

IS INTERIOR WOOD USE PSYCHOLOGICALLY BENEFICIAL? A REVIEW OF PSYCHOLOGICAL RESPONSES TOWARD WOOD

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Abstract. Over the past decades, a number of empirical studies have documented that nature or elements of nature in both outdoor and indoor settings can be beneficial for human health and well-being. Wood is a natural product and it is therefore relevant to investigate whether interior wood use might have some of the same beneficial effects. The aim of the present study is therefore to investigate whether interior wood use might be psychologically beneficial by reviewing studies that have investigated psychological responses toward wood. The study also provides a general introduction to theories that can help explain why wood might be psychologically beneficial. Studies related to psychological responses toward interior wood use have generally focused on three different outcomes: 1) perception of wood, including both visual perception and tactile sensation; 2) attitudes and preferences (aesthetic evaluation) of various wood products; and 3) psychophysiological responses toward wood. The review posits that there seem to be similarities in preferences for wood and that people prefer wood because it is natural. In addition, affective responses toward wood seem to be measurable, giving indications of psychological beneficial effects. However, caution should be made in concluding from the review that interior wood use is psychologically beneficial. Thus, theoretical, methodological, and practical implications are discussed and research needs identified.

INTRODUCTION

Wood is available in most countries as a versatile, naturally replenishable resource of raw material and has traditionally been used for making houses, tools, furniture, artwork, and paper. Today, wood is mainly used for construction purposes, but the amount of wood consumed differs substantially among different countries (UNECE 2009). It can be argued that the use of wood for construction is determined by the availability and tradition, and countries such as Austria, Canada, Estonia, Finland, Japan, Norway, Sweden, and the US all have long traditions of wood use. However, there are trends that are likely to influence the consumption of wood on a global basis. Increased focus

on environmental issues has resulted in the emergence of new sustainable building practices and design (Minke 2009; Ritchie and Thomas 2009). Because these new design strategies emphasize the use of building materials with small or moderate environmental impacts, there has consequently been an increased focus on renewable materials such as wood (Bergman and Bove 2008; Upton et al 2008; Dadoo et al 2009). Sustainable design is promoted internationally through organizations such as the World Green Building Council. Furthermore, national initiatives for implementing environmentally sustainable building practices have also been developed, eg LEED (US), Green Star (Australia), and CASBEE (Japan).

Along with the increased awareness of sustainable building design, an emphasis has also been

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placed on the relationship between occupants' health and building materials (CDC and HUD 2006). The use of wood in indoor settings and possible health benefits from wood are currently receiving increased attention from industry and research. Most previous research on health benefits of wood used in indoor environments have focused on factors related to healthy indoor quality (Jensen et al 2001; Guo et al 2002). Gasser (2001) provided an overview of the research conducted on the impact of wood on indoor climate factors. According to the overview, wood was found to have mostly positive or neutral effects on the indoor environment. Possible negative effects of wood on indoor environments are related to volatile organic compound emissions (particularly when the wood surface is treated), formaldehyde from engineered wood and wood-based panels, and problems related to transmission of sound and the need for noise barriers in wood construction (mainly an issue related to building design).

In recent years, new design strategies have emerged that seek to enhance sustainability and integrate knowledge about people's psychological, physical, and behavioral needs (Beatley 2000; Pearson 2001; Kellert 2005; Kellert et al 2008). These design strategies do not only seek to eliminate what is harmful to humans and ecological systems, but also to make the most of what is potentially good for people such as contact with nature. The psychological aspects of the relationship between the physical environment and human health and well-being are central in the field of study known as environmental psychology (Gifford 2007). One factor that is presumed to enhance psychological well-being is the presence of nonthreatening elements of nature (Kaplan and Kaplan 1989; Ulrich et al 1991; Hartig et al 1997). Over the past decades, an increasing number of solid empirical studies have documented that experiences of nature can be beneficial for human health and well-being (Health Council of The Netherlands 2004). One set of psychological benefits of nature that has received much attention in research involves aesthetic or affective responses. According to

Ulrich (1983), viewing a setting with natural elements can elicit a response of aesthetic liking that in turn leads to more positive feelings. Several studies have indicated that people in general prefer natural scenes dominated by vegetation to urban scenes lacking vegetation (Kaplan et al 1972; Zube and Anderson 1975; Knopf 1987). Indoor settings containing natural elements have also been more positively evaluated (Bringslimark et al 2009).

Findings from several studies suggest that simply looking at nature, as compared with built scenes that lack nature, is significantly more effective in promoting restoration from stress as reflected in outcomes such as reduced blood pressure, skin conductance, and muscle tension. Stress-reducing influences have been found when viewing videotapes of nature vs urban scenes (Ulrich et al 1991; Parsons et al 1998; Laumann et al 2003) and by looking at trees and vegetation out of a window vs not having a window view (Hartig et al 2003). With regard to indoor settings, several studies have reported a decrease in stress responses when indoor plants were present vs absent (for an overview, see Bringslimark et al 2009).

Psychophysiological stress-reduction benefits may also mediate a variety of short- and long-term health benefits. Some studies suggest that viewing nature from a window can lead to a reduction in the use of healthcare facilities in a prison (Moore 1981) and less use of strong painkillers during recovery from surgery in a hospital (Ulrich 1984). In the indoor context, plants have been associated with an increase in pain tolerance (Lohr and Pearson-Mims 2000; Park et al 2004), decrease in self-reported health and discomfort symptoms (Fjeld et al 1998), and a decrease in self-reported sick leave among office employees (Bringslimark et al 2007).

Thus, there exists some evidence that simply looking at nature, in both indoor and outdoor settings, can be beneficial for human health and well-being. Wood is a natural product and it is therefore relevant to investigate whether interior wood use might have some of the same

beneficial effects. The aim of the present study is to investigate whether interior wood use might be psychologically beneficial. This is conducted by reviewing existing literature that has studied human responses toward interior wood use. Before proceeding with the reviewed studies, we first provide some theoretical explanations regarding why wood might be psychologically beneficial.

Theoretical Perspectives

Why might interior wood be psychological beneficial? Why do people recover from stress and ill health simply by having visual access to nature? In the following section, we offer a brief introduction to some theoretical viewpoints. Some authors have argued by providing a cultural explanation for the benefits of nature, stating that our reaction to nature is a result of our cultural learning history (Altman and Chemers 1984; Tuan 1990). However, the cultural view has been criticized for not explaining why there are universal or crosscultural similarities in preferences toward natural scenes. Several studies have suggested that preferences for scenes with greenery and water may be universal (Yang and Brown 1992; Herzog et al 2000). In contrast to the cultural perspectives, the evolutionary perspectives postulate that because the human species has developed in natural environments, we are predisposed to respond positively to different types of nature content and environments that were once favorable to the well-being and survival of prehistoric people (Appleton 1975; Orians 1986). A related perspective is the biophilia hypothesis, which states that humans have an evolved sensitivity and need for other living entities (Wilson 1984). Thus, biophilia could be manifested as a desire to have natural elements such as wood in our surroundings (Kellert 2005; Kellert et al 2008).

The mentioned theories are quite general in nature. However, two theories have been developed that describe the more specific psychological processes involved in human reactions toward nature and especially why nature has

restorative effects (Ulrich 1983; Kaplan and Kaplan 1989). According to the Kaplan and Kaplan attention restoration theory (ART), nature possesses fascinating qualities that induce involuntary attention. In contrast to the directed attention that is often required in our daily life, the involuntary attention requires no effort, and our attentional capacity can rest. Thus, nature can provide a setting for effortless attention, and we get gradually refreshed by being in nature. Whereas ART emphasizes cognitive processes, Ulrich (1983) argues for a more affective approach. According to Ulrich's psychoevolutionary theory, positive emotions evoked by nature or natural scenes are presumed to block negative emotions and thoughts and in turn enable a decline in arousal. Differences aside, both theories assign importance to the ease with which attention is captured by elements of nature, of which an evolutionary basis is assumed. However, it should be noted that all the evolutionary theories mentioned assumes a partly biological basis for human responses toward nature and does not disregard influences from cultural and/or individual learning history.

The Review Study

By reviewing previous studies that have investigated humans responses toward interior wood use, the present study aims to explore if there exist some indication for whether wood indoors can have some of the same psychologically beneficial outcomes for humans as nature in general. In the review, wood in indoor settings includes applications such as flooring, paneled ceilings and walls as well as furniture from sawnwood, engineered wood products, or wood-based panels.

Psychological benefits signify responses toward the physical environment such as increased positive feelings and decreased psychophysiological stress responses. Stress has been a central concept in explanations for how passive views of nature affect health and well-being (Ulrich 1983; Ulrich et al 1991). As commonly defined, stress occurs when there is an imbalance

between environmental demands and individual coping resources (Lazarus and Folkman 1984). Stress is seen both as an outcome in itself, involving negative emotions and increased physiological arousal, and as a contributor to many other outcomes such as depression, impaired immune system functioning, and poorer long-term health (McEwen 1998; Lovallo 2005). Partly because of human biological predispositions, it is thought that experiences of nature can offer relief from stress or be restorative (Hartig and Staats 2003).

In general, previous studies on psychological responses toward wood have concerned three different outcomes: 1) perception of wood, including both visual perception and tactile sensation; 2) attitudes and preferences (aesthetic evaluation) of various wood products; and 3) emotional and psychophysiological responses toward wood. Although these responses are nearly related, they are generally separated when described in the psychological literature (Passer 2009). Perception concerns how we perceive the environment, involving both sensation and cognitive processes (Goldstein 2007). Preferences will necessarily also involve perception but is a more affective response involving people's like–dislike evaluation of an entity (Ajzen 2005). Psychophysiological responses are physiological responses to external stimuli. These responses are thought to have a psychological basis. Examples of this are emotional responses as well as stress responses (Andreassi 2007).

For the review, the studies published in peer-reviewed English journals were selected because they are accessible to a broader array of scientists, and they have undergone some initial quality control checks by other researchers. However, one proceeding was also included in the review (Masuda 2004).

Because this study focused on interior wood use, the psychological benefits of forests or wood used outdoors were not included. Furthermore, this study did not include studies related to the investigation of computerized pictures of wood (eg Nordvik and Broman 2009), because the

main objective of this review was the physical appearance of wood. In addition, studies related to indoor environmental quality (eg thermal, acoustic, air quality, etc) were not included, because they are exclusively related to the physical outcomes of wood use and are therefore presumed to be intermediate to the benefits and not the psychological benefits themselves.

With the constraints noted, we started our search through the literature by snowballing references from relevant works known to us in the field of wood science. We subsequently used terms such as indoor climate, consumer preferences, psychological response, psychological effects, well-being, wood interior, and room interior for searching in databases including the ISI Web of Science and OCLC. We also searched for potentially relevant materials by examining the titles of articles in journals that publish in the area of interest, including *Wood and Fiber Science*, *Forest Products Journal*, and *Journal of Wood Science*. Finally, we searched the databases for work by all authors previously known to have published on the subjects.

LITERATURE REVIEW

To understand possible psychological benefits of interior wood use, it is important to integrate research related to all three aspects of human responses toward wood: perception, preferences, and psychophysiological responses. Studies related to perception of wood can provide us with information on how humans actually perceive wood, including both visual perception and tactile sensation. If wood in the indoor setting is perceived as nature, then to a greater degree, it may support the assumption that wood have some of the same benefits as nature in general.

The earliest studies on human–nature relationships started with preference studies, especially preferences for landscapes. One of the main assumptions guiding these studies was that the aspects people like in the environment reflect on conditions important for their well-being. Thus, preferences may signal possibilities for

psychological beneficial outcomes and are therefore thought to provide indications for potential psychological benefits. Later studies investigated if these assumed benefits were actually measurable. Instead of only investigating like–dislike responses, other measures were used such as questionnaires reflecting emotional responses and psychophysiological measures that reflected physical arousal or stress responses (see *Theoretical Perspectives*).

In the following, we first review studies that have investigated how people perceive wood, move on to preference studies, and finally investigate if these preferences (or affective responses) are measurable with psychophysiological outcome measures.

Visual Perception of Wood

The visual impression of wood can differ because of a number of factors such as species, number of knots, color, structure, surface treatment, etc. Investigation on the visual perception of wood can provide us with further insight on how different properties of wood are perceived by humans.

Color. Interior spaces containing large proportions of wood are often described as “warm” and “natural” (Rametsteiner et al 2007). In an attempt to find a scientific link between wood use and individual perception of wood, Masuda (2004) hypothesized that wood might give a warm and natural impression because of the color or hue. Wood reflects long-wavelength light, which is perceived by humans as yellow to red hues and might accordingly give a “warm” impression. Masuda further argued that as wood produces little reflectance of UV light from its surface, people may experience less stimuli and consequently be less fatigued. Although directly proportional relationships between wood use and these descriptors were not found, Masuda found a positive correlation between the degree of wood in the interior settings and the evaluation of the room as “warm” (the more wood, the warmer the impression of

the setting). He also found an even larger positive correlation between settings that were evaluated as warm and the color of wood, especially with the increasing value of the yellow–red spectrum. Nevertheless, a high degree of wood in a setting was evaluated as more “natural” than “warm.”

Knots. As Nakamura and Kondo (2008) remarked, knots are the remains of branches in a tree trunk and are evidence that the wood came from a living tree. Thus, knots can give wooden materials a more natural appearance. However, knots can also reduce the mechanical strength properties of sawnwood, and too many knots are often unwanted in wooden materials (Broman 2001). In general, sawnwood with few knots is traded at higher prices in the market compared with sawnwood with many knots. To investigate why knots often are perceived as a poor visual characteristic of the wood surface, Nakamura and Kondo (2007, 2008) compared the number of knots in wood panels with subjective noticeability of knots. They recorded eye-tracking data from 20 Japanese students while they observed 55 images of wood wall panels with different degrees of knots. The results showed that there was a clear linear relationship between the number of knots in the wooden wall panels and the subjective noticeability of the knots. The authors concluded that clear wood leads to more relaxed eye patterns than knotty wood. However, features such as deep red grooves did to some degree mask the effects of the knots.

Tactile Sensation of Wood

In general, humans acquire most of their knowledge about the physical environment through their vision. Therefore, previous research on human responses toward nature has mainly focused on visual experience of nature. However, wood in the indoor setting also possesses some tactile properties. When wood is used in the indoor environment, people have ample opportunity to directly touch various wooden materials such as interior wall and floor materials as well as wooden furniture. A few studies

have examined the tactile sensation of wood compared with other materials, including their psychophysiological responses.

Tactile sensation of touching three different surfaces, oiled parquet, lacquered parquet, and laminate flooring, was investigated in Austria (Berger et al 2006). After the participants had touched the floorings with both their hands and feet, the results showed that the flooring with the natural oiled surface was perceived as warm, rough, and fairly soft. The laminate flooring was perceived as cold, smooth, and hard, whereas the parquet with lacquer was perceived as fairly cold, fairly smooth, and fairly hard. The majority of the subjects (76% in the foot test and 72% in the hand test) preferred the flooring with the natural surface.

Sakuragawa et al (2008) examined the effects of tactile contact with different wooden materials on blood pressure (an indication of physiological stress responses) and subjective evaluation of the materials. The study included planed wood samples from sugi (*Cryptomeria japonica*), hinoki (*Chamaecyparis obtuse*), oak (*Quercus crispula*), and urethane-coated oak as well as plastic and aluminum. The main points revealed by the study were as follows: 1) contact with wood produced a safe/comfortable and coarse/natural sensation and showed no increased blood pressure; 2) contact with cooled wood produced a subjectively dangerous/uncomfortable sensation, but it also produced a coarse/natural sensation and did not lead to increased blood pressure; and 3) contact with aluminum kept at room temperature or cooled plastic produced flat/artificial and dangerous/uncomfortable sensations and an increased blood pressure. The authors concluded that tactile contact with wood, when compared with artificial materials, caused no psychophysiological stress responses.

Similar results were obtained in another study, which investigated the effect of tactile contact with wood on two indices of physiological stress responses: blood pressure and pulse rate (Morikawa et al 1998). The study used sugi wood (*Cryptomeria japonica*) with a planed

surface, sugi wood with a sawn surface, hinoki wood (*Chamaecyparis obtuse*) with a sawn surface, silk, denim, a stainless steel board, and a vinyl bag filled with cold water. The results indicated that contact with hinoki and sugi wood with a sawn surface and silk had little effect on pulse rate and blood pressure, whereas contact with cold water and a stainless steel board increased the pulse rate and blood pressure. The authors concluded with that the small variations caused by contact with hinoki and sugi wood with a sawn surfaces and silk indicated that these materials induced less stress.

Summing up. According to Masuda (2004), the color or hue of wood in the yellow–red spectrum might be the reason for why wood often is perceived as “warm” or “calming.” He also found a positive correlation between the degree of wood in indoor settings and evaluation of the room as “warm.” This is an interesting approach and might be one of the reasons why wood often is perceived as warm. Nevertheless, the perception of wood does not solely depend on its color, but also on other wood properties such as knots. As shown in the Nakamura and Kondo (2007, 2008) studies, fewer knots on the surface lead to fewer eye-tracking movements. The results from these studies might indicate that fewer knots will give a more relaxed visual impression and that not all types of wood will have the same beneficial psychological effect. However, it should be noted that there are still too few studies concerning these issues to draw any clear conclusions of how these factors might affect the visual perception of wood and whether these impressions translate into psychological beneficial outcomes. For the studies on tactile sensation of wood, psychophysiological outcomes were measured, and it was observed that when compared with other nonnatural materials, touching wood did not induce higher levels of stress responses (Morikawa et al 1998; Sakuragawa et al 2008). However, simply touching wood did not lead to any decrease in stress responses indicating that tactile sensation of wood does not necessarily induce psychological benefits.

Attitudes and Preferences

In this section, attitudes and preferences toward wood are examined. Although attitudes are more complex constructs involving affective responses, beliefs, and a tendency to act (Ajzen 2005), preferences constitute the more evaluative or affective aspect of attitudes. Affective responses are emotional responses that express an individual's degree of preference for an entity (ie like-dislike). Most preference studies are motivated by the need for marketing research by industry. The body of literature ranges from simple preference studies to advanced statistical models exploring the connection between user preferences and wood materials.

A review of Europeans' attitudes toward wood was compiled by Rametsteiner et al (2007). They observed that Europeans have clearly positive attitudes toward wood and that wood is considered to be natural, warm, healthy, good-looking, easy-to-use, and environmentally friendly. In addition, they found that people feel good when they are surrounded by wood. However, the review failed to consider that people's attitudes can vary with respect to wood species, type of product, and surface treatment. In the following paragraphs, we first review studies concerning attitudes and preferences toward different wood species followed by studies concerning preferences for the appearance of wood.

Tree species. Attitudes toward different tree species might play an important role in influencing consumers' evaluation of wood. In an early study, the participants were given the names of various tree species (they did not have visual access to the material) and were asked to describe the wood (Blomgren 1965). The results indicated that people have different attitudes toward different wood species. For example, oak was seen as masculine, old-fashioned, durable, strong, and practical, whereas mahogany was seen as beautiful, elegant, and modern. However, several studies have indicated that there exists a discrepancy between consumers' opinions on wood species when they are based

on the species name compared with the wood appearance. Bumgardner and Bowe (2002) investigated students' perceptions of wood from several tree species to determine whether name-based and appearance-based evaluations differed. They found a great discrepancy between evaluations of wood by simply hearing the species name and physically viewing the actual wood sample. For example, black cherry heartwood (*Prunus serotina*) was rated as formal on the name-based evaluation and as causal on the appearance-based evaluation, whereas both northern red oak (*Quercus rubra*) and sugar maple (*Acer saccharum*) were rated as warm on the word-based evaluation and cold on the appearance-based evaluation. This study was also replicated on adult consumers, which demonstrated similar results (Bowe and Bumgardner 2004).

Attitudes toward species names have also been investigated with regard to cabinet doors. Roos et al (2005) examined whether the presence or absence of various species names could affect a cabinet door's potential market share. The result indicated that certain species names can increase a cabinet door's popularity, whereas other names can reduce it. For example, species names such as red oak and cherry positively influenced the respondents' preferences, whereas red alder had a negative effect on preferences. In contrast, the respondents reacted favorably to the appearance of red alder when the cabinet doors were not labeled.

Other studies related to the appearance of different wood species in furniture have shown that there is great variation in which tree species are preferred. Scholz and Decker (2007) investigated the preferences for different wood species in furniture, more specifically, a wooden dining table, on German subjects. Four different wood species were investigated, beech, oak, cherry, and maple. The results showed that the perception of the four wood species differed significantly and that the wood used for furniture production had a strong impact on the consumers' preferences for the products as a whole. In general, beech had the most preferred color

and was attributed as the least expensive and warmest material. Oak was regarded to have the highest quality, but it was not perceived as modern. Maple had a low rating on most factors, whereas cherry was perceived as the most expensive material. However, with regard to factors such as style and finish, oak was rated as the most preferred material.

Preferences for different wood materials.

Are there any differences in preferences for different wood materials? Are some wooden materials perceived as more natural and can this again influence preferences? Jonsson (2005, 2006) conducted a series of studies to identify factors determining preferences for different materials for floor covering. Investigations on end-consumers' choice of flooring in the UK and the Netherlands indicated that factors such as the use context, type of room refloored, and whether the dwelling is owned or not affected the choice of flooring. One of the reasons for choosing wooden flooring was that wood is considered a natural material, and Jonsson argued that the natural characteristics of wood can be used to distinguish wood products from close substitutes such as laminated flooring. He also pointed out that the salient evaluative criterion for choosing wooden flooring, the natural property, differed from other materials studied in which the customers concentrated mainly on practical issues. However, practical and functional benefits were observed to be important for wooden flooring as well as its closest substitutes, laminate and carpet. These benefits were low cost over the life cycle and hygienic aspects.

Another study was carried out to identify the attributes and associations that people use to describe different types of wood and wood-based materials and to explore how these attributes relate to preferences (Jonsson et al 2008). Nine samples were chosen to represent different materials: elm, aspen, pine, oriented strandboard, birch plexwood, BeachPlank, Kareline, wood composite, and cellulose composite. In general, the solid wood samples were most preferred, whereas BeachPlank and the

wood composite were the least preferred. A correlation between the attributes and preferences were also found in which the preference ratings correlated with the categories pleasant, natural, wood-like, living, and worth. Preferences correlated most negatively with the attributes processed, hard, and high weight. Furthermore, the category "wood-likeness" also correlated strongly with preferences. The composites were less liked and perceived as unnatural, processed, and unlike wood. Thus, the authors concluded that the appreciated properties of wood are connected to its natural origin and wood-specific properties combining harmony and activity without disturbing irregularities.

Physical properties of wood. A number of studies have been carried out on the salience of forest product attributes and how they affect preferences. A comprehensive review of the attribute research in forest products was provided by Brandt and Shook (2005). They concluded that several product attributes have an impact on consumers' preferences for wood, including both physical (visual and tactile) and intangible (service and environmental impact) attributes. However, they did not identify which wood properties are preferred and how combinations of different wood properties might influence preferences.

Broman (1995a, 1995b, 1996, 2001) conducted a series of studies to investigate people's visual impression of wood surfaces of Scots pine (*Pinus sylvestris*). The aim of the studies was to find relevant questions to ask when measuring people's preferences for different visual appearances of wood and to reveal the relationship between the combination of features in a wood surface and visual impressions. It was shown that to some extent, it is possible to connect subjective preference data with objective wood feature measurement. In general, Broman found that to assess people's preferences for wood, there are at least 10 characteristics of importance: freshness, harmony, interest, elegance, excitement, restfulness, eventfulness, naturalness, imaginativeness, and absence of gaudiness. Furthermore, he observed that there are

differences in how people judge surfaces with knots compared with those without. The most important assessments for knotty surfaces were that they should be in harmony, fresh-looking, and stimulate people's interest. For clear surfaces, it was important that they stimulated people's interest, have a genuine look, be fresh-looking, and be in harmony. Furthermore, the number and amount of knots were negatively correlated with people's liking, indicating that multiple knots had a negative impact on people's preferences.

Nyrud et al (2008) used sensory evaluation to identify and measure wood attributes that affect consumers' preferences. They applied analytical sensory profiling on wooden deck materials, Scots pine (*Pinus silverstris*), Siberian larch (*Larix sibirica*), and Ipé (*Tabebuia*). Sensory analysis (see *Tactile sensation of wood*) was used to identify visual and tactile wood properties; a panel of trained judges was used to identify and measure product attributes. The sensory data were combined with those from consumer surveys, and salient product attributes were identified. The results indicated that respondents preferred wood surfaces that exhibited tactile homogenous surface texture; wood with homogenous visual characteristics were preferred to wood with uneven characteristics.

Wood vs other materials. Perhaps one of the most interesting approaches when investigating if people actually would like to have wood in indoor settings is to investigate preferences for wood vs other nonnatural materials. Unfortunately, there have not been many studies regarding this issue, and few of them include questions about naturalness (ie whether they prefer wood because it is natural).

In a survey study, Rice et al (2006) asked subjects to evaluate different materials such as wood, ceramics, stone, leather, plastic, glass, painted surfaces, and wallpaper. In general, wood was rated higher than the other materials in terms of being perceived as "warm," "natural," "homey," "relaxing," and "inviting." Wood was also perceived as less "industrial," "artifi-

cial," and "modern" as compared with the other materials.

Spetic et al (2007) examined attitudes of Canadian householders toward two types of flooring covers, wood and carpeting. The respondents were asked to give their opinion of six different product attributes related to the two covers. The attributes were pleasantness, attractiveness, healthiness, durability, affordability, and environmental friendliness. Wood flooring was rated significantly higher than carpeting on all attributes except for affordability, which was rated equally for both.

Pakarinen (1999) examined the consumers' perceptions about the use of wood for furniture and also investigated whether wood is perceived to have superior attributes than other furniture materials. The data for the study consisted of responses to a questionnaire completed by 115 shoppers at a major furniture retail chain in Finland. Factor analysis produced five underlying concepts pertaining to wood: trendy, reliable, environmentally friendly, high value, and archaic. According to 84% of all the respondents, wood exhibits several superior attributes when compared with other raw materials in furniture.

Wood in different settings. Is wood better suited for some indoor settings than others? Do people have higher preferences for some settings with wood than others? Also, will the inclusion of wood in indoor settings heighten the preference for a setting, place, or context? An example of the latter is a study that observed that organizations with significantly visible wood products in their office environments were preferred as places of potential employment when compared with those without wood (Ridoutt et al 2002).

Another study investigated the preferences for living rooms with different amounts of wood (Rice et al 2006). After showing the respondents 25 pictures of different rooms, the results showed that the highest-rated living rooms were those that were completely wood-dominated with very few synthetic materials. Furthermore, living rooms with wood, large windows or

natural materials were in the top one-half of the 25 images. It was also found that wooden living rooms were most commonly described as “warm,” “comfortable,” “relaxing,” “natural,” and “inviting.”

Sakuragawa (2006) examined different kinds of activities such as exercising, working, relaxing, lying down, and sleeping in four types of room interiors with different extents of wood coverage: 1) wood materials on both floor and wall; 2) wood materials on floor and wainscots; 3) wood only on the floor; and 4) no wood. Photographs from the four interiors were shown to 200 subjects, who were asked which activities they preferred to do in the different settings. The results indicated that a great preference for relaxation was obtained from the photographs showing wood materials, and a strong preference for activities were obtained from the photograph showing interiors with no wooden materials. Great preferences for both relaxation and activities were obtained from the photograph showing wood materials used only as a flooring material. Furthermore, the photograph of the room interior without wooden materials was evaluated as a place the subjects did not feel like living in, whereas the photograph showing wood materials used only as a flooring material was considered as the most suitable living space.

Summing up. In general, people have positive attitudes toward wood and interior wood use. Wood is commonly perceived as natural, warm, and healthy (Rametsteiner et al 2007). Wood is also most often preferred over other materials (Pakarinen 1999; Rice et al 2006; Spetic et al 2007). However, people do have different attitudes or values toward different tree species. For example, oak is seen as masculine and mahogany as beautiful and elegant (Blomgren 1965). Another example of the intrinsic value or meaning that people assign to different tree species is that there exists a discrepancy between people’s general attitudes toward certain tree species and their visual perception of those species (ie their evaluation of a tree species changes if they are unaware of the name of the species; Bumgardner and Bowe 2002; Bowe and Bumgardner 2004;

Roos et al 2005). Thus, we can assume that people’s general attitudes toward tree species will also influence their evaluation or preferences for different wood species in the interior setting.

There are several attributes of the physical environment that can influence aesthetic preferences. According to Ulrich (1983), these attributes include the degree of complexity and depth, the presence of a focal point, gross structural qualities (eg patterns), and natural contents. Kaplan and Kaplan’s (1989) preference matrix for landscape scenes overlap to a certain extent with the attributes listed by Ulrich. These attributes include complexity, coherence, legibility, and mystery. It is interesting to note that some of the preferred physical properties of wood correspond to these attributes, namely complexity, coherence or gross structural qualities, and natural contents or naturalness.

Complexity is considered as one of the most important factors related to aesthetic preferences. In general, people prefer settings or elements that have a moderate degree of complexity, ie it should not be too low or high in diversity and richness of elements. It can be observed from studies by Broman (1995a, 1995b, 1996, 2001) that the characteristics of wood of importance for preferences include interest, excitement, eventfulness, and imaginativeness. Conversely, it also includes restfulness, and too many knots have been found negatively correlated with people’s preferences. Thus, it seems that the level of complexity of interior wood material is an important aspect with respect to people’s aesthetic preferences.

Another important property of visual quality is coherence. Coherence can be defined as “a reflection of the unity of a scene, in which coherence may be enhanced through repeating patterns of color and texture” (Tveit et al 2006, page 239). Several of the reviewed studies indicate that harmonious or homogenous visual surfaces are important attributes for preferences (Broman 1995a, 1995b, 1996, 2001; Nyrud et al 2008). In general, people prefer scenes with

homogenous texture that is structured or build up a unity (Kaplan and Kaplan 1989).

Another important attribute of preferred environments, and the factor with which the present review study builds on, is the presence of nature or natural elements in a setting. The results of the reviewed studies indicate that the natural characteristics of wood are important factors for preferences (Jonsson 2005, 2006). Wood is also more preferred than wood composites because of its natural appearance (Jonsson et al 2008). Wooden living rooms have also been described as more natural and are more preferred than living rooms with less natural contents (Rice et al 2006).

Psychophysiological Responses Toward Wood

As mentioned in the Introduction, visual access to nature can promote positive feelings and reduce negative feelings such as anxiety and anger. Findings from several studies also suggest that simply looking at everyday nature, compared with built scenes that lack nature, is significantly more effective in promoting restoration from stress as reflected in outcomes such as reduced blood pressure, heart rate, skin conductance, muscle tension, and increased electrical activity in the brain in the alpha frequency range. It is also assumed that psychophysiological stress reduction mediates short- and long-term health benefits. Within these studies, feelings are generally measured subjectively using questionnaires, whereas stress responses are measured physiologically. To date, not many studies have been conducted that investigate psychophysiological responses toward interior wood use.

Tsunetsugu et al (2005, 2007) conducted two studies on psychophysiological effects of wood in actual-sized living rooms. In the first study, cerebral blood flow, pulse rate, and blood pressure were measured while the subjects spent 90 s in the rooms. Mood and subjective evaluation of the rooms were also measured. One of the rooms was a standard Japanese living room with wood

flooring and papered walls and ceiling. In the experimental room, wooden beams and columns were added. Investigation of 15 male students revealed a significant difference in pulse rate between the two rooms. In the ordinary room, the pulse rate decreased, whereas in the room in which wooden beams and columns were added, the pulse rate increased. There were no significant differences between the two rooms with regard to cerebral blood flow, blood pressure, subjective evaluation, or mood. However, blood pressure tended to decrease in the standard room and increase in the designed room.

In the second study by Tsunetsugu et al (2007), the same measures were used, but the respondents were exposed to three actual-sized living rooms with different wood ratios. The wood ratios of the rooms were 0: no visible wooden materials, 0.45: with wooden floor and a waist-high wooden wall, and 0.9: almost the entire wall, floor, and ceiling were covered with wooden materials. For the subjective evaluations of the rooms, the 0.45 room tended to be evaluated as the most comfortable and restful. The 0 room was evaluated as most artificial, whereas both the 0.45 and 0.9 rooms were evaluated as natural. There were no significant differences in mood. For the physiological measures, diastolic blood pressure decreased significantly in all three rooms. The pulse rate increased significantly in the 0.45 room, and systolic blood pressure significantly decreased in the 0.9 room, whereas these two indices were unchanged in the 0 room.

Sakuragawa et al (2005) conducted a related study using some of the same outcome measures as described in the two studies mentioned previously. They investigated the influence of a wooden wall panel on blood pressure, pulse rate, room evaluation, and mood. There were two experimental conditions: one wall with hinoki wall panels and one with a white steel panel. A curtain in front of the wall was used as the control condition. With regard to mood, the results indicated that feelings of depression/dejection were significantly lower for the visual stimulation by the hinoki wall panel than the

control. Conversely, feelings of depression/dejection were significantly higher for the visual stimulation by the white steel wall than the control. With respect to subjective evaluation, the hinoki wall panel had a significantly higher score than the control on the factor “sense of variety and nature” (ie full of variety, interesting, warm, and natural), whereas the steel wall panel was rated as significantly lower than the control on the factor “sense of health and openness” (ie healthy, soft, nonoppressive, friendly, and open). For the physiological responses, blood pressure decreased significantly in the subjects who had reported that they liked the hinoki wall panel. With respect to the white steel wall panel, there was a significant increase in blood pressure for the subjects who had reported that they disliked the panel.

Summing up. In the first Tsunetsugu et al (2005) study, the pulse rate decreased in the ordinary room, whereas contradictory to expectations, the pulse rate increased in the room in which wood was added. There might be many reasons for this result. First and foremost, and a fact that also affects other studies related to psychophysiological responses, stress was not induced before the study. If we are testing that people get less stressed from experiencing elements of nature, there needs to be something to be less stressed from (ie they need to be physiological aroused before the study; Ulrich et al 1991). Second, the two rooms in this study were not evaluated differently by the participants. Because they were perceived in the same manner, it should not be expected that the two conditions will induce different responses. Third, it might have been extraneous factors in the experimental situation that induced the responses.

Also in the second Tsunetsugu et al (2007) study, stress was not induced before the experiment. However, in this study, the rooms were evaluated differently with the 0.45 room evaluated as the most comfortable and restful. Because blood pressure decreased in all three rooms (the subjects felt relaxed in all settings), physiological measures are difficult to interpret

and could be more so because of the experimental situation than actual settings. In addition, the pulse rate increased in the room that was evaluated as most comfortable and restful, whereas the blood pressure decreased in the 0.9 room. Nevertheless, the result for the 0.9 room does to a greater degree support the theory that elements of nature in indoor settings have stress-reducing effects.

In the Sakuragawa et al (2005) study, the subjects felt less depressed when experiencing the hinoki wall panels. The hinoki wall panels were also evaluated higher on the factor “sense of variety and nature.” In addition, blood pressure decreased for those who reported that they liked the hinoki wall panels. In addition to not including stress before the study, it should be noted that the level of stimuli differed substantially between the white steel wall and the hinoki wall panels. Thus, it might not have been naturalness that induced the different psychophysiological responses, but the differences in visual stimulation per se.

DISCUSSION

In the present article, we have reviewed studies related to psychological responses toward wood. The objective of the study was to investigate whether interior wood use can be psychologically beneficial for users. To get a more overall picture regarding how interior wood might psychologically affect users, perception, preferences, and psychophysiological responses toward wood were included in the review. Because there were rather few studies related to the same outcome measures, it is difficult to draw any clear conclusions from the results. However, some points can be made from the review.

Regarding preferences for physical properties of wood, several studies have found similarities. This might indicate that certain wood properties are preferred over others and that not all types of wood are necessarily equally beneficial. According to the reviewed studies, the most beneficial wood products will be those that show some degree of homogeneity

and harmony in the structure. In addition, wood with fewer knots are preferred over wood with many knots. Another important issue is that wood is perceived as natural and that wood products are often preferred over other products because of their naturalness. Furthermore, and what is perhaps most interesting, some of the results indicate that responses toward wood are measurable by psychophysiological outcomes. This might be the best indication that people do respond to the inclusion of wood in a setting. To go deeper into these issues, theoretical, methodological, and practical implications of the review are discussed and research needs identified.

Before proceeding with the discussion, some limitations of the review study should be noted. Because of the lack of homogeneity in the reviewed studies concerning research design, experimental manipulations, and outcome measures, it was not possible to conduct a meta-analysis on the results. Another important issue is that the reviewed studies have been limited to those that have been published in peer-reviewed English-language journals. Thus, several studies related to psychological benefits of wood in other languages, including both French (eg Marchal and Mothe 1994) and Japanese (eg Nakamura and Masuda 1990; Nakamura et al 1996) have not been included in the review. We hope in the future that these important studies will be accessible for a larger audience.

Theoretical Implications and Research Needs

At the outset of the present review, we offered some theoretical explanations of the psychological processes involved regarding people's responses toward nature. We might further ask if theories used to explain human-nature relationships in outdoor settings can be transferred into the indoor context. Most of the theories described have an evolutionary approach stating that humans are partly genetically predisposed to respond positively to nature or natural elements. Furthermore, wood in indoor settings could be understood as some representations of

nature. However, cultural and individual responses should probably be even more pronounced in built settings compared with nature outdoors (Bourassa 1991). What can be concluded is that far too little research has been conducted to state which psychological processes are engaged in generating psychological benefits of nature in indoor settings. It appears that no previous research within this field has had theory development as its main purpose, and none of the reviewed studies has discussed theory in any depth. Based on the reviewed studies, we offer some recommendations regarding research for theory development.

Many of the reviewed studies have involved preferences for wood types and characteristics, and as stated earlier, preferences are thought to provide an indication for potential psychological benefits. Like with nature outdoors, both cultural and individual differences may influence preferences for wood in indoor settings. Thus, an interesting research approach would be to investigate preferences for wood in indoor settings with a view to distinguish individual, cultural, and evolutionary contributions. A uniform preference for wood or wooden properties could be an indication of genetically based preferences.

As suggested by theories on environmental stimulation (eg Wohlwill 1974), elements of nature indoors might either decrease or increase the level of stimulation to an intermediate level. As we have seen, people seem to prefer an intermediate degree of stimulation of wood. Similarly, some authors have also noted that nature can soften the environment. According to Kellert (2005), shapes found in natural environments are often soft, rounded, mostly ambiguous, and infinitely varied, whereas the descriptive lines in most components of manmade environments are straight and enclose orthogonal shapes. Thus, one interesting approach for future research would be to investigate how elements of nature indoors are perceived and whether uniquely natural forms can generate psychological benefits by increasing or decreasing perceived levels of stimulation. This approach is also related to

studies on fractal structures. As some authors have noted, the restorativeness of nature could be because of the fractal structures that are found in natural scenes (Purcell et al 2001; Joye 2007).

Methodological Implications and Research Needs

Three issues are especially important related to research on psychological benefits of interior wood use: 1) the wood exposure (construct validity); 2) how to control for extraneous factors (internal validity); and 3) whether the results can be generalized to other settings (external validity). These topics are important to consider in experiments or quasiexperiments related to human responses toward wood.

Concerning the wood exposure, which properties should be investigated? Broman (1995a, 1995b, 1996, 2001) found 10 different characteristics of wood that are important when assessing people's preferences for wood. Thus, to assert more homogeneity in future studies, the characteristics of the wood studied should be more carefully considered.

For internal validity, what differentiates nature in the indoor context from nature found outdoors is the context. Several physical factors should be accounted for in future studies because many other factors will influence the indoor physical environment (eg lighting, sound, acoustic, and air quality).

To enhance external validity, more studies should be conducted in field settings outside of the laboratory. In addition, more studies should be conducted in different indoor settings and among different persons such as hospitals, schools, workplaces, and residences. Interior wood might be a more preferred choice in some settings than others and might differ among different people and cultures. In addition, it is essential to conduct more longitudinal studies, to get a better picture of how benefits persist or dissipate, because people can adapt to a condition over time (eg Wohlwill 1974).

Practical Implications and Research Needs

Future research can address a number of applied issues. As Van den Berg et al (2007) have noted, there is still a lack of knowledge that is needed to translate research findings about benefits into guidelines for the design of nearby nature. In terms of elements of nature in the indoor context, little is known about the spatial conditions needed to promote beneficial effects and whether natural elements are beneficial in all settings. Furthermore, there still exists much uncertainty in terms of strength of relationships between nature in different indoor settings and beneficial effects; such information would support decisions about the practical value of design interventions involving elements of nature.

Because some of the reviewed studies have showed measurable effects from wood in indoor settings, it is important to continue research on the psychological benefits of interior wood use. With increasing urbanization, people have less access to nature in their daily life. In general, people in Western societies spend most of their time in indoor settings (US Department of Labor 2009). Integrating features of natural contents into the built environment can give people access to nature to a greater degree. Research on this topic has the potential for helping planners and other environmental designers to influence properties of the built environment that can promote health and well-being. Nevertheless, based on other studies related to elements of nature in indoor settings, we might expect that the association between interior wood use and beneficial outcomes is small. However, such associations can have substantial practical significance given aggregation over a large number of people over time.

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