Sustainability in Interior Design: Interdisciplinary Research Used for Exploring Relation between Built Environment and Human

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Abstract. This paper presents achievements and results in the projects based on the Platform of BCDlab (Body Conscious Design laboratory) and the Institute of Interior and exhibition design of Faculty of Architecture, related to sustainability. The studies are related to the collection of 11 features of a supportive environment for the contemporary human – “cultural animal”. These postulated have been generated during the last years of the research or relation between the human and its natural and built environment in BCDlab. Each postulate is illustrated with some of its design outputs. The presence or lack of the supportive environment has an impact on the contemporary behaviour, well-being, social and interpersonal interactions and in a long-term interaction also on the personal and environmental integrity, belonging to the community and local culture and especially to the public health. There is also an evidence of interrelation to the sustainability approach, the paper presence studies that are emphasising the importance of the material choice by the spatial design, the role of local growth materials in its authentic and truthful form and surface.

1. Introduction - Features of the supportive environment / principles of spatial design for well-being

Our behaviour, outlook, general wellbeing and everyday social interactions are directly tied to the natural and built environment. How spaces and their structures control our everyday use have consequences, which are far-reaching - potentially impacting our long-term mental and physical health. Lack of a supportive environment contributes to civilisation diseases relevant to the public health. The paper is a summary of recent multidisciplinary research of human centred design on the platform of BCDlab. It is summarized into 11 features of the supportive environment for contemporary humans – “cultural animals”. Needs of human beings are altering with age and momentary life strategy and stage of personal development. 1. feeling of safety; 2. prospect and refuge; 3. contact with outdoor; 4. personal space; 5. intimacy vs socialisation; 6. appropriate scale; 7. Attachment; 8. local identity; 9. body consciousness; 10. appropriate environmental stimulation; 11. more natural materials. Another principle that is not directly related to well-being, but cannot be skipped by overall criteria is being aware of the environmental context that we have defined as environmental awareness. State the objectives of the work and provide an adequate background, avoiding a detailed literature survey or a summary of the results.
2. Feeling of Safety
A feeling of safety is a basic condition for a feeling of well-being. In terms of safety in the macro-environment, it means e.g. being away from endangerment of the natural elements or being in a safe quarter of a city with low crime. In terms of the microenvironment, it means being safe at home – with less endangering of privacy and territory or feeling safe from any kind of mechanical or technical/static endangering – like unstable objects. Even though in western cultures, vision is the dominant sense especially by entering a space, safety is a matter of all senses. Our visual culture precludes stimuli from other senses, but nonetheless, they are more connected to human unconsciousness, where instincts initiate an intuition that can give us “warnings” in risky situations which lead us to change our behaviour. This topic is related to our ability to be oriented in space while disorientation can cause people to feel stressed up and unsafe, that can lead to potential aggressive or psychotic behaviour.

The feeling of safety is supported by these features: the ability to protect one’s own private space; the presence of a physical barrier behind one’s back- e.g. in the form of a wall, screen or piece of furniture that unconsciously grant protection from attack from the back; overview about the entrance to the space and control over territory; horizontal structuring of space; lower ceiling; panoramic outlook over surroundings, presence of limits and barriers that according to the situation are flexible and adaptable.

3. An appropriate ratio of prospect and refuge
The possibility to combine prospect / perspective and refuge is a very basic need of Homo sapiens. It is connected with an instinctive search for situations and environmental settings where a person has a protected back and at the same time an overview of the actions and events in the space. It is about the possibility to see and be seen that is controlled while being culturally conditioned. It is essential for a person to alternate between staying in a safe controlled place (with socialization possibilities) and staying on "hunting grounds" overlooking other perspectives - alternating between privacy, socialization and challenges. Our goal of behaving in space is therefore to take the position with the best possible outlook and to have control over our territory - that is, to control not only our personal space but also the space that we can control by sight. For example, if somebody is choosing a place to sit in a café or restaurant, he usually chooses a place where he can have a wall behind his back and can overlook the door and often view through the window. It's the setting that most evokes a sense of security (the back wall hides and the view from the door and the windows look out).

4. Sufficient visual and somatic contacts with outdoors and nature
For a person - a cultural creature suffering from civilization diseases – staying in nature is actually a recovery environment and the prosperity of contact with the outdoor is there evident. The everyday view from the window can determine / influence the whole life perspective. It is definitely better to have any kind of view in our day-to-day work and housing. It is significant not only because of the need for daylight from a light-technical point of view, but to keep our natural biorhythm tuned to the period of the day, the weather and the season.

Moreover, the possibility of viewing out to the distance allows the eye to alternate between concentrated viewing on what is near (such as reading, writing and working on the computer) and looking out into the distance, thereby supporting - Saccadic eye movement. The eye will relax in this alternation, so we instinctively search for the setting in the environment. We do not have to talk about the extremes of uncivilized prisons; it is enough to go to production facilities or supermarkets with all-day artificial lighting. People exposed to long-term deprivation of contact with the exterior suffer more from civilization diseases, not to mention the frequent loss of life perspectives leading to passivity and life resignation. By creating housing concepts and public places it is very helpful to offer the potential of nature watching. Why nature watching? It is a great occasion not only for regeneration, relax and slow down, but also to be fascinated, to experience, to enjoy respect to nature which offers a deep contemplation and feeling of belonging.
5. Accurate Personal Space

The sense of security is closely related to the feeling of preserving the personal space. On this occasion, it is also necessary to mention the science dealing with the distance between persons and furnishings in space, i.e. proxemics and sociometry. The concept of proxemics was introduced in 1959 by modern American anthropologist Edward T. Hall in modern anthropology. Essential for a sense of security is the personal distance (personal space, zone of intimacy). It serves as an invisible personal bubble that surrounds the organism of any non-contact animal. Hall, in his book from 1969 - Hidden Dimension, also gave precise numerical expressions of acceptable distances for certain activities and cultures. In negotiations, for example, it is 120 to 360 cm. The opposite is, according to anthropologists, an intimate distance, which is 0 to 40 cm – where the human will not let anyone else go. In the western culture for example if someone gets too close to somebody else sitting on a bench in the park – it is felt as a disturbance of privacy, an infringement of the most private zone around the body. Even sitting very close to some strange person in transport or a waiting area is kind of disturbance in cases where there is a choice and a free capacity of places. Edward T. Hall even worked out a detailed zoning chart, dividing the zones according to the reach of senses where the visual zone is the largest, followed by the acoustic, the olfactory and the smallest and the most intuitive, the tactile. We suffer more when sitting close to someone else, for example in transport means or in the waiting room at the doctor’s. There is a greater likelihood of talking to a stranger at a safe social distance of about 120-240 cm [1-4]. According to the influential sociologist John Fruin, the shape of the touch zone is variable according to human activities [5]. The perception of the disturbance of the territory is cultural and the great difference is in the personal distance between Western and Eastern cultures.

Distances between people defined by the interior of the premises also significantly affect the non-verbal communication. That's why, for a stay at home and at the workplace, the interior and exterior furnishings allow users to protect, occupy, adapt and control the size and shape of their personal space, their own territory, through its size and arrangement.

Another important topic is the density of space. We can talk about density at all levels of the environment, from the microenvironment to the scale of human settlements. Density interferes with the private zone, which causes discomfort in the long-term interaction, but is very strongly culturally justified. In western cultures, it increases the risk of increased stress and aggression in both private and public areas. The problem of territoriality occurs, in particular, in large-scale offices with little personal space and, on the contrary, too much space in large-scale dwellings, where it is then difficult to experience the feeling of intimacy, cosiness and a sense of home.

![Figure 1](image1.jpg) Sociofugal that reduce or even discourage communication and the right picture is an example of sociopetal that is encouraging communication by placing elements “face to face”, Stockholm Arlanda airport in Sweden, photo: Veronika Kotradyová
6. Intimacy versus Socialization – Social Inclusion

Another important issue is the need for personal and intimate space, one’s own territory, and competence to occupy and control it. This is very much related to the need to switch between privacy and socialisation according to the current situation. It very much depends on a space arrangement supporting or postponing communication, about which a lot of knowledge is found in proxemics and anthropology. By all social and age groups it is very much appreciated if they live in a mixed heterogeneous community considering age and social statuses. This state provides the feeling of inclusiveness.

We can talk about intimacy and occasions – opportunities for communication-socialisation at several levels of environment, but the three of them (own body, family or other group and society-community) are the most significant whereas at all levels the main issue, is to have the possibility to switch between privacy and socialization, to switch between encouraging and preventing communication – being in sociopetal or sociofugal constellation, set by space arrangement – facing each other and having eye contact and inclination of body towards each other that supports verbal and nonverbal communication or preventing eye and body contact (figure 1). Essential here is the choice and possibility to switch between privacy and socialization as needed, which is helpful in arranging space to encourage or discourage communication and simultaneously to have control over privacy-intimacy and own territory. The need for intimacy while doing private activities or resting within own territory is an important part of the feeling of complex comfort by living and working in a group [6]. However, this is also true for public spaces where work or other activity is done for longer times in one place (receptionists in a foyer, etc.). Intimacy is the key issue, especially when performing hygiene, sleeping and other intimate activities, and it is directly related to the feeling of security. Here the physical limits and barriers are indispensable, whether there is a complete barrier such as a wall or a wall with doors that can be closed/locked or a wall with a non-closing opening or incomplete partition wall or just a hint - such as glass partitions.

For large open-space offices, the territory defined by partitions is an indicator of status and hierarchy in an organization. It can work in business, family, or any community sharing common spaces. In the case of glass partitions, however, privacy is provided only in a very suggestive way or it does not provide it at all. But it is an attribute of status and the hierarchy within the organization. The location of doors, their presence or ability to be closed, is also strategic when planning a layout, with its associated operations. For example, the best place in a business meeting is that which faces the door and the back wall. In many cultures, we can observe very interesting phenomena - preferring staying sitting on a bench by the front door, especially by traditional or progressive housing concepts (figure 2).
Figure 2. Housing settlement in Bamberg, Germany that was built on previous brownfield, consist of more different sorts of wood structure houses with different housing programs and typology that creates setting with common green yards, by entrance into the housing units there is high quality interface between outdoor and indoor supported by possibility to sit on the wooden bench and support socialization with neighbours. With its concept, it reminds lining in the village and provides more occasions to spend free time together, photo: Veronika Kotradyová

7. Human Scale and Measure
The need for an adequate human scale and balanced proportions applies to all levels of the environment, from the microenvironment to the macro- and semi-environment. When designing products and built environments, it should be taken into account that each space and material has its own radiating expression that needs to be recognized and respected in forming. Together with colour, the shape is the most important artistic category. In order for any object to be mastered on the aesthetic side, and thus to extend its moral life, all the tempering means must be mastered in it: rhythm, proportion, scale and dimension, equilibrium, unity, style and character. Most of them are derived from nature and the human body.

There are a couple of studies dealing with alternative concepts of housing, also in micro-spaces, challenging the minimal and optimal space volume for housing [7, 8].

In macro and semi-environment, cities are now overwhelmed by "oversize" administrative and commercial buildings, more users prefer smaller, more adequate housing such as family houses or lower-storey dwelling units. That is why residential units similar to the arrangement of the village or the medieval town with squares are still very welcomed [9]. Overly large and vast spaces that the human nervous system cannot handle and process in order to be able to recover is one extreme. The opposite extreme is too small and densified spaces that stress users, especially during long-term stays. But here it has to be said that the scale of the space and well-being are influenced by the cultural background.

Especially with long-term residence in the premises, each extreme creates immediate stress for our nervous system, but also deforms perceptions of the self and of life perspectives. The scale of every investment, design, and architectural achievement should be the human being - both body and mind [10-12].

8. To Allow Attachment
Human being built the “Self” through the extending, mirroring, processing and getting feedback and self-identification through the extensions [4] that is why we need the possibility to be attached to places, environmental settings and things. Important is to have the possibility (or competence) to be attached to a place or products, to have the competence to adapt them, personalize, to mirror and extend the Self /ego into the occupied space where a human lives, and thus gain a state of self-identification. This feature is important for the human as a cultural creature, but also as an animal that needs its own marked habitat. This need is extremely intensified with ageing.

According to Robert Gifford, one of the main experts from the field of environmental psychology, place attachment represents a deep experience of feeling part of a place. It is related to the richness of meaning and sense that is developed out of acquaintance with a place and, subsequently, when the place gets to be familiar. This attachment can be to our homes, properties, communities or local nature sceneries and settings. Where the attachment rises, the intensity and meaning of the place and the meaning of Self become affiliated [13]. Then the meaning of the place can become so strong that ’s self-identity starts to be restricted by the place. On the smaller scale, many people are identified with their neighbourhood, quarter, village, farms, houses and rooms.
Attachment to a place has some serious implications. Its close relative - the identity of the place / place identity, is an important dimension of the personality of the individual. The ability to adhere to spaces and things, to mirror them, to build the Self upon them, to identify the Self with them, are very strong human needs. Each individual has a different intensity of projection of unprocessed unconscious issues into their immediate living space, into the things they own, depending on their life strategy and the evolutionary stage of personality development. With elderly people, the process can be very intensive. Meaning of place can be so intensive that somebody’s Self-identity is bordered /limited by the place. Moreover “the Joneses” - others and their opinions are very important for us according to studies of cultural anthropologist Daniel Miller [14].

9. Local Identity
To bring local identity into the material culture – into the design of buildings, interiors and products – is a part of socio-cultural well-being and sustainability too. In the contemporary era of globalisation and unification in material culture, it is very important to maintain and apply elements and concepts that are special and unique for single regions. Cultural identity and tradition are inseparable parts of every society and can influence the character of local built-environment and its elements. This “DNA” of society indirectly affects the typology/morphology and semiotics of crafted products and architecture, and it creates the basics of the design language of a country or region. Local identity can be understood as the essence of a cultural heritage and genius loci and plays a very important part in self-identification. This is unfortunately very often misinterpreted in the design of contemporary building or products. Preserving local identity is a big challenge also for local industry and eco-tourism. There is also a big challenge for regional development to bring and to set the new forms of responsible and sustainable tourism – eco-, agro- and ethno tourism (figure 3). To help to improve the situation since 2017 there has been at the Faculty of architecture, STU in Bratislava a contemporary project - IDENTITY.SK – a common platform of design, architecture and the social sciences.

Figure 3. Example of bringing local identity into the built –environment, Vigilius resort, architect Mattheo Thun, Lana, South Tirol, photo: Veronika Kotradyová

Maintaining the cultural sustainability through giving local identity to build the environment and to lifestyle - this means to bring back local materials, principles, concepts, stories into the material culture – architecture, housing, lifestyle, product design.

10. Body Consciousness - According to Human Body
In industry, human factors are known mainly as one-sided stress and physical loads, but in work, school and health care facilities and households especially the problem is long-term sitting; physical passivity that can turn to dependence. The lack of physical activity in ordinary activities is a serious and complex problem of contemporary western civilization. Technological achievements physically facilitate survival, resulting in the "laziness" of civilized people. The result is a sedentary culture that has many health consequences. A serious fact here is that a long-term static convoluted sitting with a C-shaped spin causes not only problems with the spine and the motion apparatus, but also puts pressure on the internal organs, which can result in problems with digestion, fertility and mental
health. Many scientific and commercial studies have already been written lobbying for dynamic / active seating. The constant movement of the human back and legs relaxes the whole apparatus, and in addition, prevents insufficient nutrition of the intervertebral disc, but the constant micromovement can tire whole nervous system.

**Figure 4.** Chair sitting actively creates a hump in the upper spine (left), concept of living room according to Galen Cranz where all possible body postures are possible [15]

**Figure 5.** Relaxing in reclining positions according to Galen Cranz (left) and optimized standard for reclining according to BCDlab
It can be very difficult to incorporate these concepts without initial discomfort or reactions from conservative milieu. Figures 4-6 show examples of concepts that help to prevent spine deformations.

In the past, in our research, we have also been intensively engaged in an acceptable degree of added movement within the residential interior, but we have realised that increased movement or deliberate discomfort in the home environment, in order to get more movement, can be rather counterproductive. Nonetheless, the intimate environment stimulates laziness, which is here the right measure in the right place. Increased movement is likely to get more into school facilities, workplaces and public spaces. Even physical laziness can be addictive. A simple solution for stimulating users to physical activity in administrative workplaces is to place stairs and ramps in more accessible and visible places in public buildings, and to motivate people to use them even more because of their visuals and performative experience.

After several decades of development of various alternative ergonomic concepts for working and housing spaces, it is obvious that no other concept can easily fully replace standard sitting, where we are able to withstand the most prolonged time in the waking state. Sitting on standard chairs is a strong part of our western culture and getting it out of this pedestal would need several generations and the elimination of sitting as the only possibility for schools and workplaces. But the point is to equalize it with other body positions suitable for everyday activities. To achieve better physiological responses and the most natural body posture, as the most suitable is considered to be saddle sitting [17]. Developing new products with this philosophy, therefore, makes sense, and on Figure 7 are
couple of BCDlab products – saddle chair SOMA. However, if such a product is not fitted with upholstery, there is the risk that contact discomfort will soon arise from prolonged leaning, although the chair is made of softwood with good contact comfort. It is equally beneficial to equip an interior with floors and elevated surfaces such as podiums, benches or deep window parapets that are comfortable to the touch, along with adding a lot of scattered upholstery (pillows, mats, loose light mattresses, etc.). This concept has the greatest potential to create a versatile and flexible environment for taking up any physical position in the interior, as evidenced by the interior of one of the designs by BCDlab (figure 7).

A special issue is a support of positive tactile stimulation considering interrelation of object volume and surface and a human hand. It is caused by the fact that the evolution of human skills is connected with improvements of the other senses, especially vision, hearing and development of their relation. This sensuality of architecture is deeply explored in studies of finish architect Juhani Pallasmaa [18].

11. Fewer Environmental Stimuli
The nervous system of the contemporary modern human being is overwhelmed by stimuli from the environment, especially from public spaces, workplaces, digital and virtual environments. It is therefore better to “save” and reduce them and to prefer pleasant and moderate sensory stimuli, especially in long-term stay environments. It is a way to prevent further environmental stress and to reduce that which is already part of the working process, housing or some other component of the way of life. Moderate environmental stimuli relate to proportions, scales, outlines, shapes, materials - their surfaces and colours. Simplicity and clarity of the solution, easy orientation, all make it easier for the nervous system to function. Architect Mies van der Rohe’s "less is more" as well as a strong Zen approach to design have their merits here, and not only due to the minimalism trend. We therefore recommend natural or neutral surfaces on large areas in long-term stay interiors, distinctive colours to a lesser degree than accents - supplements that can be easily changed and personalized. Strong stimuli are good in public spaces, with the intention to challenge, to experience, to feel emotions, understand the context, etc., such as museums, galleries, bars, showrooms, playgrounds, etc.

12. Using of Authentic Natural Materials
In general, it is possible to declare that the more natural materials in their authentic form and more nature-evoking solutions present in the immediate surrounding environment of a human being during his long-term stay, the better. The explanation comes from evolutionary biology and psychology. Natural materials are beneficial to the nervous system, which responds to something well known to it, which does not need to be constantly "scanned". A nervous system that is directly linked to our unconscious and genetic memory responds to natural materials, is gently stimulated and can be easily recovered. Natural materials are part of our archetypes in our traditional material culture. Their use significantly contributes to the creation of a supportive environment and an environment for well-being.

However, in order to have an ecological meaning, it is necessary to apply natural materials from renewable raw materials from sustainable forestry or agriculture.

First, we examined wood as the most used natural, domestic and renewable material for interior design. In the project APVV 0594-12 Interaction of man and wood, we examined wood itself and its application as a phenomenon of the supportive environment and a "healthy interior". Its positive properties for the comfort and health of the human, for the internal environment and its microclimates can be formulated as follows:

- enhances and softens the overall atmosphere of the space, supports cosiness,
is aesthetically attractive - its shape and surface properties - the colour of the wood is warm to earthy, but not "hot" like red or orange; its colour, texture, structure, tone can also soften and "warm" otherwise cold lighting in space,

excellent haptic properties - contact comfort, especially with softwoods,

wood-based materials are well formable and adaptable to the shape of the human body, thanks to the comfort features, they allow good control over the body’s positions and the possibilities for their variation,

maintenance is possible through renewability - e.g. weaker wet-wise maintenance can be compensated, for example, by surface sanding,

has antibacterial properties, especially pine, larch and oak,

produces a pleasant sound in human interaction, and wood-based materials can enhance acoustic interaction when used on acoustic panels,

regulates air humidity and emissions,

smell (mainly coniferous species) and "taste", in direct and indirect interaction – e.g. when food is served on it,

is part of our culture, collective unconscious, and is in genetic memory.

Most of these strengths of wood are effective when the wood is free from any surface treatment.

The weakest aspect of natural materials, just in connection with its surface treatment, is its maintenance by wet methods (water and strong detergents). Application of wood significantly supports the regenerative effect of built-environment for the nervous system of human, and can contribute to recovery in health care facilities. Anyway, there are many stereotypes that are again using natural materials in their authentic form in the health care environment because of their maintenance. These properties were tested in the case study in the National Oncological Institute in Bratislava, by the emplacement of larch benches and pine wood wall and ceiling paneling with very simple archetypal design during the reconstruction of part of the foyer (Figure 8). There were executed further microbial tests of wooden surfaces and air in the space prior to the reconstruction and 3 weeks, 4 and 7 months after the reconstruction. Only the heavily used parts of sitting benches lost most of their natural antimicrobial effects, which is why it was necessary to find a solution for intensive cleaning [19]. We tested and found an appropriate way of cleaning by maintaining all positive features of wood - cleaning with ethanol. As added value to the study, there were executed also tests of VOC’s emission to support the sink-effect of the wood hypothesis. Physiological reactions of respondents were further tested by entering this space to see the reactions of the nervous system. There were measured EEG parameters by holders and EPOC helmet, change of cortisol value, face expressions and the preferences were also mapped by questionnaire and observation with the aim to test the reaction of respondents be entering and leaving room in comparison to the stay in another space. Up to this moment, it is the most complex methodology that was used by our pilot researches (figure 9).

In 2017 another case study in a health care facility – the revitalisation of room for mothers for preparation of mother milk at the Neonatology Clinic in the Faculty hospital in Košice, was executed (Figure 10). Similarly, it works with other renewable raw materials (flax, hemp, straw, cork, clay, sheep wool, etc.) and natural materials made from them. There is a need in this field to educate both the professional and the general public, to evaluate the stereotypes connected with the application of authentic natural materials in the built environment, especially at the public places.
Figure 8. Reconstructed waiting zone in foyer of pavilion M in National Oncological Institute in Bratislava made for demonstration and testing the application of wood in health care facilities, there is used pine and larch without finishing, design: V. Kotradiyová, M. Boles, photo: Noro Knap

Figure 9. Measuring of EEG responses to various surfaces, using of EEG hotlers and EPOC plus and evaluation with lab chart and mat lab, by visual and tactile contact in BCDlab
Figure 10. Reconstructed room for soaking mother milk at the department of neonatology, University hospital in Košice, all furnishings are made of solid pine wood with flax oil finishing, Slovakia, Design: Veronika Kotradyova, photo: Petr Krcho

13. Environmental Awareness
Comfort or wellbeing can or should be experienced by being conscious about the nature protection and contribution to the sustainability. Conscious users in this area can experience the advanced well-being by experiencing using products, services, concepts, environmental settings that have some ecological/green concept and can contribute to save the planet. The awareness in the field of sustainability, protection of the natural environment and social accessibility are part of the wellbeing in a broader context.

14. Conclusions
To explore the problematic of the well-being or the complex comfort in the built environments, in general, particularly requires a holistic approach. The 11 principles presented in this paper are a supportive skeleton for further research. Each principle is a topic to itself and setting some hierarchy among them is hard to do. One important principle has not yet been added in this paper - social affordability, because it transcends well-being and has a more broad meaning. One positive finding is that the environmental settings have an effect on the human behaviour that is possible to document and evaluate, and a physiology which is measurable. From our pilot research studies, we have found out that it is possible to set a multidisciplinary methodology and also to cooperate with scientists from different related branches of social sciences, medicine, physiology and engineering. The methodology has to be further deepened and tested on a larger amount of respondents. In the premises of the research design centre BCDlab, there is a testing space where the respondents are more isolated and the responses can be measured in a more effective way.

Acknowledgement
The paper was supported by the project APVV 016-0567 IDENTITY.SK – a common platform of design, architecture and the social sciences.

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