difference *in opinion* between older and younger than 65 years old participants.

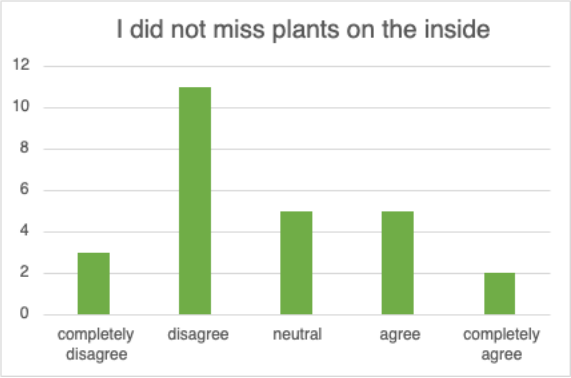


Figure 4. Opinion on statement by 65- age group

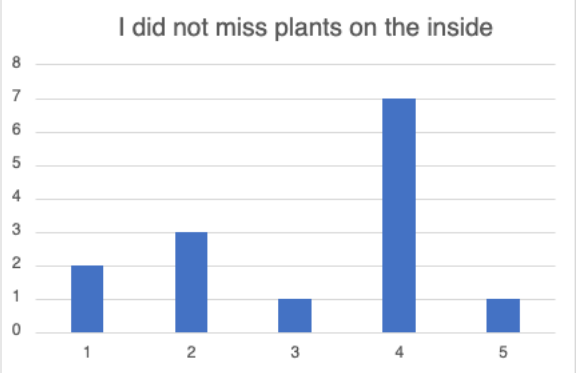


Figure 5. Opinion on statement by 65+ age group

5.2.2. Interviews

The goal of conducting interviews was to gain qualitative and in-depth understanding of the user experience in The Natural Pavilion by asking visitors for their opinion on the natural design elements (Bryman, 2016).

Methodology

The interview consisted of open-ended questions divided in six categories related to the natural design elements retrieved in SQ1. A semi-structured interview has been conducted meaning that it consisted of two predetermined questions per category, each followed by optional questions in order to go more into depth (Bryman, 2016). The first predetermined questions were related to people's opinion about natural ventilation, use of daylight, shading, temperature, plants and material in the building. The second predetermined question related to the implementation of these elements in people's own house to get an understanding of the transferability. The interview questions can be found in appendix 2.4. The aim was to interview 8-10 participants in order to explore multiple perspectives and to reserve sufficient time to process and analyse the data. In practice, nine interviews were done, all of which on Monday, 13th of June, between a quarter to three pm and five pm. Four of the interviews were done in couples, which were counted as two interviews being done simultaneously. The duration of the interview was 5-10 minutes per person. To explore differences between the same age groups as used in SQ1 and the survey of SQ2, the aim was to interview 50% of people < 65 year and 50% ≥ 65 years. The participants were required to have spent at least ten minutes in the Natural Pavilion to ensure a

minimal user experience of the building. Since none of the group members that were present could speak German, only Dutch and English-speaking visitors were approached. Of the approached visitors, only Dutch speaking visitors agreed to partake in the interview. Given that nationality was not the main focus of the research, no effort was made to find a more diverse sample of visitors.

Data analysis

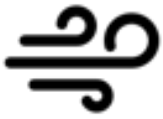
The recorded interviews were not transcribed as the core of the answers was more useful for data analysis than the exact wording by the respondents. Instead, summaries were written while listening to the recordings. Per category, a summary of the opinion of the natural design element and the implementation of it at people's home was written and interesting quotes were added.
In addition, the summary of opinions was further analysed by labelling each opinion as 'positive' or 'negative'. The same was done with the question regarding implementation in their own home. If the only reason for not implementing a natural design element into the own home was because of the condition of that building, and the general opinion on the natural element was positive, the opinion was marked as 'positive', regardless of the respondent not wanting to implement the natural design element in their own home. The general opinion per natural design element was labelled as:

- 'all positive', if every respondent would like to implement an element into their own home,
- 'mostly positive', if seven or eight out of nine respondents would implement an element into their own home,
- 'divided', if three to six respondents would implement an element into their own home,
- 'mostly negative', if one or two respondents would implement an element into their own home, and
- 'all negative', if no respondents would implement an element into their own home.

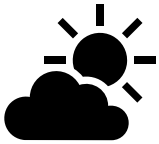
The general opinion on the elements in the building is mainly used to answer this sub question. The results about implementation at home have been used as input for the advice section on the future transferability of the natural design elements which will be discussed in the advice chapter.

Findings

Based on the nine interviews, the following results were found. In addition, some quotes are presented (translated to English) to illustrate the participants opinions.



Natural ventilation and the implementation of it at home was viewed as all positive. However, several practical concerns on the automatic ventilation system were mentioned regarding safety against burglars and insects and temperature regulation in summer.
"Natural ventilation is a must for us. Our windows are almost always open."



Large windows were viewed as mostly positive. Some negative opinions were given based on privacy, the possibility that birds fly against windows, and temperature regulation. The opinion on shaders was divided. Positive opinions were based on the control of the building user on the amount of sunlight inside. Negative opinions were based on the disturbance of the outside view and the feeling of being behind bars it caused.
"I am a big fan of daylight, you can never have enough! And you experience that here too."

Temperature was viewed as positive by all.

The opinion on plants was all positive since most of the participants liked the view on the indoor gardens and the connection with outside. Although, a preference for plants on the ground floor over plants on the first floor balconies was also mentioned by two participants. Additionally, concerns about maintenance and watering were mentioned.

"I like the balcony gardens on the first floor. They connect you with outside in a different way."

The opinion on material was mostly positive, which was explained by decorative qualities, a nice smell and warm colours of the materials that were used. However, some participants mentioned that the natural materials made some areas too dark. Other concerns referred to the quality of unprocessed material on the long-term, maintenance and cleaning of the materials.

Conclusion

Based on the survey and interviews, it can be concluded that most people stated that there was enough fresh air in the building, meaning that the visitors are positive about the natural ventilation, although there were some practical concerns about implementing these elements in their own house. Secondly, most participants were positive about the amount of sunlight in the Natural Pavilion meaning that the optimal use of daylight is experienced as pleasant, and most people would enjoy the same amount of daylight in their home. Some participants completely disagreed on shaders disrupting the view, however several completely agreed on this statement. In addition, some remarks about feeling trapped were made, caused by the shaders. So, the experience of the shaders and its influence on the view differs. The temperature in the building was experienced as comfortable as the natural climate control did not make the space too hot or too cold. Most participants experienced a connection with outside through the indoor gardens and experienced the view at the greenery as pleasant. Additionally, most people aged 65+ did not miss plants inside whereas younger visitors experienced a lack of plants. Finally, most participants experienced the use of glass windows as positive as it created an open space and liked the use of wood in the building. In addition, the warm colours and decorative appearance of the materials in the building resulted in a positive experience for most participants. However, some practical concerns resulted in a more critical experience for other participants. Most participants were neutral about implementing a seed floor in their own house, meaning that this material was not favourable for most visitors.

5.3. Sub question 3: What physical health effects can be deducted from the user experience of natural design elements?

The aim of SQ3 is to examine the conditions of the Natural Pavilion and determine, based on literature, if the natural design present is capable of maintain conditions which are healthy in a physical sense. We define health as the ability to adapt and self-manage, considering the physical, emotional and social challenges of life (Huber et al., 2011).

5.3.1 Literature Research

Methodology

This literature research gives an overview of the natural design elements inside a building and shows how it is related to physical health. As such, no systematic search or synthesis has been done, but instead, several search terms were used in PubMed. Articles were scanned for relevance related to indoor environment (e.g. light intensity, CO_2, temperature and humidity), nature benefits and physical health was included. Examples of search term are for temperature: “heated”, “cooled”, “comfort”, “indoor”, “health”, “temperature” “human temperature”, “living temperature”, “natural temperature”. Similar searches were performed for the other indoor environment categories. When relevant articles were found, a snowballing method was used to find additional relevant articles. Final results were analysed in order to answer the third research question. Due to a limit of project time, we focused on studies relating only to known values and standards for the sensor data we collected in the Natural Pavilion as well as briefly looked into the effects of meeting or not meeting these standards.

5.3.2 Sensor Data

Methodology

On every floor in the Natural Pavilion a sensor was placed which measured light intensity, CO_2 concentration, air temperature and air humidity. The specific sensors are *Sensi sensors* from the company Huygen (Huygen, -). All sensors were positioned at a height that is within the range that is advised by the National Institute for Public Health and the Environment (in Dutch: (RIVM)). The advice is between 1.5 and 4.0 m above the ground. Sensor 1 (ground floor) was placed 210 cm high, sensor 2 (first floor) was placed 232 cm high, sensor 3 (second floor) was placed 260 cm high. The data of all sensors from 31st of May till 13th of June 2022 was used. The data was downloaded from the dashboard https://sensi.huygen.net and analysed with Excel.

Data Analysis

Results were analysed per category. An average day/timepoints-score (00:00-00:00) was calculated with data from the fourteen measurement days. Meaning that the average CO_2 concentration at 09:00 was calculated from the combined CO_2 concentration at 09:00 of every day and divide by 14. The minimum score was a minimal CO_2 concentration measured in the period of our data analysis. The same is true for the maximum score. Identical analysis was executed for temperature and humidity. Light intensity was analysed in a different way. The average score per day over a 14 day-period was calculated (from 00:00-00:00), together with the average score per working-day hours (09:00-16:45) over a 14-day period. Data of one afternoon, 13th of June from 12:30 – 16:45, was used to compare the light intensity with a comparison building with no windows (see appendix 4 for a picture).

Findings

CO_2

Healthy CO_2 concentrations should not exceed 1000 ppm.

CO_2 is important for human health and an indicator for quality of indoor ventilation. The higher the CO_2 concentrations, the worse the room is ventilated. In general, CO_2 concentrations above 1000 parts per million (ppm) are related to adverse health effects (Gaihre, Semple, Miller, Fielding, & Turner, 2014). For example, heart rate increases with 2 beats per minute per increase of 1000 ppm CO_2. In addition, a two-fold increase in ventilation rate results in an estimated improvement in productivity of 1.7% (Wargocki, Wyon, Sundell, Clausen, & Fanger, 2000). The number of building users determines the level of CO_2 inside, because humans emit CO_2. This process is shown in the sensor data of the Natural Pavilion as well (see and figure 7), as the CO_2 concentration rises during the day, when visitors and staff enter the building, and it drops during the night. People are 2.1 times more likely to suffer from sick-building syndrome with an increased level of CO_2 (Arikan, Tekin Ö, & Erbas, 2018).

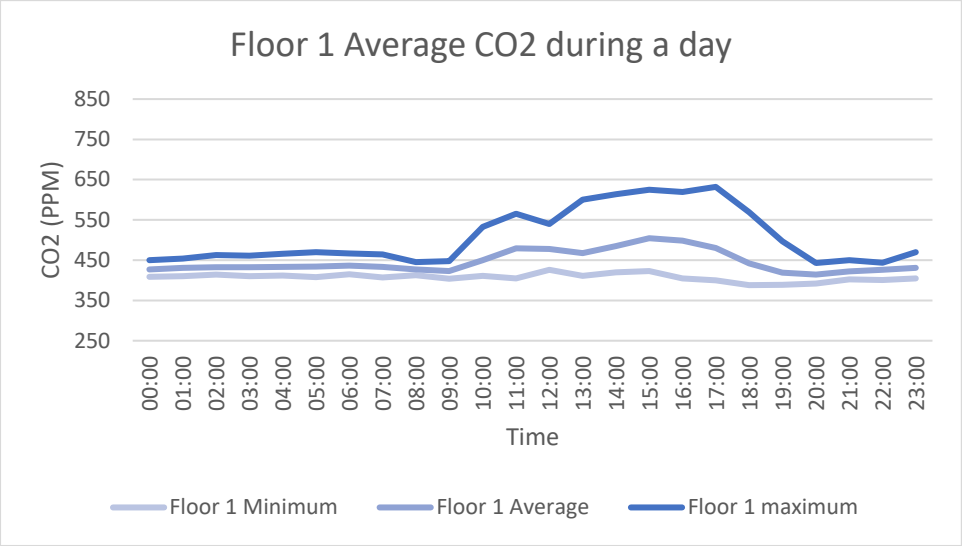


Figure 6 . The minimum, maximum and average CO2 (ppm) measured over the 14-day span.

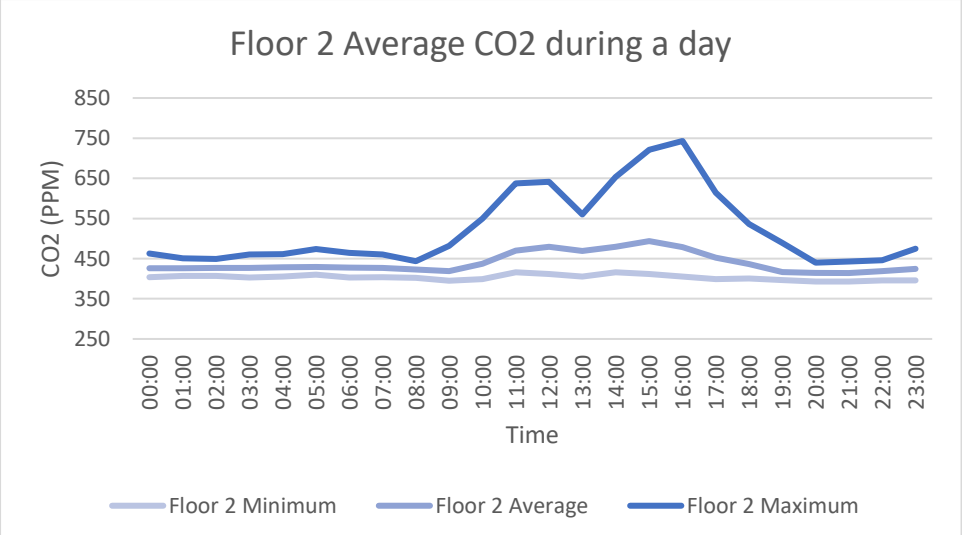


Figure 7 The minimum, maximum and average CO2 (ppm) measured over the 14-day span

At the Natural Pavilion an average daily level of 466 parts ppm was present during regular working hours (09:00 – 17:00) (see Figure 6). The highest measured CO_2 concentration was around 750 ppm (16:00, second floor, see Figure 7). The lowest concentration was 388 ppm (18:00, first floor), which is similar to normal concentrations for outdoor air (Health, 2022). In addition, there are minor differences seen between the two floors.

Temperature

It was not possible to indicate what the optimal temperature for a healthy indoor climate is, as it differs per individual and context. However, extremes should be avoided.

Temperature is important for both comfort and health. Whilst exact indoor healthy and comfortable temperature ranges are not known, ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning) indoor thermal comfort temperature zones are 24 °C to 29 °C in summer and 19 °C to 25 °C in winter (Albatayneh et al., 2021).

Studies have, however shown that temperatures above 26 could exacerbate symptoms of diseases related to blood pressure, blood glucose, cognition, mental health, influenza, respiration and physical functioning (Tham, Thompson, Landeg, Murray, & Waite, 2020). Negative health effects are also present for temperatures which are too cold. During winter, indoor temperature is more important than outdoor temperature in determining the blood pressure of building users (Saeki et al., 2014). In general, it can be said that a colder house is associated with a higher systolic blood pressure, which is a bigger risk for stroke and heart disease than elevated diastolic blood pressure (Brunström & Carlberg, 2018).

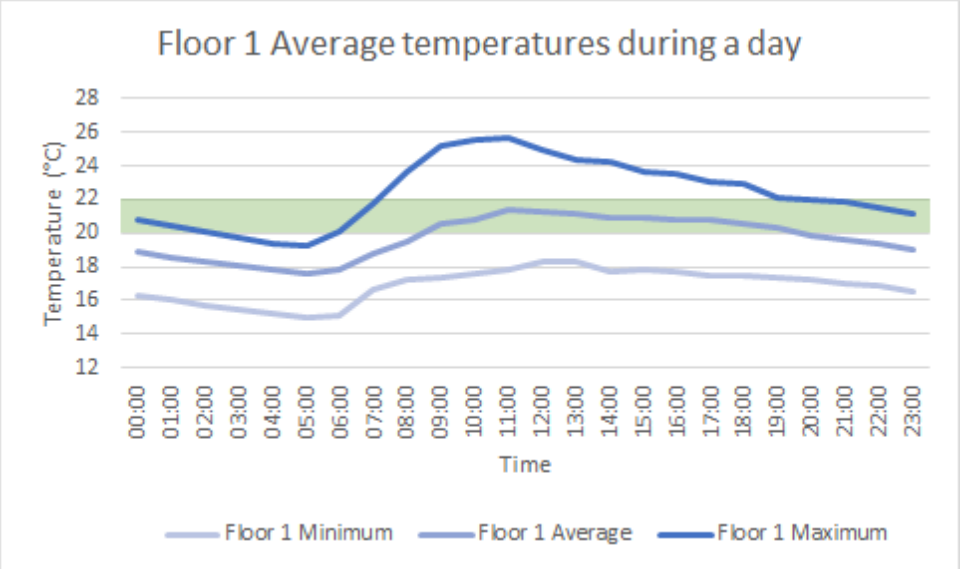


Figure 8 Shows the average temperature at the Natural Pavillion, with the minimum and maximum measured values indicated by the light and dark blue lines.

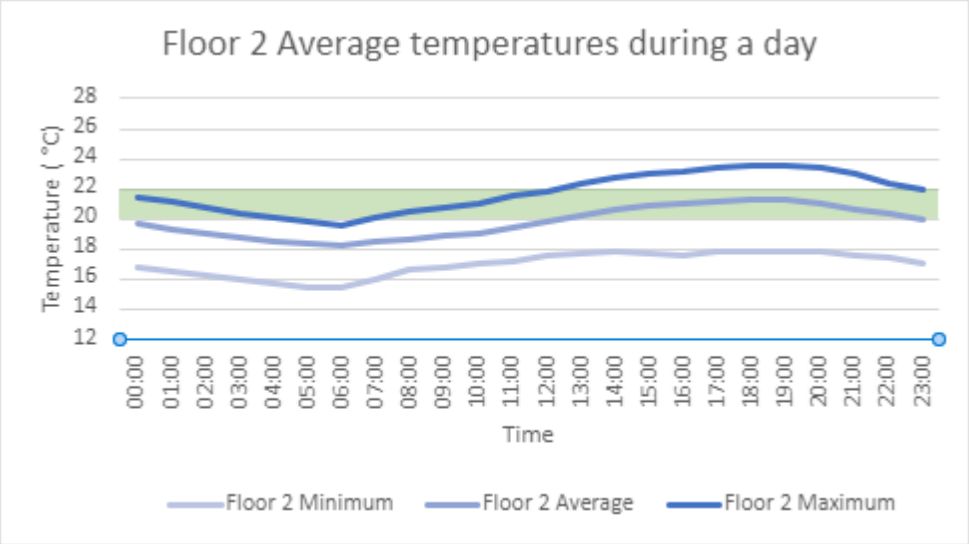


Figure 99 Shows the average temperature at the Natural Pavilion at the second floor. The middle blue line indicates the average temperate at a specific time based on measurements of 14 days. The dark blue line and the light blue line show respectively the maximum

At the first floor of the Natural Pavilion, the daily average temperature fluctuates between 17,6 and 21,3 °C, see**Fout! Verwijzingsbron niet gevonden.**) The second floor reached in general a lower temperature compared to the first floor (see Figure 99). A maximum temperature of 26,6 °C is reached at 11:00 at the first floor, while a maximum score of 23,6 °C is reached at 19:00 at the second floor.

Humidity

Healthy indoor humidity is a range between 40-60%

Humidity is important for human health, as dry air is related to sensory irritation in the eyes and upper airways (Wolkoff, 2018). In addition, viral upper airway infections such as COVID-19 spread faster in dry air (Ahlawat, Wiedensohler, & Mishra, 2020). On the contrary, a high humidity can also be detrimental to health. It can cause a feeling of stuffiness especially in combination with high temperatures. People who describe their environment as “stuffy” are 2.6 times more likely to suffer from sick-building syndrome (Arikan et al., 2018). In general, a humidity level of 70% or higher is related to health problems, but some people experience health problems at already 50%. This is mostly related to multiplication of mites and the spread of airborne fungi (Jokl, 2002). As such, it's important that an optimal humidity is maintained in an indoor environment.

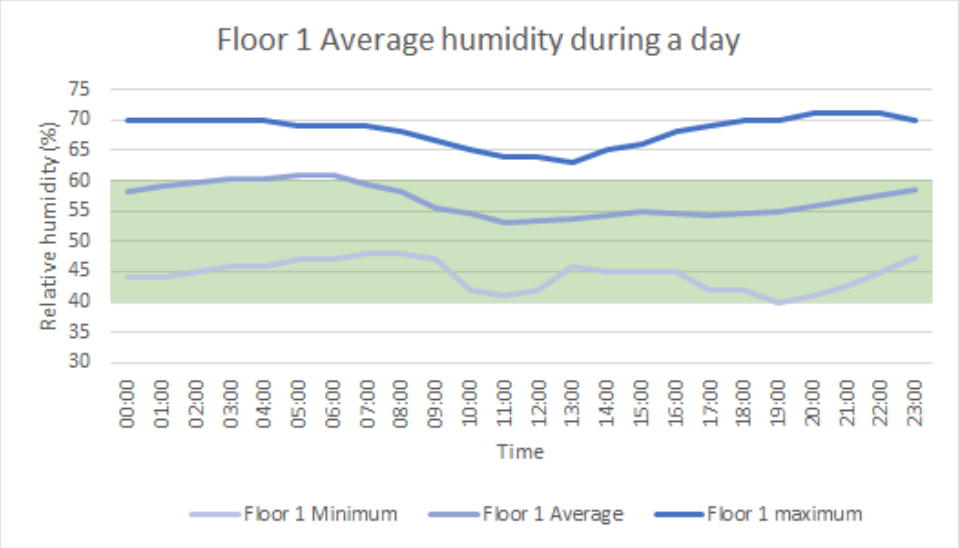


Figure 10 Shows the average, minimum and maximum humidity at the Natural Pavilion at the ground floor.

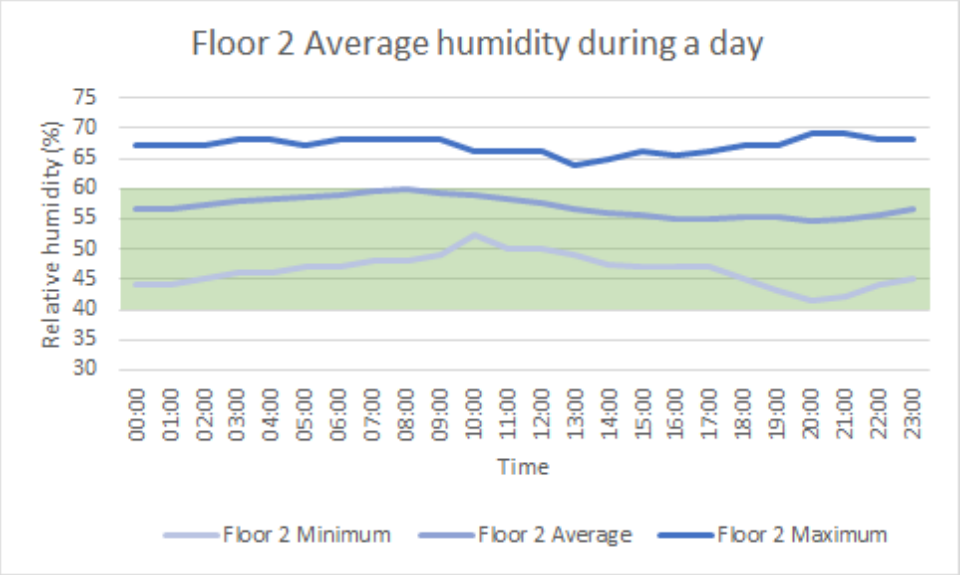


Figure 11 11 Shows the average, minimum and maximum humidity at the Natural Pavilion at the first floor.

The humidity level at the Natural Pavilion was on average between 53 to 61% (see Figure 10). The maximum humidity is above the recommended healthy range. Especially during the night and the beginning of the morning the humidity was high. The value approaches 67%. Moreover, floor 1 has a slightly higher maximum humidity compared to floor 2 (see Figure 11). The minimal humidity was 40% (floor 1, 19:00).

Natural Light

A healthy minimum illumination for younger people 50 lux - 500 lux and for elderly people 155 lux and 775 lux.

After the age of 20, one's need for light increases with 1% per year. Therefore, the required lighting for elderly is higher than for younger people. The light illuminance recommendation for elderly according to an Adapted Standard (adapted from European standard specific for elderly) is between 155 lux and 775 lux or higher, depending on the location and location activities. If the illuminance is not high enough, this can increase the risk of accidental falling and injury (De Lepeleire, Bouwen, De Coninck, & Buntinx, 2007).

Apart from this, it is not clear what the biological effect of higher illuminance is. Some literature says exposure to "moderately bright light", 1000 lux, has multiple self-evaluated health benefits such as improved mood, alertness and happiness particularly in elderly people without disrupting biological rhythm (Kohsaka et al., 1999). Other findings suggest even moderate light of 500 lux changes melatonin rhythm (Laakso, Hätönen, Stenberg, Alila, & Smith, 1993). The effect of artificial light at night has been investigated more, as artificial light at night benefits humans by facilitating activities during otherwise dark hours. The downside of this is that circadian rhythm can be distorted by the light. Especially blue lights of short wavelengths are considered harmful (Laakso et al., 1993; Wyse, Biello, & Gill, 2014). Other findings suggest even moderate light of 500 lux changes melatonin rhythm (Laakso et al., 1993; Wyse et al., 2014) In animal research it was shown that disruption to circadian rhythm causes metabolic dysfunction (Nash et al., 2019). Biological darkness is stipulated at illumination below 100 lux (de Zeeuw et al., 2019).

Only few studies investigated a relationship between light during the day and health. The use of daylight-like LED lightning is beneficial for the human circadian rhythm (Nie et al., 2020). It could be that day-like LED lighting prevents people from living in biological darkness and contributes to a healthier light spectrum. Sleepiness can be reduced if the light spectrum is optimised (Nie et al., 2020). Despite this benefit, it was shown in mice that one should be careful using high illuminance artificial light for long hours (Seke Etet et al., 2017).

At the Natural Pavilion, an average light intensity of 620 lux was measured. During working hours (09:00-17:00), it was estimated to be 1067 lux. A control location with few natural elements and no natural lighting mechanism (see appendix 3), only had an average light intensity of 65 lux measured over one afternoon. At the same afternoon, the Natural Pavilion had an average of 1322 lux.

Conclusion

In the Natural Pavilion the CO_2 concentration was within the healthy range of a maximum of 1000 ppm. The CO2 levels in the Natural Pavilion never exceeded healthy range and increased with an increase of people present in the building. The lowest CO2 values emulated outdoor conditions stipulated in literature.

All temperatures at the Natural Pavilion were within known thermal comfort zones. The maximal values do, however, approach conditions which could be unhealthy. The Natural Pavilion had a maximum value of 25,6 °C when, according to literature, temperatures above 26 °C could have adverse health effects. Humidity is never below the minimum healthy range but in some instances does increase to levels which could be unhealthily high. The Natural Pavilion had a maximum humidity of 71% where the maximum level deemed healthy in literature is 60%. The design of the Natural Pavilion aided in making the indoor environment better lit than the conventionally built control building. The natural pavilion is capable of meeting minimum light requirements stipulated in literature but also displayed lighting with higher lux (over 1000 lux) which, according to some sources, could have negative physical health effects.

5.4. Sub question 4: What effects on mental health can be deducted from the user experience of natural design elements?

The initial aim of SQ4 was to investigate the impact of natural design elements on mental health. In order to determine the feasibility of studying the effects on mental health on visitors in the Natural Pavilion, it was necessary to gain some insights from an expert. The initial plan was to carry out an intervention on the level of stress of visitors in The Natural Pavilion. After meeting with Dr. Sjerp de Vries, an environmental psychologist, it turned out that studying mental health was not possible during this project. Studying mental health would have required time and pre-knowledge on participants that was not possible to obtain in the present study. Furthermore, most existing studies in literature focus on wellbeing. The goal of SQ4 was therefore adapted to include a broader look at wellbeing and not focus on only mental health. An adjusted research question was then derived: "**What effects on wellbeing can be deducted from the user experience of natural design elements?**" The methods used were adapted to focus on a broad-scope idea of the potential benefits of the natural elements present in the Natural Pavilion. This was obtained using literature research. Examination of the combined effects of these natural elements on the visitors in the Natural Pavilion was done through focusing on restorative ability, perceived vitality and reduced stress of people in the Natural Pavilion.

The human experience is always both physical and mental. It should be noted that health and wellbeing influence each other, as a healthy person will most likely rate their own wellbeing higher (Simons & Baldwin, 2021). To clarify the difference between SQ3 and SQ4, SQ3 focuses entirely on physical health effects in the Natural Pavilion and is based on relating sensor data to standards in literature. SQ4 aims at a more wholistic approach and encompasses all the effects of natural elements present in the Natural Pavilion with "wellbeing" as the outcome of measurement of the effects of these elements.

5.4.1 Literature research

Methodology

In order to explore the impact of natural design elements in buildings on wellbeing, literature research has been conducted focusing *only* on elements present in the Natural Pavilion. As such, no systematic search or synthesis has been done, but instead, several search terms were used in PubMed. Articles were searched in relation to sensory input (e.g. see, hear, touch, smell), natural design elements and wellbeing. Taste was not included, since there was nothing to taste at the Natural Pavilion. For example, for hearing, the following search terms were used: "sound", "noise", "nature", "indoor", "health", "wellbeing". Similar searches were executed for the other senses. When relevant articles were found, a snowballing method was used to find additional articles. Results were analysed in order to answer the fourth research question and include only what could be considered potential effects on wellbeing in the Natural Pavilion.

Findings

Wellbeing is defined as a state of being comfortable, health or happy (Franco, Shanahan, & Fuller, 2017). As such, it is a broad term which includes important factors, such as positive state of mind, satisfaction of life, and mental wellbeing (Simons & Baldwin, 2021). The indoor experience of natural

design elements involves all our five senses: see, smell, taste, touch and hear. What follows is an overview of the potential effect of natural design elements which were present in the Natural Pavilion on wellbeing, categorized per sense.

See

Vision is by far our most important sense in terms of yielding information about indoor environments (Roger S. Ulrich, 1979). It's already sufficient to look at nature, rather than being surrounded by nature, to experience a benefit in health (Velarde, Fry, & Tveit, 2007). Seeing landscapes and/or gardens through a window positively affects wellbeing and health, when compared to an urban view. The sight of a natural landscape can result in a reduction in stress, fear, sadness, anger/aggression while an improvement is seen in mood, well-being, and attentional fatigue (Hartig, Evans, Jamner, Davis, & Gärling, 2003). The following facts are obtained in the literature research. Vision is by far our most important sense in terms of yielding information about indoor environments (Roger S. Ulrich, 1979). It's already sufficient to look at nature, rather than being surrounded by nature, to experience a benefit in health (Velarde et al., 2007). Seeing landscapes and/or gardens through a window positively affects wellbeing and health, when compared to an urban view. The sight of a natural landscape can result in a reduction in stress, fear, sadness, anger/aggression while an improvement is seen in mood, well-being, and attentional fatigue (Hartig et al., 2003). The following facts are obtained in the literature research:

- Improvement in blood pressure, heart rate, muscle tension, and brain activity can already be achieved by looking at nature within 5 minutes (Roger S. Ulrich, 1981).
- Patients with a view on nature recover faster after surgery and need less pain medication (R. S. Ulrich, 1984).
- A 'micro-restorative moment' is experienced in the homes of residents when looking through a window which overlooks natural elements. This results in improvement of sense of wellbeing and satisfaction of surrounding (Kaplan, 2001).
- The main sight characteristics of nature that determine these effects on health are through nature's colours, the lines and shapes that are present and a variety in sight (Franco et al., 2017).

Visual effects of gardens

Extensive research has been done on the effect of seeing gardens and wellbeing. Below are some of the effects specifically of hospital gardens.

- In hospital gardens, reduction in stress is obtained when there are visual elements present such as verdant foliage, flowers, calm water elements and visible wildlife such as birds (R. Ulrich, 2002).
- Hospital patients rated the sight of trees, greenery, flowers, and water as most pleasant. As such, they contribute to a restoration in mood (Marcus & Barnes, 1995).
- Blood pressure decreased for participants who reported liking wood when exposed to the sight of a wooden wall. Participants who reported disliking wood did not have a change in blood pressure after exposure to a wooden wall (Sakuragawa, Miyazaki, Kaneko, & Makita, 2005).

Visual effects of wood

- In general, wood is positively perceived, because it gives feelings of warmth, comfort, relaxation and it reminds people of nature (Nyrud & Bringslimark, 2010).

- Wood in the interior of an indoor environment positively impacts stress levels of occupants (Burnard & Kutnar, 2015).
- Blood pressure decreased for participants who reported liking wood when exposed to the sight of a wooden wall.
- Participants who reported disliking wood did not have a change in blood pressure after exposure to a wooden wall (Sakuragawa et al., 2005).

Smell

Smell in the indoor environments has been shown to exert a great influence on our mood and well-being, although this is mostly unconscious (Franco et al., 2017). Interestingly, outbreaks of sick-building-syndrome in the 1980s were linked to the smell of an unfamiliar odour in closed office buildings (Spence, 2020). In the Natural Pavilion, a woody smell was present.

Olfactory effects of wood

- The smell of a pine tree smell is often described as being natural, pleasant and harmonizing (Herz & Cupchik, 1992).
- Wood odour is often associated with a positive impact on health (Matsubara et al., 2011).
- Essential oil from various pine trees has been demonstrated to reduce levels of arousal and improve recovery from mental fatigue. As such, it has the potential to reduce sleep disorders, restlessness and anxiety (Schreiner, Bauer, & Buettner, 2018).
- Wooden walls can be perceived pleasant and assisted people in remaining physiologically relaxed under stressful conditions (Weber & Heuberger, 2008).

Olfactory effects of plants

- Smelling of natural plant odours results in improvement in self-rated calmness, alertness and mood (Weber & Heuberger, 2008). This effect is independent of age (Glass & Heuberger, 2016).
- An important reason for geriatric patients to be in the garden is to smell the scent of flowers, soil and greenery (Ottosson & Grahn, 2005).

Touch

A touch of nature is perceived by the human skin. Our touch, or tactile sense, is important in health and wellbeing as it can reduce stress, and it's crucial in social aspects and bonding of human beings (Gallace & Spence, 2010). A division can be made in animal touch (e.g. petting a dog or horse), or non-animal touch of nature. Touchable materials focused on from the Natural Pavilion were wood, wood-like materials such as cork, bamboo and straw as well as mycelium. Most literature available is on the effects of touching wood.

Tactile effects of wood

- Touching a wooden wall with ones palms induces physiological relaxation, by reducing prefrontal cortex activity and increasing parasympathic activity (Harumi Ikei, Song, & Miyazaki, 2017). Touching a wooden wall with ones palms induces physiological relaxation, by reducing prefrontal cortex activity and increasing parasympathic activity (Harumi Ikei et al., 2017).
- Contact with wood, both cold or warm, did not increase people's blood pressure in comparison to artificial materials. These results show that even in a cooled state, touching wood did not cause physiological stress (Sakuragawa, Kaneko, & Miyazaki, 2008).

- Touch of wood with feet induces physiologic relaxation, which resulted in the feeling of being "comfortable," "relaxed," "natural," "warm," "uneven," "dry," and "soft" (H. Ikei, Song, & Miyazaki, 2018).

Hear

Hearing tweeting birds can calm us down (Alvarsson, Wiens, & Nilsson, 2010), while daily noise pollution can cause serious health effects and diseases, such as an elevated blood pressure, poor attention and productivity, memory problems, sleep deprivation, increased risk of myocardial infarction and annoyance. In addition, complete silence in a natural environment is a sign of a predator arriving, which can increase stress and anxiety (Franco et al., 2017). This highlights the importance of sounds for our sense of wellbeing and health. The nature sounds present in the Natural Pavilion are bird songs and material to dampen noise and improve acoustic qualities of the building, such as wooden walls. People are 1.2 times more likely to suffer from sick-building syndrome in a place with increased noise level (Arikan et al., 2018).

Auditory effects of birds

- The sound of birds is experienced as pleasant and eventful, and it can compensate the loudness of air traffic (Coensel, Vanwetswinkel, & Botteldooren, 2011).
- Birdsongs are rated more pleasant compared to the build environment and it can increase stress recovery and attention recovery when exposed to it for a short period of time (Ratcliffe, Gatersleben, & Sowden, 2013).
- There are individual differences in which bird sounds may aid perceived restoration. Being mindful about which bird sounds to use is warranted (Taborda, Gomes, Rocha, & Samelli, 2021).

Auditory effects of natural noise-dampening materials

- The usage of, amongst other things, wooden furniture in classrooms, resulted in reduction in noise pollution and annoyance (Taborda et al., 2021).

5.4.2 Survey: Restorative Outcome Scale, Subjective Vitality Scale and Visual Analogue Scale

As mentioned above, wellbeing is multi-sensory and linked to many different experiences of natural elements. During this 8-week study it was not possible to investigate all these potential health effects and so a more holistic measurement of wellbeing was needed. So, this study looks at measurable outcomes closely related to wellbeing such as restoration, perceived vitality and perceived stress. Restoration is an important aspect within wellbeing since exposure to natural environments has proven to increase physiological restoration to humans (Neale, Lopez, & Roe, 2021). In this research, restoration refers to our ability to recover from stress, low mood and mental fatigue.

Methodology

In order to investigate state of mind, the Restorative Outcome Scale (ROS) and Subjective Vitality Scale (SVS) have been used. These research methods are used to measure perceived restorative outcomes (Ojala, Korpela, Tyrväinen, Tiittanen, & Lanki, 2019) and have been applied in similar research regarding mental wellbeing and restoration (K. M. Korpela, Ylén, Tyrväinen, & Silvennoinen, 2008; Kalevi M. Korpela, Ylén, Tyrväinen, & Silvennoinen, 2010). Restorative outcome refers to positive changes in human activities when visiting or seeing natural environments (K. M. Korpela et al., 2008).

For example, visiting a park can relieve fatigue and emotional stress and these positive changes in activity are restorative outcomes. In order to investigate state of mind, the Restorative Outcome Scale (ROS) and Subjective Vitality Scale (SVS) have been used. These research methods are used to measure perceived restorative outcomes (Ojala et al., 2019) and have been applied in similar research regarding mental wellbeing and restoration (K. M. Korpela et al., 2008; Kalevi M. Korpela et al., 2010). Restorative outcome refers to positive changes in human activities when visiting or seeing natural environments (K. M. Korpela et al., 2008). For example, visiting a park can relieve fatigue and emotional stress and these positive changes in activity are restorative outcomes.
The ROS consists of six items that correspond to relaxation and calmness, attention restoration, and clearing thoughts (appendix 3.1). The SVS consists of one item and measures perceptions of vitality in environmental settings and reflects on how vital and lively people feel (Ojala et al., 2019). Participants were asked to mark their answer at the scale ranging from 'completely' (1) to 'not at all' (7) to the following question: *"To what extent do the following statements correspond to your current emotional state? Mark your answer with an 'X'."*

The multi-sensory aspects of natural environments, such as hearing, smelling, touching, feeling and seeing, can have a positive impact on mental states such as reducing stress (Franco et al., 2017). In order to investigate the effect of the natural design elements in the Natural Pavilion on stress of the visitors, the Visual Analogue Scale (VAS) is used. Within the survey, after the questions regarding the ROS and SVS, participants were asked: *"How stressed do you feel right now?".* The participants could fill in their answer by filling in a percentage at a scale from 'Not at all stressed (0%) and 'Maximally stressed' (100%). Age and sex of the participants were asked to test for potential effects of these demographics on the outcome (Jiang, Chang, & Sullivan, 2014)

In order to explore the effect of natural environments on restorative effects relating to state of mind, pleasantness and stress, a control environment and control group need to be explored as well to ensure the internal validity (Bryman, 2016). As a result, the effect of the natural design elements in the Natural Pavilion regarding ROS, SVS and VAS, is also investigated in Woonzorgcentrum Flora (see appendix 4). This building is located at the Floriade near the Natural Pavilion. Woonzorgcentrum Flora is a residential building for elderly people with dementia (Zorggroep-Almere). The survey is conducted at an exposition about dementia on the ground floor in the building. This area was suitable to use as a control environment since it represented a more standard building design without natural design elements implemented. The visitors of the exposition in Woonzorgcentrum Flora were of the same age categories as the visitors of the Natural Pavilion and therefore a suitable control group. The control group filled in the same survey as the participants in the Natural Pavilion. The aim was to conduct 20 surveys with visitors of the Natural Pavilion and 20 surveys with visitors of the exposition in the control building. This number seemed viable as Woonzorgcentrum Flora was quieter than The Natural Pavilion and due to time constraints the team only had one day. People of all ages were approached with the only requirement being that the participant had spent at least ten minutes inside the building in question. Literature shows that looking at nature for five minutes, already causes improvement in blood pressure, heart rate and brain activity (Roger S. Ulrich, 1981). For this reason, the minimum visit of ten minutes was chosen.

Data analysis

Results were analysed with Excel. A mean score was obtained for the Natural Pavilion group and the control group. Scores were compared above and below 65 years old. In addition, results were compared to literature.

Findings

In total, 20 participants were obtained in both the control and the Natural Pavilion. The number of participants was equally distributed over gender in the Natural Pavilion and over age category in the control building (see Table 3.)Table 3 2 Distribution of survey participants in the Natural Pavilion and control building Woonzorgcentrum Flora over age category and gender.

Table 3 2 Distribution of survey participants in the Natural Pavilion and control building Woonzorgcentrum Flora over age category and gender.

	Natural Pavilion	**Woonzorgcentrum Flora**
Male	10	5
Female	10	15
<65	14	10
>64	6	10
Total Number of Participants	20	20

Table 4 3. Average scores of the ROS test in both the Natural Pavilion and control building

ROS	**NATPAV**	**CONTROL**	**DIFF**
+65	4.86	4.39	0.47
-65	4.56	4.16	0.40
M	4.68	4.27	0.41
F	4.61	4.29	0.32
ALL	4.65	4.28	0.37

Table 5 4. Average scores of the VAS test in both the Natural Pavilion and control building

VAS	**NATPAV**	**CONTROL**	**DIFF**
+65	31.50	38.69047619	-7.19
-65	27.37	20.625	6.74
M	21.43	34.58333333	-13.15
F	32.93	24.73214286	8.20
ALL	28.31	29.6577381	-1.35

For the ROS and SVS, participants allocated a score from 1-7 to each score. The higher the score the higher the restorative outcome (Lesage, Berjot, & Deschamps, 2012). Overall the responses for the ROS questions in the Natural Pavilion had an average score of 0.51/7 higher than that of the control (see Table 4 3). The higher the score the higher the restorative outcome (Lesage et al., 2012). The biggest difference was observed in the below 65 category with the Natural Pavilion being 0.58/7 higher than the control. The smallest difference was observed for men with a difference of 0.36/7 from the control to the Natural Pavilion. The trend of the Natural Pavilion scoring higher than the control was not true for the SVS question where people in the Natural Pavilion rated their vitality lower by 0.48/7. The biggest difference was in the female category where the Natural Pavilion scored on average 1.05/7 lower than the control. The smallest difference was observed for the above 65 category where participants rated their vitality and an average of 0.17/7 better in the Natural pavilion than in the

control. The overall average of responses to questions in the ROS ranged from 4.4 to 4.9 in the Natural Pavilion. And 3.9 to 4.55 for the control.

Results of the VAS showed minor differences on average between the buildings (see Table 5). Participants in the control rated their perceived stress as 1.35/100 more stressed than in the Natural Pavilion. The biggest difference in stress was observed in the male category where men in the Natural Pavilion rated themselves as 13.15/100 less stressed than in the control. The smallest difference was found in the above 65 age group where participants felt 7.19/100 less stressed in the Natural Pavilion. The other categories, below 65 and females, did not show improvement in the Natural Pavilion but rather rated their stress as less in the control building by average scores of 6.74/100 and 8.20/100 respectively.

According to literature, average scores to answers of the ROS survey range from 3,39 to 3,46 in an urban environment, 4.88 to 5.51 in a recreational park environment and from 5.2 to 5.7 in a community forest. This would put both the control and the Natural Pavilion as slightly below the average values given in a recreational park environment but higher than in an urban environment (Lesage et al., 2012; Raman, Abdul Aziz, & Yaakob, 2021). In previous studies the mean of SVS questions were seen to be 4.68 in a city environment, 4.71 in a recreational park and 4.74 in a Forest. The average value of 5 for the Natural Pavilion and 5.48 for the control is therefore above the average perceived vitality that people have in a fully natural forest environment (Raman et al., 2021). The large differences between men and women in the SVS observed in the present study were not considered so seriously as the distribution of men and women was not even enough for this to be a good representation of differences in demographic.
Lastly, literature shows that during exposure to natural environments participants had an average VAS score of 14.33/100 perceived stress. During exposure to a simulated natural environment participants gave an average score of 21.72/100 (Kjellgren & Buhrkall, 2010). The VAS scores found in this study showed an average of 28.31/100 in the Natural Pavilion and 29.66/100 in the control. These results are slightly higher than the perceived stress of those in a simulated natural environment.

Conclusions

Wellbeing in the Natural Pavilion is potentially affected by a range of natural elements present. These natural elements affect almost all the sensors of visitors. In addition, the Natural Pavilion is found to have higher restorative and stress reducing capacities than Woonzorgcentrum Flora. No evidence, however, is found for improvement of feelings of vitality.

6. Integrated Findings

This chapter aims to combine findings from all the sub-questions per element and starts with a re-iteration of the main findings from each sub-question. The chapter ends with an answer to the main research question.

- No major differences between the two age categories were found during researching the impact of natural design elements and the user experience of these elements in SQ1 and SQ2.
- The explicit and implicit impactful natural design elements did not have a different effect on user experience according to the responses of SQ2. The elements were not ‘experienced’ (smelling/feeling/touching/seeing/hearing) in a different way according to our analysis. This

implies that implicit or explicit elements do not influence the user experience in a distinctively way.

- The Likert scale survey in SQ2 mostly resulted in positive to neutral user experiences for the natural design elements. Generally, this was also the case for the interview results, however, during the interviews, some more practical concerns did come up.
- SQ3 found that the Natural Pavilion can maintain healthy indoor conditions for human physical health. Some demographics, such as elderly people, require more specific conditions which the design of the Natural Pavilion is mostly able to accommodate for.
- Wellbeing assessed via multiple tests in SQ4 was found to be overall better in the Natural Pavilion than in a control building. There were differences in responses in different age groups.

6.1 Natural Ventilation

Impact: Natural ventilation appeared to be an impactful element in the Natural Pavilion.
User experience: Most people did not feel stuffy, there was enough fresh air in the building and the humidity was not too high. Visitors would enjoy living in a house with wind-dependent ventilation. This came back in the interviews as natural ventilation was viewed as positive by all interviewees. Their experience was positive because the fresh air made the building more spacious and gave the feeling as if one was outside. In addition, they enjoyed the economical side of saving costs and requiring less energy. Some practical concerns were mentioned regarding safety against burglars and insects and temperature regulation in summer.
In literature, the CO_2 concentration is often used to measure the air ventilation. The sensors in the **Sensors:** Natural Pavilion showed that the CO_2 concentration was of satisfactory levels. The literature research of SQ3 suggests that (natural) ventilation contributes to preventing cardiovascular diseases. In addition, as shown in SQ3, poor ventilation is one of the key causes of the sick building syndrome.
Conclusion: The natural ventilation system in the Natural Pavilion is therefore sufficient according to literature as well as user experience.

6.2 Optimal Use of Daylight

Impact: This category came up as an explicitly impactful element.
User Experience: The survey of SQ2 showed that it was not too bright or dark inside, neither was there too much sunlight inside. Visitors would enjoy living in a house that is mainly lit by daylight coming in through large windows. The shaders did not disrupt the outside view. The visitor's opinion about living in a house with shaders varied between neutral and agree. The findings from the interview only partly conform this. It confirmed that visitors enjoyed the big glass windows, but the opinion on the vertical and horizontal shaders was divided. This is different from the Likert results where most respondents did not think they disrupted the view. In addition, some negative opinions were given in the interview based on privacy, possibility of birds flying against windows, and temperature regulation. The words used to describe the positive attitude towards daylight were pleasant and sunshine.
Sensors: Sensor data from the Natural Pavilion showed the optimal use of daylight was capable of providing moderately bright light during working hours which, according to literature, is above minimum required standards. Some literature, however suggests this level to be too high. Indoor light requirements vary depending on the room purpose. It is not clear if the lighting system at the Natural Pavilion could meet specialised needs.
Conclusion: Visitors at the Natural Pavilion enjoy and would have in their own home the optimal use of daylight present. This, however, may be conditional to the fact that practical needs are met. The light present in the Natural Pavilion is at a healthy to high level according to literature.

6.3 Natural Climate Control (Temperature and Humidity)

Impact: Temperature came up as an another explicitly impactful element in the building.
User Experience: SQ2 showed that it was not too hot or cold, the temperature was experienced as comfortable, and visitors would enjoy living in a house that uses natural climate control. This was confirmed during the interviews as well. All participants were positive and commented on the pleasant temperature and climate. It indicates a relationship between comfort and temperature. Few people mentioned stuffiness or the feeling of it being too humid.
Sensors: Sensor data and literature analysis confirmed that the Natural Pavilion can maintain healthy indoor temperatures specific to what is found in winter times. Contrary, the humidity in the Natural Pavilion is at times high.
Conclusion: The natural climate control present in the Natural Pavilion maintains a pleasant indoor climate, however air humidity is a point of attention.

6.4 Plants

Impact: Plants came up as an implicitly impactful element
User Experience: The user experience of plants differed a little bit between age groups. Most of the people who noticed plants in SQ1 were under 65 years. SQ2 also showed that under 65 years missed plants inside more than over 65. Interview participants expressed a preference for plants on the ground floor over plants on the first-floor balconies was mentioned. The plant in the garden provided enough ambience in the building. Visitors would enjoy living in a house with plants growing in the building. Visitors extremely enjoyed seeing plants inside the buildings they use. The positive user experience of plants mainly related to the visual aspects of plants. The colour green was mentioned, in addition to descriptions such as beautiful and nice.
Wellbeing: Literature showed that looking at nature and greenery has positive and restorative effects. SQ4 found increased restoration and decreased stress in the Natural Pavilion compared to the control. Levels of wellbeing described by these terms are like those of natural and simulated natural environments.
Conclusion: Plants in the Natural Pavilion contribute to a positive user experience as well as restorative and stress reducing effects. The focus and interest in plants is, however, age dependant.

6.5 Materials

Impact: Materials as an element was added after it came up as an implicitly impactful element in SQ1.
User Experience: *Sub question 2 showed that people agreed heavily on wanting to touch the wood. They enjoy living in a house mainly built from wood, the use of glass created an open space and they would enjoy living in a house with big windows. Most visitors reacted neutral or positive on using a seed floor in their own house.* The interviews confirmed this. The opinion on material was mostly positive, which was explained by decorative qualities, a nice smell and warm colours of the materials that were used. Negative views were based on concerns on the quality of unprocessed material and maintenance and cleaning of the objects. Many different sensory experiences were named, from seeing to smell to sound and touch.
Wellbeing: Literature shows that both the touch and smell of wood has positive effects on wellbeing, relaxation and noise pollution. The increased restoration and decreased stress in the Natural Pavilion compared to the control confirms that visitors in the Natural Pavilion are receptive to this.
Conclusion: The use of natural materials are noticed by and contribute to the wellbeing of visitors in the Natural Pavilion.

6.6 Main research question

Based on the answers on the sub research question and the integrated findings stated above, the main research question "**What is the user experience of people visiting the Natural Pavilion and how is this linked to physical and mental wellbeing?**" can be answered. Visitors experienced the Natural Pavilion through hearing, seeing, feeling, smelling and touching. The natural design elements all contributed to these sensory experiences and users are receptive to the positive effects of these natural elements found in literature. The Natural Pavilion is furthermore also capable of maintaining physically healthy indoor climate conditions.

7. Discussion

7.1 General

A number of limitations were present during the data collection phase of this study. Due to the fact that the study was completed in only eight weeks, it was only possible to visit the Floriade four times. Because of this, a limited sample from the Natural Pavilion and control building was gathered. Although the aimed numbers of participants were achieved for every survey and interview performed, these numbers still may not accurately reflect the opinions of the population of visitors. This is particularly apparent when investigating dynamics between different demographics of participants such as male and female or between people above and below 65 years old. In some cases, surveys or interviews did not have equal numbers of respondents from different demographics and often a particular group was underrepresented. This made it almost impossible to deduce exact differences between types of people. However, it could be valuable to conduct more research on the potential differences addresses in this report.

Another time-dependant limitation was that this study was conducted in relatively similar and pleasant early summer weather conditions. Since this research mainly focused on how participants felt regarding climate conditions such as temperature, this study can only make deductions about conditions in the Natural Pavilion of similar weather conditions. In order to generalize these findings to other seasons, more research in other time periods is needed.

The last time-dependant limitation is related to the duration of visiting time in the Natural Pavilion and control building and the contact time with the participants. Most visitors visited the buildings quite quickly. Setting a requirement for participants of spending at least ten minutes inside the building is still not a comparable time to how long people would spend in buildings with the desired application according of Oosterhoff. Such as elderly care institutions or natural environments. Having limited contact time between participants and surveyors/ interviewers resulted in some surveys being filled out in a rushed manor and potential misunderstanding of the questions. Furthermore, it limited the depth of the study to evaluations based on only 10-15 minutes of interaction. This limited the research on mental and physical health which require knowledge or history of participants that was not possible to gather in this time. A suggestion would be to conduct larger randomized control trials in order to investigate the effect of natural design elements on well-being and physical health in more depth.

Other than time, possible limitations also included language barriers. The final output of the study was delivered in English but due to the nationality of visitors at the Natural Pavilion, surveys and interviews were predominantly conducted in Dutch and German. The translation of reputable surveys and tests

that were used in literature into Dutch and German created an opportunity for meaning to be lost. Furthermore, the translation of responses back to English created another opportunity for inconsistency. The interpretation of results leads to another area of restraint namely subjectivity in both the data collection and data analysis phase. How participants felt on the day they were interviewed or surveyed, or how participants felt about being asked questions could have played a role in how and what they answered making it difficult to obtain subjective responses. Secondly, even though the interpretation of responses in the data analysis phase was performed as objectively as our abilities would allow, as described to the best of our abilities in this report, it is still possible that the analyses of responses could vary depending on who performed the analysis.

Finally, as the sensors that were used for this research fell on the floor frequently and one stopped working, the sensor data was not entirely reliable. A suggestion for future research could therefore be to conduct long-term research to measure, interpret and explain the concentrations and differentiations. Additionally, a sensor measuring decibel in the building could be valuable to further explore the effect of natural design elements on noise pollution.

7.2 Future research

A number of research gaps were found during this study. In general, it would be helpful to carry out similar studies on physical health and wellbeing but with more participants and over a long period of time. The balance between creating a multisensory experience and overwhelming building users also draws the attention. In this report it is suggested to create zones that allow people to experience a wide variety of circumstances. However more research could be useful in determining to what extent and in what ratio to more sober environments multisensory experiences are in fact beneficial. Furthermore, there are specific research gaps present for each element investigated.

It would be helpful to investigate the natural use of daylight by looking at the full spectra of light as well as examining if the methods employed at the Natural Pavilion are capable of meeting variable requirements of different indoor settings.

Not a lot is known on the exact requirements on temperature. Humidity and CO_2 levels are more well defined. Future research should include more reliable sensor data and the inclusion of a more long-term study on a control building for better comparisons. Furthermore, this study should take place over multiple seasons to observe if the system in the Natural Pavilion is robust in different conditions. Another area of importance is studying the implementation of personal control, variability of conditions within a building and the benefits of having such variability.

Some of the effects of plants and flowers have been mentioned in the advice section of this report. For different implementations, more research should be conducted to find the effects that different plants have on different age groups. Furthermore, it would be helpful to investigate the application of positive effects of plants other than visual.

There has been quite some extensive research on the effect wood has on user experience. However, for other natural materials more research is needed. Tactile benefits can be studied in relation to multisensory experiences. Does sitting in a chair of mycelium lead to reduction in stress? Or does feeling the wind result in lower levels of cortisol? There are a wide variety of questions in relation to new (biobased) materials that are of crucial importance to determine their attractiveness and usability. Another topic that deserves more attention is the sound and noise pollution. As mentioned

in the above literature searches, natural building materials, particularly wood, can reduce noise pollution.

An element which comes back in many studies, but not in the Natural Pavilion, and that is highly relaxing for humans, is water. It is often mentioned in relation to mediating stress, so therefore it could have a positive mental and physical effect (Marcus & Barnes, 1995; Whitehouse et al., 2001). Further research is needed whether water belongs to the most effective natural design elements.

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9. Appendices

Appendix 1: surveys for SQ1

Appendix 1.1: 5 second test survey:

- **Introduction (English/Dutch/German):**
  - Hi there, we are students from Wageningen and we are researching The Natural Pavilion. Would you mind if we ask you a quick questions? It will take 30 seconds.
  - Hallo, wij zijn studenten van Wageningen Universiteit en we onderzoeken The Natural Pavilion. Is het goed als we een korte vraag stellen? Het zal 30 seconden duren.
  - Gutentag, wir sind Studenten der Universität in Wageningen du wir untersuchen The Natural Pavilion. Dürfen wir Ihnen eine kurze Frage stellen? Es wird 30 Sekunden dauern.
- **Question for participants (English/Dutch/German)**:
  - "From when you were in the building, what from the natural elements of the building do you remember seeing/hearing/smelling and feeling *not including* the expositions?" [start time **after** asking this questions]
  - Von Ihrer Zeit in diesem Gebäude, *abgesehen von* den Ausstellungen, was können Sie sich erinnern von den Naturelementen gesehen, gehört, gerochen und gefühlt zu haben? [start time **after** asking this questions]

Appendix 1.2: Likert scale survey:

- **Introduction (English):**
  - Hi there, we are students from Wageningen and we are researching The Natural Pavilion. Would you mind if we ask you a to fill in this form about your impression of the building from where you are standing right now? It will 3 to 5 minutes.
  - **Explain to participant:** Before filling in the table, please read the statement above. If anything is unclear, feel free to ask. Mentioned again that it is about their current perspective.
- Let the participant fill in the table below:

Dutch/English:

Leeftijd/Age:...

Stelling: **"De elementen in het paviljoen vielen op".** Selecteer één antwoord per element met een 'X'

Statement: ***"The listed element in The Natural Pavilion stood out."*** *Select one answer per element with an 'X'.*

Elementen ***Elements***	Helemaal mee oneens *Completely Disagree*	Oneens *Disagree*	Neutraal *Neutral*	Eens *Agree*	Helemaal mee eens *Completely agree*
Ventilatie *Ventilation*					
Licht *Light*					
Schaduw *Shade*					
Temperatuur *Temperature*					

Planten *Plants*					
Geur *Smell*					
Kleur *Colour*					
Geluid *Sound*					
Zijn we nog iets vergeten?: *Did we miss anything?:*					

German:

Age.....

*Aussage: "Die angegebenen Elemente in **The Natural Pavilion** fielen auf." Wählen Sie eine Antwort aus per Element, indem Sie ein Feld mit 'X' ausfüllen.*

Elemente	Ich stimme gar nicht zu	Ich stimme nicht zu	Gleichgültig	Ich stimme zu	Ich stimme sehr zu
Lüftung					
Licht					
Schatten					
Temperatur					
Pflanzen					
Geruch					
Farben					
Geräusch					
Fehlt etwas?:					

Appendix 2: SQ2

Appendix 2.1: Survey

Survey Instructions

Introduction: Hi, I am a student from the University of Wageningen and we're researching the Natural Pavilion. Would you like to participate in our survey, which will only take a couple of minutes?

Ask participant: In this survey several statements about the Natural Pavilion and your opinion are listed in the table. Per statement, we would like you to fill in whether you 'totally agree' or totally disagree by filling in the box. We would also like you to fill in your age.

Dutch:

Leeftijd: ___	Sterk mee oneens	Oneens	Neutraal	Eens	Sterk mee eens
Het is benauwd binnen					
Er is genoeg frisse lucht in het gebouw					
Het is te vochtig					
Leven in een huis met natuurlijke ventilatie vind ik prettig					
Het is te donker binnen					
Er is te veel zonlicht binnen					
Leven in een huis dat voornamelijk verlicht wordt door grote ramen vind ik prettig					
De horizontale / verticale lamellen verstoren het zicht naar buiten (omcirkel een van de opties)					
Leven in een huis met horizontale of verticale lamellen vind ik prettig					
Het is te warm / koud binnen (omcirkel een van de opties)					
Ik ervaar de temperatuur als comfortabel					
Leven in een huis met natuurlijke temperatuur regeling vind ik prettig.					
Er ontbreken geen planten in het gebouw					
De planten rondom het gebouw geven genoeg sfeer aan het gebouw					
Leven in een gebouw waar planten binnen groeien vind ik prettig					
Het gebruik van hout zorgt ervoor dat ik het wil aanraken					
Leven in een huis dat voornamelijk uit hout bestaat vind ik prettig					
Het gebruik van glazen ramen creëert een open ruimte					
Leven in een huis met grote ramen vind ik prettig					
De kleur van het hout is prettig om naar te kijken					

Leven in een huis met een vloer gemaakt van zaden vind ik prettig					

English:

Age: ___	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I feel stuffy.					
There is enough fresh air in the building.					
The humidity is too high.					
I would enjoy living in a house with wind-dependent ventilation.					
It is too bright/dark inside.					
There is too much sunlight inside.					
I would enjoy living in a house that is mainly lit by daylight coming through large windows.					
The horizontal/vertical shaders disrupt the outside view.					
I would enjoy living in a house with horizontal and vertical shaders.					
It is too hot/cold inside.					
I experience the temperature as comfortable.					
I would enjoy living in a house with natural climate control.					
I enjoy seeing plants inside of buildings I use.					
I did not miss plants on the inside.					
The plants in the gardens provide enough ambience in this building.					
I would enjoy living in a house with growing plants in the building.					
The use of wood made me want to touch it.					

I would enjoy living in a house mainly built from wood.					
The use of glass windows created an open space.					
I would enjoy living in a house with big windows.					
The colour of the wood was pleasant to look at.					
I would enjoy using a seed floor in my own house.					

German:

Lebensalter: ___	Ich stimme gar nicht zu	Ich stimme nicht zu	Neutral	Ich stimme zu	Ich stimme sehr zu
Es ist stickig.					
Die Luft im Gebäude ist frisch.					
Die Luftfeuchtigkeit ist zu hoch.					
Es würde mir gefallen in einem Haus zu leben, in dem es wind-abhängige Lüftung gibt.					
Es ist zu hell/dunkel drinnen.					
Es gibt zu viel Sonnenlicht drinnen.					
Ich würde gerne in einem Haus leben, das vor allem durch Tageslicht durch große Fenster erhellt wird.					
Die waagerechten/senkrechten Lamellen stören die Aussicht.					
Es würde mir gefallen in einem Haus zu leben, in dem es waagerechte und senkrechte Lamellen gibt.					
Es ist zu warm/kalt drinnen.					

Ich empfinde die Temperatur als angenehm.					
Es würde mir gefallen in einem Haus zu leben, in dem es natürliche Klimakontrolle gibt.					
Es gefällt mir Pflanzen zu sehen in Gebäuden die ich benutze.					
Mir haben drinnen keine Pflanzen gefehlt.					
Die Pflanzen in den Gärten geben dem Gebäude genug Ambiente.					
Die Verwendung von Holz hat mich dazu gebracht, es berühren zu wollen.					
Es würde mir gefallen in einem Haus zu leben, das vor allem aus Holz gebaut wurde.					
Die Verwendung von Glasfenstern hat einen offenen Raum geschaffen.					
Es würde mir gefallen in einem Haus mit großen Fenstern zu leben.					
Die Farbe des Holzes war angenehm anzusehen.					
Es würde mir gefallen einen Samenboden in meinem eigenen Haus zu haben.					

Appendix 2.2. Summary of answers to survey

I feel stuffy: very similar. The 65- felt slightly less stuffy than the 65+ group.
Overall common answer: completely disagree

There is enough fresh air in the building: Very similar.
Overall common answer: agree

The humidity is too high: Slightly more “neutral” answers for the 65- group.
Overall common answer: disagree

I would enjoy living in a house with wind-dependent ventilation: Very similar, 65+ group is slightly less enthusiastic.
Overall common answer: agree

It is too bright/dark inside: Very similar

Overall common answer: completely disagree

There is too much sunlight inside: more responses for neutral & agree in the 65+ group, but overall, still similar.
Overall common answer: disagree

I would enjoy living in a house that is mainly lit by daylight coming through large windows: Very similar.
Overall common answer: completely agree

The horizontal/vertical shaders disrupt the outside view. Similar for both
Overall common answer: disagree

I would enjoy living in a house with horizontal and vertical shaders: some slight differences. More neutral responses for the 65- group, and more completely disagree for the 65+ group.
Overall common answer: agree

It is too hot/cold inside: Similar
Overall common answer: neutral

I experience the temperature as comfortable: Similar
Overall common answer: agree

I would enjoy living in a house with natural climate control: Similar
Overall common answer: agree

I enjoy seeing plants inside of buildings I use: similar
Overall common answer: completely agree

I did not miss plants on the inside: 65+ group mostly agreed on this, 65- group mostly disagreed on this.
Overall common answer. Disagree and agree

The plants in the gardens provide enough ambience in this building: very similar
Overall common answer: agree

I would enjoy living in a house with growing plants in the building: more completely agreement in 65- group, but otherwise similar.
Overall common answer: agree

The use of wood made me want to touch it: very similar
Overall common answer: agree & completely agree

I enjoy living in a house mainly built from wood: very similar
Overall common answer: agree

The use of wood created an open space: very similar
Overall common answer: agree

I would enjoy living in a house with big windows: slightly more completely agreement for the 65+ group, but otherwise similar

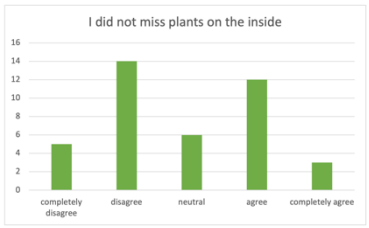
Overall common answer: agree and completely agree

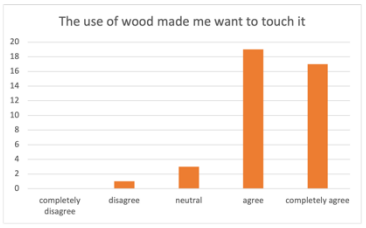
The color of the wood was pleasant to look at: very similar
Overall common answer: agree

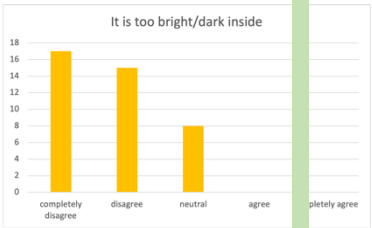
I would enjoy using a seed floor in my own house: very similar
Overall common answer: neutral

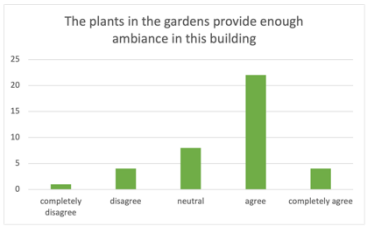
Appendix 2.3: Analysis per statement

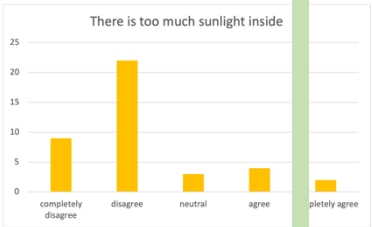
See next page.

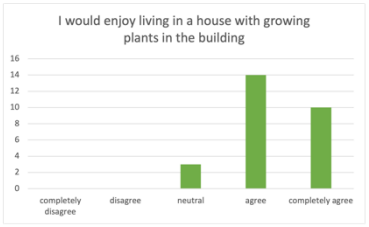


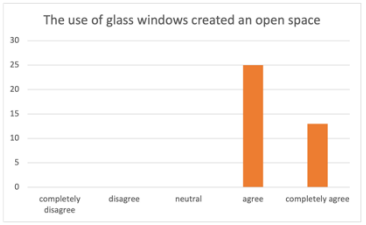


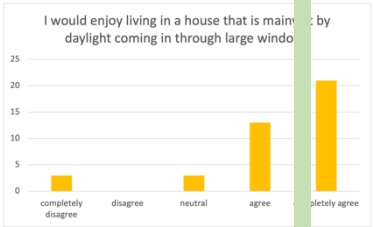


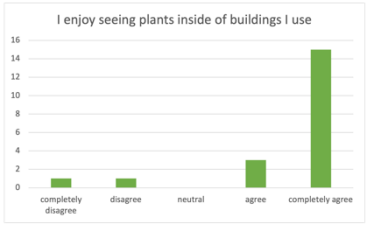


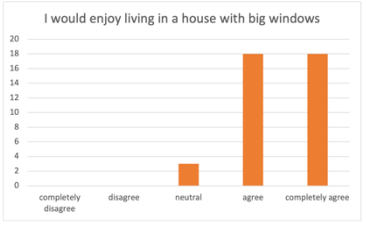


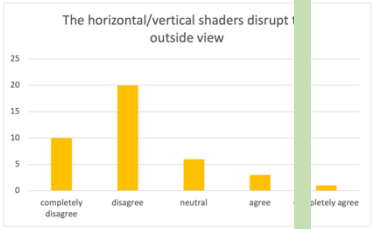


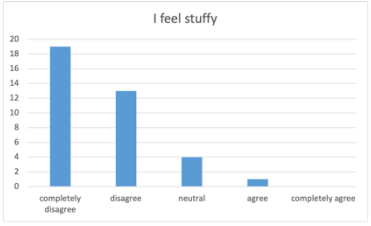


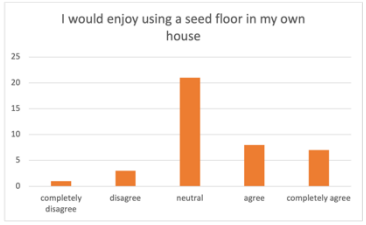


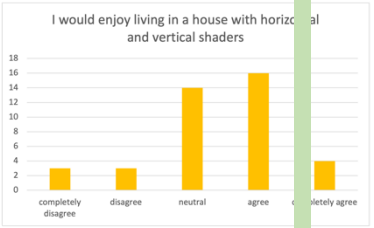


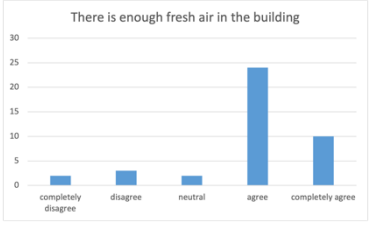


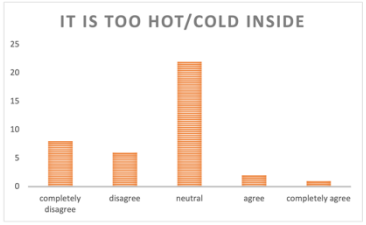


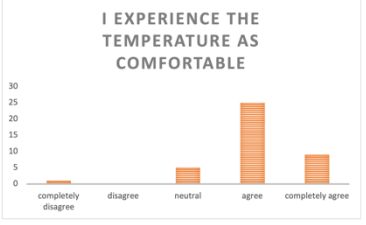


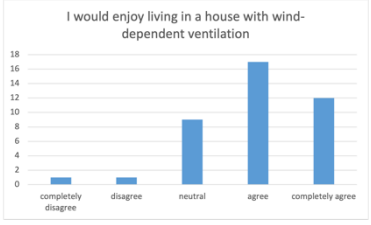












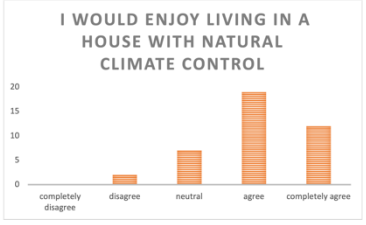


Figure 1212. Total answers pe statement. Blue represents th category natural ventilation. G een represents the category plants Orange (filled) represents the category materials. Orange (s iped) represents the category natur climate control. Yellow repres nts optimal use of dayligth.

Interview Instructions

Introduction: Hi, I am [name], a student from the University of Wageningen and together with my 6 others, we're researching the Natural Pavilion. Would you like to participate in a short interview about your opinion about this building? It will take about 15 minutes.

Explanation to participant:
-Do you give permission to record the interview? The record will only be used to analyse the findings for our report and will be deleted afterwards. Only your age and sex will be noted, no other personal information will be asked.

-During this interview, one of us is asking questions and the other person keeps an eye on the questions to see if everything is covered.

- "The recording has started. The data acquired from this interview will be used to assess how people **experience** the effects of the natural design elements in the Natural Pavilion. The data will be processed and analysed by seven students and the data will be shared with our commissioner Oosterhof and the WUR. Do you give permission for us to record this interview? And do you give permission for us to use your data, in this case your age, sex and opinion? Please answer with yes if you agree." "Is there anything else you would like to know before we proceed to the interview?"

Dutch:

Interview

Gecontroleerde natuurlijke ventilatie

a. Hoe ervaart u de luchtkwaliteit in het in The Natural Pavilion?
    i. Waarom ervaart u dit op deze manier?
b. Wat heeft u opgemerkt aan de ventilatie in het gebouw?
    ii. Wat vindt u hiervan?
c. Wat zou u ervan vinden als uw huis natuurlijke ventilatie zou hebben?

Optimaal gebruik van daglicht

d. Hoe ervaart u de inval van daglicht in het gebouw?
    iii. Waarom ervaart u dit op deze manier?
    iv. Voelt u zich anders binnen door het binnenvallende licht dan dat u zich buiten voelt?
    v. Hoe voelt u zich anders?
e. Wat zou u vinden van het optimale gebruik van natuurlijk daglicht in uw eigen huis?

Gebruik van schaduw

f. Hoe ervaart u de schaduw binnen in het gebouw?
    i. Waarom ervaart u dat op deze manier?
g. Hoe zou u het vinden om lamellen in uw eigen huis te hebben?

Natuurlijke klimaat controle, geen verwarming en koeling

h. Hoe laat de binnentemperatuur u voelen?
    vi. Waarom ervaart u dat op deze manier?
    vii. Laat de temperatuur binnen u zich anders voelen dan de buitentemperatuur?
    viii. Op welke manier laat het u zich anders voelen?
i. Wat zou u ervan vinden als huw huis gebruik maakt van natuurlijke klimaat controle?

Planten binnen en buiten het gebouw

j. Wat vindt u van de balkontuinen en waarom?
k. Wat vindt u van het zicht op planten buiten het gebouw en waarom?
l. Wat zou vinden van een balkontuin binnen in uw eigen huis?

Materiaal

m. Wat vindt u van het materiaalgebruik in het gebouw en waarom? [Als participant geen antwoord heeft help dan met suggestie: hout, vloer met zaden, ramen, mycelium, isolatiemateriaal]
n. Zou u het prettig vinden als uw eigen huis bestaat uit deze materialen? (waarom wel/niet)

English:

Interview

Controlled natural ventilation

a. How does the air (quality) inside the Natural Pavilion make you feel?
    i. Why does it make you feel that way?
b. What do you notice of the ventilation?
    i. What is your impression of that?
    ii. Why did you notice it?
c. What would you think of having controlled natural ventilation in your own house?

Use of daylight

d. How does the light inside make you feel?
    i. Why does it make you feel that way?
    ii. Does the light inside make you feel different than outside?
    iii. How does it make you feel different?
e. What would you think of having optimal use of daylight in your own house?

Use of shading

f. How does the shade inside make you feel?
    i. Why does it make you feel that way?
g. What would you think of having shaders in your own house?

Natural climate control, no heating or cooling

h. How does the temperature inside make you feel?
    i. Why does it make you feel that way?
    ii. Does the temperature inside make you feel different than outside?
    iii. How does it make you feel different?
i. What would you think of having natural climate control in your own house?

Plants growing in/outside the building

j. What do you think about the indoor gardens and why?
k. What do you think about the view on the outdoor plants and why?
l. What would you think of having indoor gardens in your own house?

Material

m. How do the building materials make you feel? [If they don't know, help them by suggesting wood, seed floor, glass, mycelium, isolation material (as mentioned in interviews SQ1)]
    i. Why does it make you feel that way?
n. What would you think of having [these materials] in your own house?

German:

Umfrage

Kontrollierte natürliche Lüftung

a. Wie fühlen Sie sich durch die Luft(qualität) im Inneren des Naturpavillons?
    i. Weshalb fühlen Sie sich so?
b. Wie ist Ihr die Lüftung?
    i. Was ist Ihren Eindruck davon?
    ii. Weshalb bemerken Sie sie?
c. Was halten Sie von einer kontrollierten natürlichen Lüftung im eigenen Haus?

Verwendung von Tageslicht

d. Wie fühlen Sie sich durch das Tageslicht im Inneren des Naturpavillons?
    i. Weshalb fühlen Sie sich so?
    ii. Fühlen Sie sich durch das Licht drinnen anders als draußen?
    iii. Weshalb fühlen Sie sich deshalb anders?
e. Was halten Sie von einer optimalen Verwendung von Tageslicht im eigenen Haus?

Verwendung von Lamellen

f. Wie fühlen Sie sich durch die Schatten im Inneren des Naturpavillons?
    i. Weshalb fühlen Sie sich so?
g. Was halten Sie von Lamellen im eigenen Haus?

Natürliche Klimakontrolle, keine Heizung oder Kühlung

h. Wie fühlen Sie sich durch die Temperatur drinnen?
    i. Weshalb fühlen Sie sich so?
    ii. Fühlen Sie sich durch die Temperatur drinnen anders als draußen?
    iii. Weshalb fühlen Sie sich deshalb anders?
i. Was halten Sie von einer natürlichen Klimakontrolle im eigenen Haus?

Pflanzen, die innerhalb/außerhalb des Gebäudes wachsen

j. Was halten Sie von den Gärten innerhalb des Gebäudes? Wieso?
k. Was halten Sie von der Aussicht auf die Pflanzen draußen? Wieso?
l. Was halten Sie von Gärten innerhalb des eigenen Hauses?

Materialien

m. Wie fühlen Sie sich durch die Baustoffe? [Holz, Samenboden, Glas, Mycelium, verschiedene Isolationsmaterialien]
    i. Weshalb fühlen Sie sich so?
n. Was halten Sie von [diesen Materialien] im eigenen Haus?

Appendix 3: Wellbeing questionnaires

Appendix 3.1: Restorative Outcome Scale- Survey

Geslacht/Geschlecht/Sex..... Leeftijd/Alter/Age.....

In hoeverre komen de volgende uitspraken overeen met uw huidige gemoedstoestand? Markeer uw antwoord met een X/ *In wieweit passen die folgenden Aussagen zu Ihrem jetzigen emotionalen Zustand? Füllen Sie das passende Feld mit einem X /* To what extent do the following statements correspond to your current emotional state? Mark your answer with an X

1 – Helemaal niet / *gar nicht* / not at all --> 7 – Volledig / *ganz und gar /* completely

Ik voel mezelf rustiger nadat ik hier ben geweest *Ich fühle mich ruhiger nachdem ich hier war* *I feel calmer after being here*	1	2	3	4	5	6	7
Ik voel mijzelf hier enthousiast en levendig *Ich fühle mich hier enthusiastisch und lebhaft* *I feel enthusiastic and brisk here*	1	2	3	4	5	6	7
Ik kan hier de dagelijkse zorgen vergeten *Ich kann hier die täglichen Sorgen vergessen* *I can forget everyday worries here*	1	2	3	4	5	6	7
Na een bezoek aan deze plek voel ik mij hersteld en ontspannen *Nach einem Besuch an diesem Ort fühle ich mich erholt und entspannt* *After visiting this place I feel restored and relaxed*	1	2	3	4	5	6	7
Mijn concentratie en alertheid nemen hier duidelijk toe *Meine Konzentration und Aufmerksamkeit nehmen hier deutlich zu* *My concentration and alertness increases here clearly*	1	2	3	4	5	6	7
Dit bezoek is een manier om mijn gedachten op te helderen en te verduidelijken *Dieser Besuch ist eine Möglichkeit um meinen Gedanken zu klären* *Visiting here is a way of clearing and clarifying my thoughts*	1	2	3	4	5	6	7
Ik voel mij levend en vitaal *Ich fühle mich lebendig und vital* *I feel alive and vital*	1	2	3	4	5	6	7

Appendix 3.2: VAS-survey

Dutch/German/English:

Hoe gestresst voelt u zich op dit moment? Markeer uw antwoord met een X / *Wie gestresst fühlen Sie sich gerade? Geben Sie Ihre Antwort mit X an/* How stressed do you feel right now? Mark with an X

0% | | | | | | | | | | 100%

Appendix 4: Picture Control building – Woonzorggroep Floriade

Figure 13 Picture of the control building at the Floriade.