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Physiological and psychological effects of wooden materials used in sustainable alternative living spaces on human health

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ABSTRACT: Regional population growth, depletion of natural resources, and environmental problems have caused people to rapidly turn to mobile spaces that consume less energy and are environmentally friendly living spaces. These mobile spaces should be designed within the scope of sustainability principles and offer innovative solutions. Elements such as energy efficiency, renewable energy sources, use of recyclable and sustainable materials, modular and flexible design, minimalist life and optimum the use of compact space, adaptation to climate and environmental conditions, social and economic sustainability, portability and low environmental impact are essential in the design and production of sustainable mobile living spaces. Wood is a natural, renewable, and sustainable material that solves these requirements. When evaluated in terms of physiological health, the thermal balance of wood material, moisture-regulating properties and natural fibre structure, and its harmony with the human body are the reasons for preference. Regarding psychological health, the natural atmosphere it creates in interior spaces, its stress-reducing, relaxing and peaceful effects, its air quality-improving properties, and low volatile organic compound emissions have positive effects. This study investigated the physiological and psychological effects of using wood, a frequently preferred living material in designing and producing mobile spaces with sustainable alternative living spaces suitable for road transportation and transport, on human health.

Keywords: Furniture, Mobilite Life, Caravan, Tinyhouse

Sürdürülebilir alternatif yaşam alanlarında kullanılan ahşap malzemelerin insan sağlığı üzerine fizyolojik ve psikolojik etkileri

ÖZ: Bölgesel nüfus artışları, doğal kaynakların tükenmesi ve çevresel sorunlar, insanların hızla, daha az enerji tüketen, çevre dostu yaşam alanı olan mobil mekanlara yönelmesine neden olmuştur. Bu mobil mekanlar sürdürülebilirlik ilkeleri kapsamında tasarlanmalı, yenilikçi çözümler sunmalıdır. Enerji verimliliği, yenilenebilir enerji kaynakları, geri dönüştürülebilir ve sürdürülebilir malzeme kullanımı, modüler ve esnek tasarım, minimalist yaşam ve kompakt alanın optimum kullanımı, iklim ve çevre koşullarına uyum, sosyal ve ekonomik sürdürülebilirlik, taşınabilirlik ve düşük çevresel etki gibi unsurlar, sürdürülebilir mobil yaşam alanlarının tasarlanması ve üretiminde önemlidir. Bu gerekliliklere bir çözüm olarak ahşap, doğal, yenilenebilir ve sürdürülebilir bir malzemedir. Fizyolojik sağlık açısından değerlendirildiğinde, ahşabın termal denge, nem düzenleyici özellikleri ve doğal lif yapısı, insan vücudu ile uyumu, tercih nedeni olmaktadır. Psikolojik sağlık açısından ise, iç mekanlarda oluşturduğu doğal atmosfer ile stres azaltıcı, rahatlatıcı ve huzur verici etkileri, hava kalitesini iyileştirici özellikleri ve düşük uçucu organik bileşik salınımı olumlu etkilere sahiptir. Bu çalışmada, sürdürülebilir alternatif yaşam alanlarına sahip, karayolu ile ulaşım ve taşımaya elverişli mobil mekanların üretiminde sık tercih edilen bir yaşam malzemesi olan ahşap malzeme kullanımının insan sağlığına fizyolojik ve psikolojik etkileri araştırılmıştır.

Anahtar kelimeler: Mobilya, Mobil Yaşam, Karavan, Küçük ev

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1 Introduction

Being on the move has become central to many individuals' and societies' lifestyle choices (McIntyre et al., 2006). The main reason for this situation is related to the fact that lifestyle mobility, which emerged based on the phenomenon of mobility, has a fluid, continuous and transitional meaning (Duncan et al., 2013). In addition, today's global mobility has made life more dynamic than in the past. When this situation is evaluated in the context of people's spatial belonging, and social identity, it has reshaped the definition and scope of the concepts of lifestyle, living space, travel, and tourism in societies. When the concept of mobility is evaluated in the context of living space, cheaper living costs, milder weather conditions, a more comfortable or peaceful lifestyle, the desire to see new places and cultures, and, in general, the desire for quality life constitute the main factors among the reasons for the adoption of the mobile lifestyle. The development of the human relationship with mobile devices is the essence of freedom of movement (Sager, 2006). This is because individuals are more accessible and flexible when planning vehicle trips. Which route they follow, where and when they stop, is up to the individual's initiative. These trips offer individuals freedom but also the opportunity to experience many emotions, such as loneliness, anonymity, intimacy, and escape, and trigger these emotions. However, personal-use vehicles are popular because they combine autonomous and independent mobility with privacy, power, and speed (Merriman, 2009).

Caravan and tiny house living is an economical choice in terms of having the least contact with the environment compared to classical residences, and it exhibits an environmentalist approach in terms of energy saving and complies with sustainability criteria as a vital activity. Regarding interior design, caravans and tiny houses offer a flexible understanding of space with efficient space solutions that can be produced in a limited area and likened to a mobile miniature house. In this respect, they combine comfort and freedom. Vehicles are designed with comfort in mind, offering a cozy living space and enhanced quality of life through materials, heating, lighting, ventilation, and the latest technological systems (Gürtekin, 2011).

Humans come into contact with the world through their bodies as physiological beings and psychologically through their souls, establishing a relationship and interacting with it. When people's relationship with the world is defined through the body in the physical sense, this situation is decisive for the formation of space. However, when this formation is evaluated in the triangle of the dynamic relationship between space, body and soul in interaction, the design can be realized effectively. The interaction of the body and the soul is not static in the space but is a moving, perceiving and responding mechanism. The human body, a static entity, maintains integrity with space design principles. To ensure sustainability, spaces should be designed from the user's perspective, providing physical and spiritual satisfaction, rather than mass-producing standards for the static body. This approach ensures a sustainable existence. Pallasmaa expresses this as "architectural space is lived space rather than physical space, and lived space transcends geometry and measurability".

Along with these factors, another important issue in space design is the harmony between the design materials, their arrangement and layout. All materials used in mobile space design should serve the purpose in a useful way and positively contribute to users' lives. Since one of the most important differences between mobile space designs compared to typical fixed space designs is to make a practical application with a quality design in a compact area, it is also imperative to evaluate the space volume most effectively (Er, 2023).

However, people's need for spiritual and psychological satisfaction is more important than physical satisfaction. While the physical demands of human beings are met with a certain

level of facilities, the level of satisfaction is generally high since spiritual and psychological needs are constantly changing. The fixed and routine use of the mobile living space after the architectural design and implementation of the mobile living space following the needs provides physical satisfaction, the desire to see new places, experience discoveries, and constantly change the location and view of the space by having a space that is continually on the move is the most obvious indicator of a much higher level of spiritual and psychological satisfaction. However, due to the limited living and movement space in the mobile space and the necessity to spend time in the interior space independent of the outdoor space for a certain period for accommodation purposes, it is important to use design and materials that are spiritually and psychologically spacious, peaceful and calming along with the provision of physical facilities in interior design and application. For example, factors such as taking anthropometric data as a reference when creating furniture used in mobile spaces, creating a psychological comfort distance for users in the interior space, and avoiding hard edges and angular designs in caravan furniture for safety reasons are physiologically meaningful. In psychological terms, caravan furniture is designed with different colour combinations. Natural wood tones are more compatible with the caravan concept, and users prefer mostly light colours or wooden furniture colours. Choosing light colours that do not strain the eyes in caravans, which are places with limited space, creates a feeling of spaciousness in users. Simple and easy on the eyes colours should be preferred in spaces integrated with nature. Such colours evoke a sense of order, calmness and confidence in users.

This study examined the physiological and psychological effects on human health of wood and wood-based materials used in mobile spaces with sustainable alternative living spaces, together with the issues of space as a living space, life in mobile space, design and application in mobile space. In particular, the contributions of wood and wood-based materials to the sustainability of mobile spaces and human health are focused. In addition, scientific research in the literature on the environmental effects of wood as a natural material and its effects on human psychology and physiology has been compiled. A perspective on using this material in sustainable alternative living spaces has been presented. In addition, since its natural structure offers many advantages in terms of both aesthetics and health, the psychological effects of wood material on individuals, its role in reducing stress and anxiety levels, its positive contributions to mood, creating a natural environment feeling with biomimetic designs, offering living space in harmony with human nature, improving indoor air quality, providing moisture balance and thermal comfort are detailed, and the design and technical advantages of using wood in the flexible and portable structure of mobile spaces are also evaluated.

2 Literature summary

2.1 The concept of mobile (dynamic) space

Human beings perform the act of voluntary or involuntary movement by nature. While this action may have many reasons, such as social, cultural, political, economic or natural disasters, spaces have been transformed, especially under the influence of conditions such as the global pandemic. Houses built by people for shelter and protection are designed with the desire to be mobile, mobile, easily relocatable and mobile, sometimes not being fixed due to technical impossibilities and nomadic culture, and sometimes moving by different needs (Tuncel, 2007). A shelter that has mobility, can be moved from one location to another by itself or with a motorized vehicle through the motorized parts it contains, and has the necessary equipment to carry out vital activities for short or long periods is defined as a mobile (mobile) space. The architectural structures presented in parallel with mobile life

involve a much more profound transformation as opposed to a temporary solution. As technological developments, materials and communication continue, these structures are fully included in everyday life. In this context, mobile and micro dwellings are also gaining importance (Er, 2023). In this direction, when the reasons for the increasing interest in mobile spaces are considered, reasons such as sustainability, motivation, productivity, belonging, individuality, and functionality have an essential place in people's adoption of the mobile lifestyle over time by bringing a different dimension to their habitual lifestyles every day (Buldaç, 2021).

2.2 Types of mobile spaces

Mobile spaces include offshore structures, containers, trailers, prefabricated structures, capsules, disaster housing and caravans (trailers and motorhomes). However, they are classified under two main headings: immobile (relocatable, removable) and mobile (portable) mobile spaces.

2.2.1 Immobile spaces

Stationary mobile spaces paces that are attached to the ground and can be dismantled and assembled. These spaces can be dismantled for specific purposes, reassembled and fixed in the same way in another location. Relocatable structures are constructed according to the conditions of the area, transported in sections and allow for the creation of larger spaces than other mobile spaces. The most commonly used types are tiny houses, THOW and containers (Figure 1.). They can be used in regions with different climatic conditions and are preferred for less material waste and sustainability. Solar energy systems run electricity and ventilation in the buildings in these spaces, providing ecological sustainability.

Tiny house (THOW): The term "tiny house" literally means "small house". Structures that are on wheels but cannot move on their own and are non-motorized are called "tiny houses" or "THOW (Tiny House on Wheels)" in English. Tiny Houses have wheels and chassis and are towed by connecting to another vehicle. These houses were built in specific sizes to enable overland travel (Evans, 2017).

Figure 1. Tiny house (Evans, 2017)

2.2.2 Mobile spaces

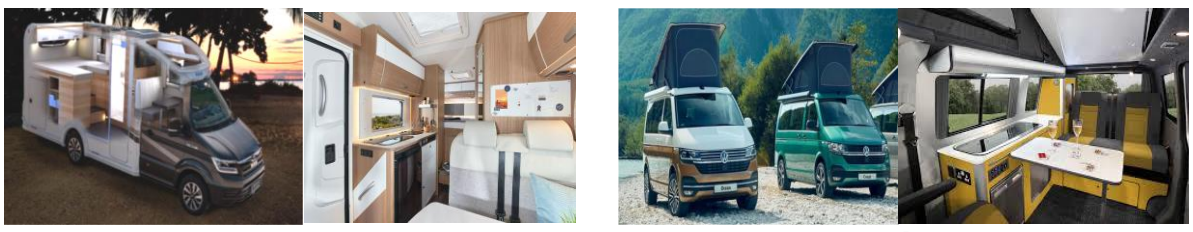
Movable mobile spaces can be towed or moved as a whole with the help of a vehicle without being divided into parts. Mobile dwellings can be transported by towing vehicles, railways, trucks and lorries, can be positioned horizontally or vertically in the area where they are transported, and can be added and removed due to their modular design. Movable mobile

spaces are lightweight structures that can be used in all seasons, personalised, easy to disassemble and install, and more economical than stationary dwellings. This is why mobile spaces are preferred over standard residences (Er, 2023).

Suppose it is necessary to classify these spaces according to their usage areas. In that case, it is usual to list them as caravans for permanent living, caravans for shelter, temporary caravans for emergency aid, caravans open to public use, caravans used for medical or scientific activities, caravans for use in different natural conditions. In Türkiye, caravans are predominantly used for tourism purposes. With the increasing population, reasons such as the desire to go to quiet places, changing lifestyles and consumption patterns, and natural disasters are essential in regaining the former attractiveness of the caravan culture. Especially considering the global pandemic process caused by the COVID-19 virus, the number of caravan users who leave their current living spaces and move to different areas for physical and mental relaxation and motivation, where people have to be isolated, has increased day by day. Despite the uniform/uniform housing solutions, caravans are designed with an approach that acts more holistically and includes all the necessary equipment. In addition, the fact that the interior space arrangement fulfils the maximum function: it is easy to clean, the responsibility is less than a conventional housing type, it has a lightweight carrier system, and the simultaneous and flexible use of the interior space with the exterior space, etc. can be seen as factors that increase the interest in caravans (Akgül, 2006). Caravan types designed for different purposes of use and showing change and development with the effect of time and technology are as follows;

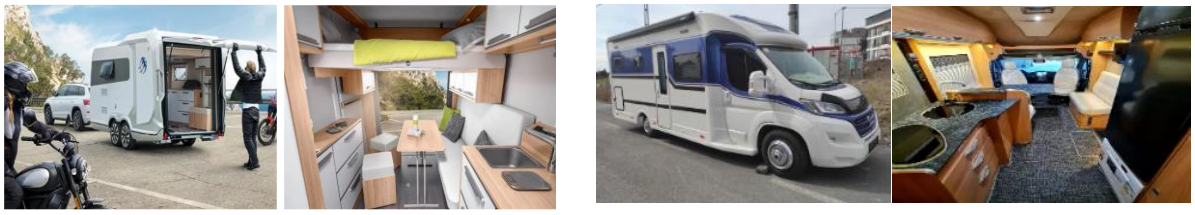
Towing Caravans: These caravans are not equipped with moving equipment but are connected to a motorized vehicle with suitable fasteners and moved by towing. Users can detach their vehicles from the towing caravan at any time. Unlike relocatable and removable spaces, they can be moved by pushing and pulling. Users leaving their caravans in parking lots can travel with their vehicles. This is an important factor in the preference of towing caravans (Çolak, 2005).

Motorized caravans (Motocaravans): These caravans (Figure 2) are built on a chassis with a gear and engine system (Davidson, 1973). Among motorhomes, the type modified only inside the vehicle by preserving the standard features outside the vehicle is called an integrated Caravan (Figure 3). The type with various changes in exterior dimensions and interior positioning by placing composite blocks on the chassis is called Alkovenli Caravan, and the type with standard sizes and more limited living facilities with an upgradeable roof is called Campervan. In addition, these vehicles are defined as mobile living spaces that meet the standard dimensions of motor vehicles and can meet the actions that users need on a minimum scale. Campervans and alkoven caravans have interior designs with kitchen, toilet, shower, living, sleeping, and storage areas. Commercial vehicles are used for campervan models. Alkoven caravans have a bed area above the driver. Semi-integrated caravans have kitchen, toilet cabin, seating group, and dining table (Ören, 2021).



(a) (b)

Figure 2. Alcoven Caravan (a), Campervan (b), (Kılıç, 2024)



(a) (b)

Figure 3. Trailer Caravan (a), Semi-integrated Caravan (b), (Kılıç, 2024)

2.3 Mobile space design criteria

From the user perspective, the following criteria are effective in space design:
Spatial Requirements: Static and dynamic anthropometric dimensions of the person in the space, their actions and behaviours, and how their actions are performed.

Thermal Requirements: Suitable temperature, humidity, radiation and air movements in the space.

Auditory Requirements: Suitable sound intensity and sound reflection-diffusion properties in the space.

Visual Requirements: Suitable light intensity-brightness levels in the space.

Tactile Requirements: Desire to satisfy the material texture used in the space.

Health Requirements: Provide clean water for the space, eliminate waste, and protect the user from microbes and pests.

Safety Requirements: Provide adequate structural strength of the space to protect against fire, disaster, theft, and accidents.

User Psychosocial Requirements: Positive reflection of the user's living space-environment relationship on their psychology.

Privacy Requirements: The space suits auditory, visual, personal and social privacy.

Behavioural Requirements: The distances that people need at the moment of their actions in the space are the individual limit of 45 cm, the distance between individuals is 45-120 cm, the distance within the community is 120-360 cm, and the public distance is the distances depending on the visual relationship that is greater than 360 cm.

Aesthetic Requirements: The appropriate form, colour and textural features of the space.

Social Requirements: The social relations in the space, the requirements of the social structure-organization.

Sustainable Energy Consumption and Low Carbon Emission Requirement: The use of energy-labelled white goods, the consumption of clean energy such as solar energy for electrical appliances and lighting, and the provision of low or zero carbon emission rates (Çolak, 2005).

2.4 Types of wood materials used in mobile spaces

Natural wood or solid wood material obtained without changing its characteristic features and wood-based material developed by changing its characteristic features for more efficient

use by utilizing technology, wood composite material obtained by combining woody material with a non-wood material, are used in mobile spaces, especially in the production of furniture and structural elements (Table 1).

Table 1. Types of Wooden Materials Used in Mobile Spaces (Kılıç, 2024)

1. Wood Based Panels
a) Plywood
b) Plyboard
c) Particleboard [Particleboard, Waferboard, Flakeboard, OSB (Oriented Strand Board)]
d) Fibreboard (MDF, HDF, Insulation Board)
2. Structural Composites
a) Structural composite timbers [PSL (Parallel Strand Lumber), LSL (Laminated Strand Lumber), OSL (Oriented Strand Lumber), LVL (Laminated Veneer Lumber), GLULAM (Glued Laminated Timber)]
b) Structural board products [Structural plywood, structural flakeboards (waferboard, OSB)]
c) Wooden beams
3. Mechanically Laminated Elements
4. Molded Products
5. Wood-Non-Wood Material Reinforced Composites
d) Composites using inorganic materials as binders (Gypsum boards, magnesium cement boards, portland cement boards)
e) Wood fibre - thermoplastic composites (High thermoplastic content composites, low thermoplastic content composites, non-woven textile type composites)
f) Translucent wood
g) Wood-reinforced fibre cement panels
h) Waste wood and waste gypsum-based boards
i) Paper-reinforced wood products

2.5 Space from a physiological and psychological perspective

2.5.1 Spatial perception

Perception is an active process that takes place in the form of reading environmental information through the senses and a mental process (Ozen, 2006). In architecture, perception is mainly addressed from the ecological or spatial perception perspective, and the objective world is transferred to subjective consciousness through the senses. In this process, the perception of space and its elements consists of four elements: symbolic, visual, sensory and selective perception. A symbol that represents an element but has another quality automatically directs the person to a mental process and directs them to find the whole symbol and what it means. Symbols, important data of *Symbolic Perception* located in space, are learned "stimuli" that have value and meaning for the individual and have an abstract feature. Still, they are closely related to concrete space.

Visual perception is the mental acquisition of the mental image of any event or object through elements such as colour, texture, and form in space, using data from visual sensation. Visual perception is essentially a physiological process, but psychological factors influence its functioning and visual perception occurs when the individual selects from the chaos of images around them in line with their needs and motivations and performs the visual process (Inceoğlu, 2010).

Cognitive/mental perception is the process in which the individual conceptualizes the information they have obtained spontaneously due to psychological and mental transformations and creates it through coding, storage, recall and analysis (Ozen, 2006). *Sensory perception* is the experiencing of information received from the environment through sensory organs such as visual (light-colour), olfactory (smell), auditory (sound), tactile (texture-heat) and dimensional (Yazıcıoğlu, 2010).

Colour in visual perception: Experimental studies have determined that light colours illuminate the space they are used in; dark colours darken it and make it difficult to

understand (Brebner, 1985). The direction, intensity and glare level of the light used are practical for changes in the visible amount of the colour (Göler, 2009). Colours close to yellow have a warm effect, and colours close to blue have a cold effect.

Light in visual perception: Light is the primary physical perception related to colour. In general terms, colour cannot exist without light because the perception of colour is caused by energy in the form of light. The smaller a light source or, the more parallel the light beam emits, the more contrasting the light it gives, and the sharper and darker the shadows. Conversely, the larger the light source, the more widespread it emits, the less contrasting the light it gives, and the more transparent the shadows (Göler, 2009).

Auditory Perception: Auditory perception of space produces different effects according to the echo and reverberation (reflection) period. Depending on different form features, a long reverberation period creates the feeling of being in a small space. The fact that the materials used in forming the space have different absorption qualities due to their textural characteristics allows them to be used as a factor affecting auditory perception (Hede and Bullen, 1981).

Smell perception: Smell in the space creates positive and negative feelings in individuals. While unwanted smells such as sink drains, smoke, and food that occur due to the use of the space create negative emotions, natural smells found in natural environments or essential smells applied to make a positive effect on the environment have positive effects on the psychological health and morale of the person.

Heat in tactile perception: The yellow-red colour of fire creates a warm colour association; the blue-green colour of ice creates a cold colour association, which causes the colour, which is the visual variable of the space, to be divided into two as 'warm' and 'cold' colours. It has been determined through experiments that some textural features create a warmer or colder effect due to the perception of the space. While a smooth textured surface creates a freezing effect, a rough surface creates a warm effect. We generally perceive closed, narrow and low spaces as warm; open, comprehensive and high spaces as relaxed, crowded and secluded as warm (Porter, 1979).

Texture in tactile perception: Texture dramatically affects the visual values of the space and is a stimulating communication element that simultaneously activates two emotions, vision and touch, which characterize the space-surface-material relationship (Gezer, 2007). Textural features on surfaces of the same color and strength can create varying tone differences, with smooth textures causing a colder effect and rough textures causing a warm effect (Porter, 1979).

2.5.2 Spatial meaning

Living spaces and the meanings attributed to these spaces are one of the most critical elements of communication between the individual and the space and the interaction between the environment and the person. Physical space is an environment that transmits and affects the traditions, cultures, values, judgments, and worldviews of those living in it, and it contains many meanings. In other words, interaction with the lived space is individual. Therefore, the meanings attributed to the space change according to time, situation, and people. In architecture, it is possible to see the use of objects and their benefits in psychology studies on meaning, especially in studies on symbols that guide behaviour. In short, spatial meaning is used mainly in semantic models based on linguistics, in studies based on symbols, and in studies based on nonverbal communication in anthropology, psychology, and ethnology. The meaning of space, place identity, place attachment, and sense of place are also significant in studies on environmental psychology (Gustafson, 2001).

2.5.3 Spatial sustainability

Sustainability is physiologically and psychologically crucial in defining and implementing the spatial structure of designed interior spaces. To reduce *carbon emissions (carbon footprint)* to the atmosphere, it is necessary to use *biomimetic sustainable building materials* that are environmentally friendly and compatible with nature in these spaces. It is expected that the effectiveness of naturalness on interior space structures will be increased, the hidden carbon footprint in structures and products will be reduced, and sustainability will be contributed. *Biomimicry* is defined as taking inspiration from nature's forms and processes and imitating nature to solve people's design problems (Benyus, 1997). As Ataç (2019) mentioned in her thesis, the definition of biomimicry in architecture is expressed as using natural and ecological materials in structures. *Biomaterials* are materials that can be destroyed without causing natural destruction or are functionalized for reuse when the structure completes its useful life and thus do not create waste. Natural and ecological materials constitute the content of biomaterials, and microorganisms provide sustainable approaches to such structures.

Carbon footprint, in the 21st century, global warming accelerated by greenhouse gas (GHG) emissions, especially carbon dioxide, poses a crisis for the environment and human society (Solomon et al., 2007). Product design with a low carbon footprint has become the focus of scientific research and industrial production since the signing of the Kyoto Protocol (Xu et al., 2015). The Protocol, which includes a series of specifications such as ISO (14040/44/64/65/66/67) and PSA (2050/60), aims to regulate carbon emissions from products (Su et al., 2012) and forces companies and designers to modify products to meet low carbon requirements (Tang et al., 2017). Research shows that approximately 84% of greenhouse gases are obtained from carbon emissions from energy production (Park et al., 2009). Therefore, strategies that focus on researching the carbon footprint and developing low-carbon design strategies effectively reduce carbon emissions (Song and Lee, 2010). When analysing and designing a product for the carbon footprint of an interior space, it is often challenging to integrate low-carbon, innovative products with the conceptual design process. To solve this problem, the use of biomaterials, a new low-carbon design method based on multi-layered carbon footprint research, is becoming important in interior spaces (He and Hua, 2017). Based on this approach, using renewable materials in interior spaces, low-carbon ecological designs should be made. When the production processes of sustainable, low-carbon emission interior and exterior spaces are considered globally, they are essential for humanity's physiological and psychological health to last for centuries. When the carbon footprint decreases, every living creature in the natural habitat is positively affected.

3 Results and discussion

Physiological and psychological effects of using wood materials in space design : According to the World Health Organization constitution, health is defined as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (Colburn, 1968). How people perceive and interact with their environment can affect their well-being, stress levels and general health, and for most people, their living spaces are their primary environments (Wade and Tavris, 2000). Therefore, the psychological well-being component is also important within a person's health framework, and this needs to be added to the concept of healthy space. To fully understand the meaning of health in living spaces, it is essential to reveal its psychological effects. Recent scientific evidence shows a

strong connection between space and health (Krieger and Higgins 2002). For the user, the lived space is more than just a building; it constitutes a system in which many parts, including its structure, lighting, acoustics and air quality, are interdependent (Building Science Basics, 2001). A general framework for a healthy space includes environmental sustainability, universal design and consideration of user health (Spetic et al., 2005). Research on user health often considers indoor air quality, water quality, lighting, and acoustic properties, with improving indoor air quality being a key focus. (Spetic et al. 2005).

Building biology examines the relationship between structure, physiological, and psychological health. Negative factors in interior and exterior structures and the negative impact on health due to these factors should be considered. (Balanlı and Öztürk, 2006). When this situation is ignored, the Sick Building Syndrome develops the disease symptoms that occur during the construction and use of the structure as a living space and continue throughout its use. This disease, also called Plaza Disease, occurs because the materials preferred for various reasons during the interior design and production of the structure are not suitable for human nature and optimum quality of life, the amount of chemicals used in the production of the materials are high and harmful to human health, they are not preferred for indoor use, and there are insufficient space ventilation opportunities, and such reasons cause problems such as coughing, irritation, sneezing and upper respiratory tract disorders in humans. High carbon footprints in architecture materials like steel, concrete, aluminium, plastic, and glass contribute to greenhouse gas emissions whereas biomaterials, like wood, hemp, paper, flax, and cork, reduce these emissions. (Lippiatt, 2011).

The terms “green building”, “nature-connected design” and “biophilic design” refer to interior designs that use natural materials, shapes, forms and colours that give a sense of connection with nature. Wooden buildings are also relatively unique in their thermal properties and effects on light and noise conditions. However, wood is a renewable material that can store carbon in the structure for decades, and the production of wooden building materials is less CO2-intensive than traditional building materials such as steel and concrete. Wood is also promoted as a material that enhances the sense of nature in interior spaces, thus increasing the comfort and well-being of the user. In addition, interdisciplinary studies in architecture and neuroscience have become widespread regarding how people perceive their built environment and how this affects their behaviour. Scientists have investigated how behaviour is affected by various stimuli, including in the built environment, and how this process can occur throughout life (Jarmusch, 2003).

However, many studies have investigated the *physiological and psychological effects* of using wood in interior spaces. In a study conducted in Finland with 729 participants, those living in log-framed houses reported their general health as “good” more often than those living in lightweight-framed houses or masonry/concrete houses (Anttila et al., 2012). This situation is also the case in mobile living spaces where wood is predominantly used in ceiling, wall and floor coverings and objects in the living space. Indeed, it is estimated that the positive effects of natural climatic external factors and the use of wood in the interior spaces of mobile spaces, generally located in rural areas, will contribute to further improvements in the users' health. A study among 87 workers in three old brick buildings and 42 workers in an old wooden building in Norway assessed tear film stability, subjective symptom frequency (often, sometimes or never), symptom indices (general, mucosal and dermal), and perceived indoor work environment (Bakke et al., 2011). Workers in wooden buildings reported lower fever, subjective symptoms, general and mucosal indices, and fewer complaints about air congestion compared to brick buildings, as shown in a Swedish study. (Walinder, 2001). These results show that solid wood materials used in the compact area of mobile space tend to

reduce upper respiratory tract discomfort. Solid wood products are important to improve the respiratory quality of mobile space with limited and narrow space due to limited oxygen amount. In a study conducted by Sakai et al. (2004), it was determined that although the common VOC (Volatile Organic Compound) emissions in modern non-wood (stone or concrete) houses in Nagoya with wooden structures were lower than other building types, formaldehyde concentrations were significantly higher than in wooden houses. This situation can be assumed as a fundamental reason why wood is preferred among various construction materials in mobile space. Using materials that have carcinogenic effects in mobile spaces where sheltering activities are carried out will cause significant problems.

Some studies have also reported the physiological effects of visual stimulation of wooden room interiors. Tsunetsugu et al. (2007) investigated the difference in physiological effects of visual stimulation of rooms with different designs and wood proportions. Actual rooms (13 m^2) were constructed for the study. Living rooms in Japan usually contain about 30% wood. Based on this, four rooms (all 13 m^2 in area) were constructed for this study: a typical wooden living room (30% wood), a room with extra wood added to the walls (45% wood), and a room where almost all the walls and the entire floor and ceiling were covered with wood (90% wood). Visual stimulation with a 30% wood room decreased participants' diastolic blood pressure and pulse rate, indicating physiological relaxation effects in this room.

In contrast, visual stimulation with a 45% wood room increased pulse rate. In a 30% wood room with added wood columns and cross beams (a designed room that increased the total wood content to 40%), participants' pulse rates increased similarly to those in the 45% wood room, indicating physiological alertness. Sueyoshi et al. (1995) investigated the effects of auditory stimulation with wood on physiological response with a study involving experiments on floor impact sounds in a wooden house. The effects of light floor impact sound on the participants' EEG (Electroencephalography) values and systolic and diastolic blood pressure were investigated. The measurements were carried out in a room in an experimental two-story wooden house. Each participant, sitting on a chair in the middle of the room downstairs, was exposed to light floor impact sounds produced by a percussion machine upstairs for 5 minutes. Four light floor impact sounds at 54, 63, 73 and 78 dBA and a control (no impact sound, leaving an average background noise level of 47 dBA) were randomly generated for each participant. This showed that the frequency of alpha and theta waves in the EEG decreased as the level of the light floor impact sound increased and that the increase in systolic blood pressure immediately after exposure to light floor impact sounds depended on the level of the sounds. In Japan, several studies have focused on olfactory stimulation with Japanese cedar (*Cryptomeria japonica*), a common and well-known coniferous tree, and Taiwan cypress (*Chamaecyparis taiwanensis*). Tsunetsugu et al. demonstrated the effects of olfactory stimulation with Japanese cedar wood chips on participants' prefrontal cortex activity and blood pressure. Following olfactory stimulation with Japanese cedar chips, participants showed decreased total haemoglobin (total Hb) concentration in the left and right prefrontal cortex and reduced systolic blood pressure. This indicated that olfactory stimulation has a physiologically relaxing effect.

In addition, in many studies, the general acoustic comfort level in wooden buildings is satisfactory (Bard et al., 2019). It has been observed that ground vibration is below the recognized human comfort thresholds. Späh et al. also found that the general acoustic satisfaction scores of the occupants in wooden buildings are high. (Späh et al., 2014). Along with the sound insulation provided by the material in mobile living spaces, the effect of sound elements on the living space's external environment is an important factor in determining the quality of the living space. At this point, studies show that the acoustic satisfaction level of

the user will increase, especially when wood is preferred for the coatings on the walls, ceiling and floors of the mobile space. Impact sound insulation in the low-frequency range is an important point regarding the satisfaction of the occupants of light wood-based buildings (Caniato et al., 2017). According to the data determined in all these studies, it is clear that using wood in mobile spaces affects respiration, blood pressure, light reflex, olfactory comfort, acoustic balance and other personal health improvements. Therefore, many positive effects of solid wood on physiological health have been proven.

Wooden interior spaces have been studied for psychological effects, with participants rated brighter and warmer in light brown and dark brown walls compared to simple white walls. (Zhang et al., 2016). In addition, Masuda (1992) found in his study that the natural variability of wood, especially across cultures, evokes different psychological feelings in individuals. For example, in Japan, knots are seen as defects or deficiencies, and people associate them with "cheapness". The Japanese prefer clean wood because it is more compatible with their fondness for "purity". On the contrary, in Europe and North America, wood products containing knots are widely preferred and associated with descriptors such as "natural" and "rustic". At this point, personal preference is prioritized in mobile spaces, and solid wood material cut in transverse, radial and tangential directions and solid panel wood material combined in a way that can create different visual qualities can respond to user preferences more than ever since it is obtained from different tree species.

Studies conducted in Japan have attempted to establish a scientific link between the use of wood and individual interpretations and feelings about the environments created by its use. The findings showed that interiors containing a high proportion of wood were generally described as "warm" and "calming". Interestingly, a positive relationship emerged between these descriptors and wood colour, significantly as its value increased in the yellow-red (YR) spectrum. Parallel to this study, the wood materials used in the interior design of mobile spaces are generally yellow-red and brown tones, offering a warm and calming effect to the user in various tones. In a study conducted in a room with an artificial climate at the Center for Environment, Health and Field Sciences, Chiba University, the results of the participants' subjective touch of an experimental combination of marble, tiles, stainless steel and cedar plywood were examined by measuring tactile stimulation. As a result, oxy-Hb concentrations in the left/right prefrontal cortex decreased immediately after touching white oak with the palm (Masuda et al., 1988).

Similarly, the mean oxy-Hb concentration was significantly lower in the right prefrontal cortex when touching white oak than when touching the other materials. In terms of “feeling of comfort,” participants gave subjective reports of feeling “somewhat comfortable” after touching white oak but reported feeling “indifferent to slightly uncomfortable” after touching the other materials. Thus, touching white oak was significantly more comforting than touching other materials. Furthermore, in terms of “feeling of relaxation,” participants reported feeling “slightly relaxed” when touching white oak but “indifferent to slight arousal” when touching tile and “slightly to moderately aroused” when touching marble and stainless steel. Thus, white oak was significantly more comforting than the other materials. The results of this exploratory study suggested that people have an innate understanding of wood environments as healthy environments, with wood rooms generally being positively perceived as “warm,” “relaxing,” “restful,” “natural,” and “inviting/relaxing” spaces. According to the data determined in all these studies, it is clear that the use of wood in mobile spaces has harmony, simplicity, balance, a peaceful and stress-free environment, and other relaxing and psychological healing effects. Therefore, many positive effects of solid wood on physiological health have been proven (Cohen et al., 2007).

In addition, many studies have proven that biophilic design, including wood, can improve human health and well-being. For example, the use of biophilia in interior design has been found to provide various physical benefits, including improved physical fitness, lower blood pressure, increased comfort, fewer disease symptoms, and improved health, as well as various mental benefits, such as increased satisfaction, motivation, less stress, anxiety, and improved problem solving, increased attention and concentration, improved social interaction, and less aggression and productivity (Yin et al., 2018).

4 Conclusion

- Incorporating innovative, low-carbon products into the conceptual design process can be challenging when assessing and creating the carbon footprint of an interior product. Applying biomaterials in interior design, a new low-carbon design approach based on a multi-layered carbon footprint study, becomes important to address this issue. This method suggests that interiors should be designed with renewable materials to create low-carbon ecological designs.
- The long-term physical and mental well-being of people should take into account the global production processes of sustainable, low-carbon indoor and outdoor environments. All living beings in their natural habitat benefit when the carbon footprint is reduced.
- The materials chosen for the interior design and construction of the building are not suitable for human nature and the best possible quality of life for a variety of reasons, including the high and hazardous chemical content of the materials' production, unsuitability for indoor use, lack of proper ventilation, etc. High levels of greenhouse gas emissions, materials such as steel, concrete, aluminium, plastic and glass and their production processes can be given as examples. These reasons lead to upper respiratory tract disorders, sneezing, coughing and discomfort. The primary cause of these problems is the high carbon footprint of materials used in buildings today.
- The increase in blood pressure resulting from contact with artificial materials such as metals and acrylic is significantly affected by the temperature of the material. Wood is a material that should be preferred, especially in interior spaces, because contact with it does not increase blood pressure, whether cold or at room temperature.
- Since they are obtained from different tree species, solid wood material is cut in tangential, radial and transverse directions and solid panel wood is combined to create various visual qualities that can respond to user preferences in mobile spaces.
- According to the findings of this exploratory study, individuals naturally view wooden spaces as healthy, and wooden rooms are generally viewed positively as "warm", "relaxing", "restful", "natural", and "inviting/relaxing" places. Personal preferences affect resource allocation, and wood's aesthetic appeal and technological advantages make it a superior choice for mobile living spaces.

Author Contributions

İsmail Derda Güler: Conceptualization, Determination of methodology, Conducting the research, Drafting the article, Writing the article, Resources. **Önder Tor**: Conceptualization, Determination of methodology, Conducting the research, Drafting the article, Writing the article, Review and editing. Supervision, Verification

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