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Does sustainability address perceived restoration? An exploratory study on Biosphera 2.0, a net zero energy house

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Abstract

Individuals are not passively affected by the physical characteristics of the environment, on the contrary they react to it and try to modify it; their efforts are towards environments more restorative and sustainable from a cognitive point of view, i.e. environments where daily life is less stressful and more satisfying. The aim of this exploratory research study is to verify how energy zero house answers to these requirements. To this aim 29 volunteers (M age = 33.68; 14 males and 15 females) accepted to spend a couple of days/nights in Biosphera 2.0, a passive house award winning prototype. Participants were administered the Perceived Restorativeness Scale, the semiotic and sensorial aesthetic attributes and a Post Occupancy Evaluation questionnaire. Results showed that Biosphera 2.0 is not restorative per se, participants - in particular women - appreciate the experience of being-away from daily routine for a couple of days. However, participants are satisfied on a few specific characteristics of the prototype usually lacking in our daily environments: the absence of environmental stressors. Biosphera 2.0 covers the basics to be a restorative environment. Though exploratory and with limitations this research study shows that sustainable doesn't mean restorative.

Key words: Attention Restoration Theory; Biophilic Design; Biosphera Project; Net Zero Energy Building; Perceived Restorativeness Scale; Post Occupancy Evaluation.

Introduction

This exploratory research study aims to verify how restorative is Biosphera 2.0, a housing module devised to be environment friendly. The purpose is to investigate to what extent a "sustainable" environment addresses the sphere of individuals' perceived restoration.

Theoretical framework

The theoretical framework of the study is Environmental Psychology, a discipline which studies environmental perception and cognition, affective appraisal (environmental preference), spatial behaviour and cognitive maps, memory for the environments, attitudes towards the environment, the impact of the physical environment on the behaviour and environmental stress: the way an individual perceives, evaluates, uses and reacts to the physical environment (Gifford, 2009). More specifically, Environmental Psychology offers interesting insights into the origins of human preference for the natural environment (Barbiero, 2009; 2014), together with the cognitive and physiological benefits deriving from exposure to Nature (Berto, 2019), and useful indications for turning the built environment into a restorative environment (Berto & Barbiero, 2017a; Bolten & Barbiero, 2020). Individuals are not passively affected by the physical characteristics of the environment. On the contrary, they react to it and try to modify it. Their efforts are towards environments more sustainable from a cognitive point of view (Berto, 2011) and more restorative (Berto & Barbiero, 2017a), i.e. environments where daily life is less stressful and more satisfying. How does energy zero house satisfy these requirements?

Environmental stress. A brief overview

Stress occurs when the individual cannot cope with the demands from the environment. This mismatch causes at first a state of discomfort and then symptoms and illnesses related to the stress response (Baroni & Berto, 2013). Environmental stress isn't due exclusively to the presence, indoor or outdoor, of so-called environmental stressors (noise, heat, cold, inadequate lighting, crowding, air pollution, traffic, architectural dysfunctions, etc.), but also when environmental information is too intense, complex or incoherent, and when the individual has no control over the environment (Figure 1). These situations cause negative physiological responses, the appearance of negative feelings and emotions and the decreasing of cognitive skills (see Figure 2).

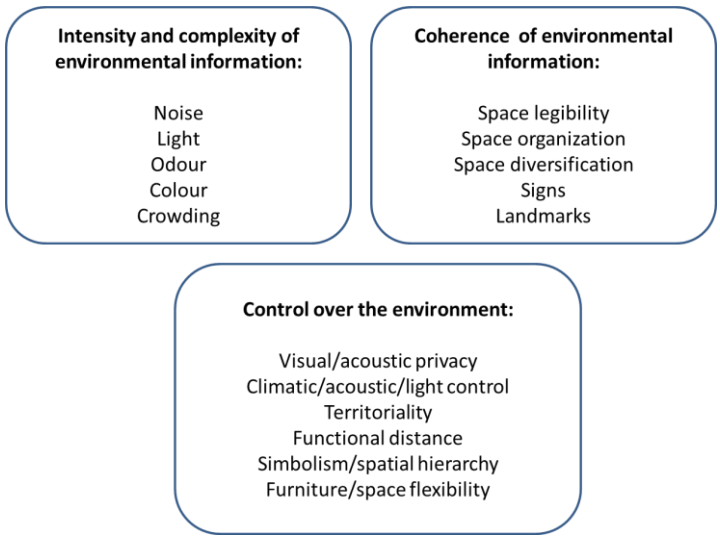

Figure 1: Physical characteristics of the environment that may cause the stress response in the individual. From: Baroni & Berto (2013).

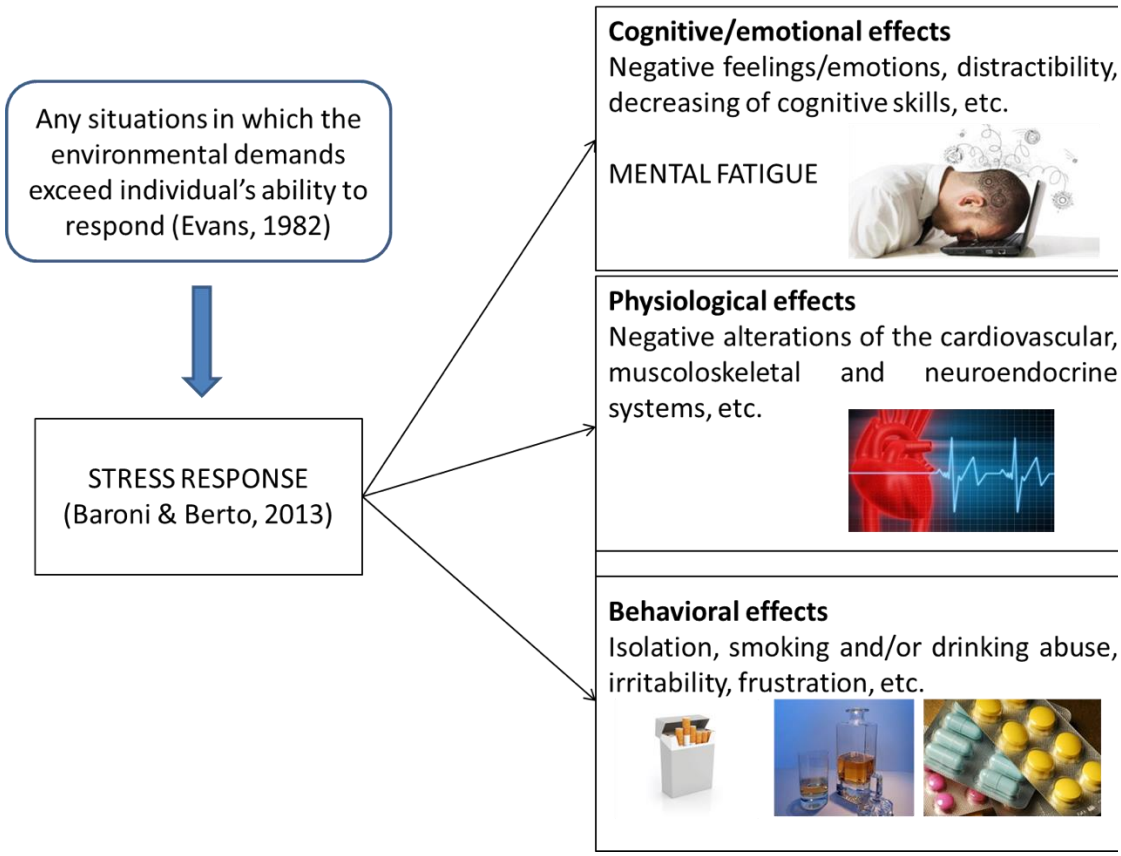

Figure 2: The negative effects of stressful situations on individuals' cognitive, emotional, physiological and behavioral response. Source: Berto, R. (2019b) Il Biophilic Quality Index: L'importanza di progettare ambienti di lavoro rigenerativi. Proceedings of the workshop *Il Design Biofilico per gli ambienti di lavoro rigenerativi*. April 4th, 2019, Milano, Italy.

The individual tries to contrast the effect of the stressors by enacting "coping strategies" (Lazarus & Folkman, 1984) to regain wellbeing. One of the quickest and most effective ways to recover from cognitive and physiological stress is exposure to natural environments (Berto, 2014). The natural environment, thanks to its restorative potential, brings benefits at a physiological and cognitive level, promotes recovery from stress, and plays an important role in the process of emotional regulation. Accordingly, restorative environments allow individuals to regulate the level of physiological activation (arousal), keeping it at an optimal level, to bring out positive emotions and feelings that consequently improve mood and produce a calming effect on the individual. Along these lines, Stress Recovery Theory and Attention Restoration Theory were developed.

According to Stress Recovery Theory (SRT; Ulrich, 1984) individuals' reactions to exposure to Nature have a parasympathetic component, not present in the response to urban scenes. The sympathetic nervous system allows human beings to respond quickly and easily to a general state of activation of the organism to threatening situations but involves fatigue and alterations in endocrine and cardiovascular chronic responses that may compromise individuals' health. On the other hand, exposure to Nature and the activation of the parasympathetic system promotes positive emotions, the increase of perceptual sensitivity and physiological changes of heart rate, muscle tension, skin conductance and blood pressure to optimal level (Barbiero et al., 2014; Berto & Barbiero, 2014).

For Attention Restoration Theory (ART; Kaplan 1995), exposure to Nature favours the regeneration of individuals' direct attention, the voluntary attention component that requires

intense mental effort to be maintained, and which needs to be restored after a state of mental fatigue. Exposure to natural environment allows directed attention to rest and be restored. Nature activates fascination, a type of involuntary attention which does not require any mental effort.

Restorative environments are therefore those places that offer the opportunity to reduce mental fatigue (ART) and recover from stress (SRT). Basically the process of attention restoration and stress recovery occur when an environment is characterized by (Kaplan, 1995): *being away*, i.e. it provides the opportunity for mental/physical distance from daily routine; *fascination*, i.e. it is characterized by elements which attract involuntary attention, e.g. natural elements; *compatibility*, i.e. it offers a wide range of activities which match personal interests; *extent*, i.e. it offers the opportunity to be explored in time and space, e.g. ecosystems to observe, paths to follow. Depending on the combination of the restorative factors, some environments are more restorative than others. The greater the presence of each component, the greater the restorative potential of the environment (Kaplan S., 1993; Hartig et al., 1996; Purcell, Peron, Berto, 2001, Peron, Berto, Purcell, 2002).

Buildings should provide a restorative experience for those living/working in them. To this end, each space within the restorative building has to be specifically designed to foster human wellbeing and a sense of *here-ness*, by providing an environment which allows recovery from urban stress and daily mental fatigue, and is configured in such a way as to allow the experience of relaxation, fascination and interaction with the environment, *enclosure*, *separation from distractions*, *environmental stimulation*, *coherence*, *complexity*, *affordances*, opportunities for *visual contact with Nature* and the presence of *biomorphic patterns,* characteristics that have to be carefully assessed in a building in order for it to be restorative (see the Biophilic Quality Index; Berto & Barbiero, 2017a).

Environmental preference

Natural environments are restorative not only because they favour the recovery from psycho-physiological stress and mental fatigue, but also because they evoke positive emotional reactions, which for ART and SRT are triggered by the innate preference of the individual for certain characteristics typical of natural environments. Environmental preference is directly related to the restorative value of the environment. High levels of preference are associated with high levels of perceived restoration and vice versa (Hernandez et al., 2001; Purcell, Peron, Berto, 2001; Berto, Magro, Purcell, 2004; Berto, 2007). The relationship between environmental preference and perceived restoration derives from the experience Humans had of the natural environment, i.e. the environment in which they evolved, in particular from the development of sensory mechanisms in response to natural stimuli (Balling, Falk, 1982; Kaplan, Kaplan, 1989) which makes the preference for natural environments innate (Berto et al., 2018). From this perspective, environmental preference and the need for restoration can be considered expressions of an adaptive behaviour that the individual enacts to get away from "potentially dangerous" environments, in order to find the most suitable refuge in a safer and more comfortable environment (Kaplan, 1992).

According to the Environmental Preference model (Kaplan & Kaplan, 1989), the most preferred environments are those characterized by the right combination of four factors: coherence, complexity, legibility and mystery. *Coherence* defines a space characterized by meaning, i.e. by the repetition of some elements or the presence of textures (e.g. the crown of the trees, the lawns) or well-defined areas. *Complexity* is given by the quantity of stimuli present in an environment. Usually environments offering a good level of stimulation – quantity and quality – are more appreciated than those with a lower level of stimulation. *Legibility* characterizes environments easily to understand which support orientation and wayfinding. Finally, *mystery* is the possibility of obtaining further information from the environment, which leads the individual to explore and discover (e.g. entering a forest and encountering curved paths and vegetation that partially obscures the view). These four predictors that affect individuals' preferences derive from the immediate or inferred satisfaction of two basic human needs: comprehension and exploration.

The most preferred environments (natural or built) show the right combination of the four

predictors, in that they are environment coherently complex, where environmental information is legible to sustain behaviour while maintaining an element of mystery to cherish interest and curiosity (Berto, Barbiero, 2017a). In addition to the four factors, the *content* of an environment, namely its degree of naturalness and the level of *familiarity* the individual has with it are two important aspects affecting environmental preference.

Biosphera 2.0: The energy zero house

The object of this research study is Biosphera 2.0, an experimental prefab dwelling, part of a broader project which started in 2014 and will end in 2020. Biosphera 2.0 is the second step of the project (see Table 1), and is built to Passivhaus and Minergie energy standards, i.e. Biosphera 2.0 produces as much energy as it consumes thanks to passive house design and rooftop solar panels. In 2016 Biosphera 2.0 was tested in a yearlong tour around Italy, where the prototype was located in six different locations and was inhabited by people as part of the research project. The 25-square-metre Biosphera 2.0 started with installation in the Italian town Courmayeur. From there the mobile home moved to Aosta, then Milano, Rimini, Torino, and finally Lugano (Switzerland). Indeed, thanks to the passive house design and effective insulation, the Biosphera 2.0 can adapt to a variety of environmental conditions, such as urban pollution, and temperatures from -21 degrees Celsius (-5.8 Fahrenheit) in winter to 39 degrees Celsius (102.2 Fahrenheit) in summer.

In spite of its small size, the zero-energy dwelling offers the comforts of a "real" home including a bedroom, a bathroom, a living area, a kitchen and outdoor deck. The interior air temperature fluctuates between 21 to 25 degrees Celsius (69.8 to 77 Fahrenheit) all year-round without the need for an external heating or cooling network. The home is also equipped with LEDs and constructed from PEFC-certified timber.

	Biosphera 1.0	Biosphera 2.0	Biosphera Equilibrium
Period	2014-2015	2016-2017	2018-2020
Concept	Passive house	The zero-energy house	The regenerative house
Focus	Modularity	Energy autonomy	Dwelling wellbeing

Table 1: The three concepts of the Biosphera project developed from 2014 to 2020.

Method

Participants

A total of 29 adults, recruited from different parts of Italy, voluntarily participated in this field study: 14 males and 15 females, mean age 33.68 (SD = 12.20). Participants were asked to spend a couple of days (mean permanence: 2/3 nights). Since Biosphera 2.0 was devised to host two people, participants were allowed to bring a friend.

The experimental setting: Biosphera 2.0

Biosphera 2.0, the setting of this study, was made up of (see Figure 3, 4 and 5):

- Living area with a fitness corner, a relaxation space and an induction kitchenette
- Sleeping area with two bunk beds
- Bathroom connected to the technical room
- Technical Room

Two full-height windows convey natural light into the living and the sleeping areas. The windows are positioned on angled walls, in order to maximize natural lighting inside the module. A third smaller window is placed on the opposite side, in the bathroom. The main building material is wood, chosen for its environmental sustainability and natural feel. It is used both for the load bearing walls (X-LAM) and the interior furnishing.

Figure 3: Biosphera 2.0 - External perspective view

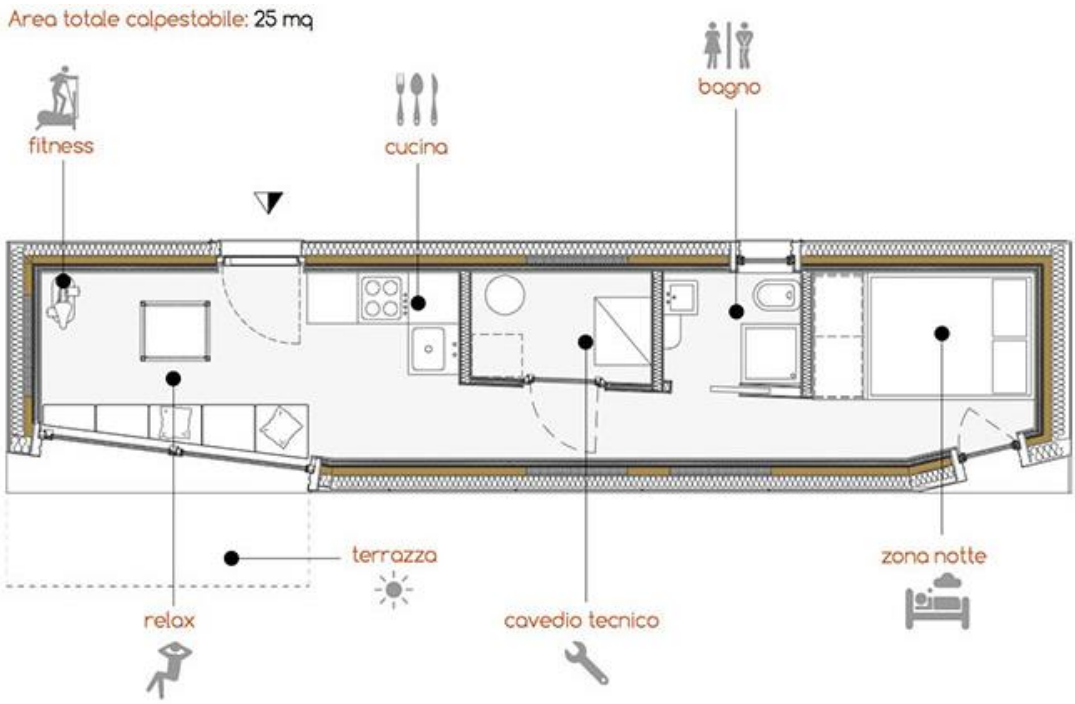

Figure 4: Biosphera 2.0 – Plan

Biosphera 2.0 is internally equipped to satisfy all the basic needs of inhabitants' everyday life. The module is characterized by cutting-edge installations, such as photovoltaic solar panels, LED lighting to reduce artificial lighting impact and new generation sensors to optimize energy performance, as well as others.

Figure 5: Internal view of Biosphera 2.0. The living area (on the left) and the sleeping area (on the right).

In a low impact perspective, occupants play an active role on Biosphera 2.0 “energy performance”. They can act at any time on an innovative monitoring system, providing personal control of the internal microclimatic conditions. This system collects and integrates data from 25 variables such as internal and external temperature, humidity, indoor air quality, dust, electromagnetic fields, outdoor and indoor noise, external and internal pressure, photovoltaic system production and power usage.

Instruments

Participants were administered a set of measurement instruments: The Perceived Restorativeness Scale (PRS-11; Pasini et al., 2014); the semiotic and sensorial aesthetic attributes (SSAA; Nasar, 1994); a Post Occupancy Evaluation questionnaire (POE).

The Perceived Restorativeness Scale-11

The Perceived Restorativeness Scale-11 (PRS-11; Pasini et al., 2014) measures the individual perception of the restorative value of the environment, which means how much the environment enhances fascination and accordingly the restoration of direct attention from mental fatigue. The self-report scale is made up of 11 items measuring the presence of four restorative characteristics of the environment: being-away (BA), fascination (FA), coherence (COH) and scope (SCO); coherence and scope derives from “extent”, (see section 1.3).
The items of the PRS-11 submitted to the participants were slightly adapted to the experimental setting, e.g., “BIOSPHERA 2.0 is a refuge from everyday concerns” (Being-away item), “In BIOSPHERA 2.0 my attention is attracted by many interesting things” (Fascination item), “There is a clear order in the physical arrangement of BIOSPHERA 2.0” (coherence item), “BIOSPHERA 2.0 can be explored” (scope item). Two items were added to the PRS-11: one to measure preference (PREF: I like BIOSPHERA 2.0.) and one for familiarity (FAM: BIOSPHERA 2.0 is familiar for me) for a total of 13 items in total. All items are assessed on an 11-point scale, from 0 to 10, where 0 = not at all, 6 = a lot and 10 = very much.

The Post Occupancy Evaluation questionnaire

The Post Occupancy Evaluation questionnaire (POE; Nasar, Preiser & Fisher, 2007) allows evaluating how much the individual is satisfied with the environment characteristics/features. Post-occupancy evaluation is defined as "the process of evaluating buildings in a systematic

and rigorous manner after they have been built and occupied for some time" (Preiser, Rabinowitz & White, 1988). Since the 1960s, the POE has been tackled from approaches which differ for the method adopted and/or for the criteria chosen for the evaluation. Since the 1990s the most common approach to address building POE is from a technical, energetic and environmental sustainability point of view. Our participants were administered a POE questionnaire made up as follows: two open questions asking about the positive/negative aspects found in the module: "what did you like most about Biosphera 2.0?" and "What did you like least?"; a list of 17 features assessing the design quality and the liveability of the module: exterior and internal aesthetic, interior lighting, acoustics, smell, floor, walls, ceiling, space, movement, arrangement, view to the outside, temperature, safety, installation, flexibility and accessibility. The level of dis/satisfaction is assessed on a scale from 1 (totally unsatisfied) to 7 (totally satisfied). Two final open questions that are: "According to you, list in order of importance what is missing in Biosphera 2.0"; "What do you suggest in order to improve Biosphera 2.0?"

The Semiotic and Sensorial Aesthetic Attributes

The Sensorial and Symbolic Aesthetic Attributes (SSAA; Nasar, 1994) are a list of 10 physical-aesthetic characteristics to be assessed on the following 5-point scale: 1 = nothing – 2 = very little – 3 = quite much – 4 = much – 5 = very much. The attributes are vegetation, variety, harmony, spaciousness, brightness, representative building, cleanliness, maintenance, recreational activities, and originality. Participants were asked to assess how much each attribute applied to Biosphera 2.0.

Procedure

Participants were administered the set of instruments when entering Biosphera 2.0 for the first time (pre-assessment) and when leaving it (post-assessment). Though literature shows that familiarity doesn't affect the perception of restorativeness (for a review see Berto, 2014), a recent study pointed out that familiarity together with the sense of connection to Nature may affect the individual's perception of the restorative value of an environment. To this end, the PRS-11 was administered at the first encounter and after the brief stay in Biosphera 2.0, i.e. when some familiarity has been built. Familiarity is expected to affect preference as well. The PRS-11 scores will be put in relation with the CNS scores to assess whether participants differ on this construct and also if differences in the CNS scores go with differences in PRS-11 scores. Finally, the relation between PRS-11 scores and the presence of the SSAA and the 17 features of the POE questionnaire will be considered. Instruments were administered as follows: Pre-assessment: CNS, PRS-11; Post-assessment: SSAA, PRS-11, and POE.

Results

To start, the average scores of the PRS-11, FAM and PREF were calculated for the pre- and the post- assessment on the entire sample (see **Table 2**).

	PRE assessment	POST assessment
PRS-11	5.97 (1.21) *	6.52 (1.19) *
PREF	8.78 (1.03)	9.15 (0.89)
FAM	7.68 (2.18)	8.47 (1.26)

Table 2: Average scores and standard deviation (in parenthesis) of the PRS-11, PREF and FAM across the two assessments. *statistically significant difference

Paired sample t-tests showed a significant difference between the two assessments for the PRS-11 score: $t(18) = -2.90$, $p = .009$ ($p < .05$), whereas no significant differences emerged for PREF ($p > .05$) and FAM ($p > .05$), though both variable scores increased from the pre- to the post-

assessment.

Paired sample t-tests were run again to verify whether, within the male and the female group, differences exist for the PRS, PREF and FAM scores from the pre- to the post- assessment (see **Table** 1). The only significant difference emerged for FAM in the male group: t (10) = -2.60, p = .02 (p < .05).

Independent sample t-tests run on the males' and females' scores of each assessment showed a significant difference between genders for PREF of the post assessment: t(17) = -2.91, p = .01 (p < .05), with females scoring higher (see **Table 3**).

	Males (N = 14)	Females (N = 15)
PRS-11 pre	6.04 (1.27)	5.87 (1.20)
PRS-11 post	6.51 (1.40)	6.54 (0.91)
FAM pre	7.00 (1.84) *	8.62 (2.38)
FAM post	8.27 (1.10)	8.75 (1.48)
PREF pre	8.72 (1.00)	8.87 (1.12)
PREF post	8.72 (0.90)	9.75 (0.46)

Table 1: Average score and standard deviation (in parenthesis) of males and females for the PRS-11, FAM and PREF. * = statistically significant difference

At this point the mean score of each restorative factor was calculated for the pre- and the post-assessment first on the entire sample, and then for the male and female group separately (see **Table 4**). From the paired sample t-tests a significant different has emerged for BA for entire sample: t (18) = -3.14. p = .006 (p < .05), and for the male group: t (10) = -2.82. p = .018 (p < .05). Pearson bivariate correlation was calculated between the scores of the restorative factors for each assessment. In the pre- assessment the correlation BA*FA and COH*FA turned out positive and significant (p > .05; see **Table 5**). In the post- assessment was positive and significant the correlation between SCO*FA (p > .05; see **Table 6**).

	Entire sample	Males	Females
BA-PRE	5.17 (2.64) *	4.60 (2.99) *	5.95 (2.00)
BA-POST	6.31 (2.74)	5.33 (3.01)	7.66 (1.65)
COH-PRE	5.29 (1.10)	5.10 (1.28)	5.54 (0.83)
COH-POST	5.57 (1.00)	5.66 (1.12)	5.45 (0.88)
SCO-PRE	6.65 (1.39)	6.27 (0.93)	7.18 (1.79)
SCO-POST	7.10 (1.52)	6.86 (1.70)	7.43 (1.26)
FA-PRE	7.00 (1.48)	6.96 (1.48)	7.04 (1.57)
FA-POST	7.35 (1.39)	7.30 (1.66)	7.41 (1.00)

Table 4: average scores and standard deviation (in parenthesis) of the 4 restorative factors across the two sessions for the entire sample and across the two genders. * = statistically significant difference

PRE assessment	BA	COH	SCO	FA
BA	1	0.263	0.135	0.397 *
COH	0.263	1	0.237	0.473 *
SCO	0.135	0.237	1	0.388

Table 5: Pearson bivariate correlation between the restorative factors for the pre- assessment. BA = being-away, COH = coherence, SCO = scope, FA = fascination. * = correlation is significant at the 0.05 level (two-tailed)

POST assessment	BA	COH	SCO	FA
BA	1	-0.072	0.401	0.395
COH	-0.072	1	0.250	-0.150
SCO	0.401	0.250	1	0.519

Table 6: Pearson bivariate correlation between the restorative factors for the post- assessment. BA = being-away, COH = coherence, SCO = scope, FA = fascination. * = correlation is significant at the 0.05 level (two-tailed)

The SSAA mean scores were calculated both on the entire sample and for the two genders separately. To all participants, the features that most characterize Biosphera 2.0 are: harmony, brightness, representativeness and originality (see **Table 7**). No significant differences emerged between males' and females' scores from the independent sample t-test ($p > .05$).

	Total sample	**Males**	**Females**
Vegetation	0.91 (0.94)	0.92 (1.03)	0.90 (0.87)
Variety	2.39 (0.98)	2.38 (0.65)	2.40 (1.34)
Harmony	**3.26 (0.63)**	**3.15 (0.68)**	**3.40 (0.69)**
Spaciousness	2.17 (0.83)	2.38 (0.96)	1.90 (0.56)
Brightness	**3.39 (0.78)**	**3.46 (0.51)**	**3.30 (1.05)**
Representative building	**3.34 (0.77)**	**3.38 (0.76)**	**3.30 (0.82)**
Cleanliness	2.91 (0.79)	2.76 (0.72)	3.10 (0.87)
Maintenance	2.73 (0.81)	2.61 (0.76)	2.90 (0.87)
Recreational activities	2.26 (1.00)	2.15 (0.80)	2.40 (1.26)
Originality	3.30 (0.97)	3.15 (1.14)	3.50 (0.70)

Table 7: Mean scores and standard deviation (in parenthesis) of the semiotic and sensorial aesthetic attributes for the entire sample and for males and females respectively. *Note*: attributes scoring higher than 3 (in **bold** in the Table) can be considered "**very present**" in Biosphera 2.0.

The level of satisfaction for the 17 characteristics measured by the POE was calculated for the entire sample and for males and females separately (see **Table 8**). On these scores independent sample t-tests were calculated. Significant differences between males and females emerged for: external aesthetic: t (20) = -2.32. p = .031 (p < .05) and for space t (20) = 2.33. p = .030 (p < .05).

At this point, the mean score for the CNS was calculated for the total sample (M = 2.44; SD = .38). The independent samples t-tests showed no significant difference between the males (M = 2.44. SD = .41) and the females' score (M = 2.45, SD = .36), (p > .05).

	Entire sample	Males	Females
External aesthetics	5.04 (1.86)	5.16 (1.74)	4.90 (2.07)
Internal aesthetics	5.81 (1.18)	5.33 (1.30) *	**6.40 (0.69)**
Lighting	**6.27 (0.76)**	**6.16 (0.71)**	**6.40 (0.84)**
Acoustics	**6.00 (1.53)**	**6.08 (1.56)**	5.90 (1.59)
Smell	**6.09 (1.13)**	**6.00 (1.41)**	**6.20 (0.78)**
Floor	5.50 (1.30)	5.41 (1.16)	5.60 (1.50)
Walls	5.59 (1.05)	5.66 (1.15)	5.50 (0.97)
Ceiling	5.72 (0.98)	5.66 (0.88)	5.80 (1.13)
Space	4.90 (1.19)	4.41 (1.31) *	5.50 (1.07)
Movement	5.09 (1.10)	4.75 (1.13)	5.50 (0.97)
Arrangement	5.81 (0.90)	5.83 (0.83)	5.80 (1.03)
View to the outside	**6.40 (0.85)**	**6.41 (0.99)**	**6.40 (0.69)**
Temperature	**6.45 (0.96)**	**6.66 (0.49)**	**6.20 (1.31)**
Safety	5.63 (1.04)	5.91 (0.99)	5.30 (1.05)
Installations	5.90 (1.10)	**6.00 (1.04)**	5.80 (1.22)
Flexibility	5.04 (1.53)	5.00 (1.65)	5.11 (1.45)
Accessibility	2.36 (1.39)	2.33 (1.55)	2.40 (1.26)

Table 8: Mean scores and standard deviations (in parenthesis) for the 17 features of the POE questionnaire across genders and for the entire sample. *Note*: scores higher than 6 (in **bold** in the Table) mean a **good level of satisfaction** with the feature. * = statistically significant difference

Pearson's bivariate correlation was calculated between the PRS-11 and FAM scores for each assessment (pre- and post-). The pre- assessment shows the correlation PRS* FAM and FAM*PREF and significant (p < .01) (**Table 9**).

PRE assessment	PRS	FAM	PREF
PRS	1	0.521**	0.327
FAM	0.521**	1	0.679 **

Table 9: Pearson's correlations between PRS, FAM and PREF for the pre- assessment. ** = correlation is significant at the 0.01 level (two-tailed)

The same correlation was calculated for the post assessment; again, the significant correlation PRS*FAM and FAM*PREF has emerged (see **Table 10**).

POST assessment	PRS	FAM	PREF
PRS	1	0.321	0.489*
FAM	0.321	1	0.532*

Table 10: Pearson's correlations between PRS, FAM and PREF for the post- assessment. * = correlation is significant at the 0.05 level (two-tailed)

Discussion

Results show that in spite of familiarity (as expected), preference and perceived restoration increase from the pre- to the post- assessment, while the only significant difference is for perceived restoration which increases for males and females. On the contrary, familiarity and preference show an opposite trend across genders. Males' familiarity increases from the pre- to the post- test, whereas females' preference increases. However, correlations show that perceived restoration, preference and familiarity assessments are related. The literature shows positive relation between preference and perceived restoration (see Berto 2014 for a review) whereas the role of familiarity on preference and in particular on perceived restoration has been shown recently (Tang, Sullivan & Chang, 2015; Berto et al., 2018). Moreover, in this study familiarity seems to play a role.

Looking at the perception of the restorative factors separately, only *being away* increases significantly across the assessments. This result was expected, since spending an average of 3 days and 2 nights in Biosphera 2.0 certainly provided a physical, and maybe even a mental, distance from daily routine. This is particularly true for females, who scored higher than males on being away (see also Berto & Pasini, 2007). The higher the sense of being away, the higher the preference for Biosphera 2.0.

As far as the semiotic and sensorial aesthetic attributes are concerned, here males' and females' scores correspond. Indeed, they both consider Biosphera 2.0 mostly characterized by harmony, brightness, representativeness and originality, whereas the least present characteristic is vegetation. In particular, participants are satisfied by the natural lighting (offered by the floor to ceiling windows) and view to the outside, by the indoor temperature and absence of any smell and sounds from the outside, features guaranteed by a good insulation of the module. On the contrary, participants show the lowest level of satisfaction with space and accessibility. This result doesn't come as a surprise, considering the spatial limitation of Biosphera 2.0 which doesn't allow accessibility to everyone. In particular, males are less satisfied than females with space and internal aesthetics, showing different gender expectation concerning internal space.

Conclusions

The aim of this exploratory research study was to verify how energy zero housing addresses perceived restoration. Though no attentional and/or physiological measures were collected, qualitative data obtained from the self-report instruments can give useful hints on this issue. Biosphera isn't restorative per se. Basically, participants appreciated the experience of *being-away* from daily routine for a while. However, participants appreciated a few specific characteristics of Biosphera 2.0, which are usually lacking in our daily environments, such as a lot of natural lighting, the absence of any smell and sound from the outside and the comfortable indoor temperature. Basically, participants appreciated the absence of environmental stressors. The absence of stressors is the prerequisite for an environment to be restorative. Biosphera 2.0 accomplished the basics, now it is time to improve this passive house award winning prototype in order to convert it from green to

restorative (Berto. 2011; Berto & Barbiero, 2017a). This transformation requires panoramic, trans-disciplinary thinking and coordinated actions, because sustainability does not really push architects to go beyond form and scale design to encompass the wellbeing and quality of life of users, which should be among the most important architectural considerations today.

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