

Health Benefits of Wood, Plants and Nature in the Human Environment:

An analysis of the past 15 years of research and its application potential

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Abstract

The health benefits (psychological and physical) of wood, plants and views of nature in the human environment is a relatively new field of study. After an extensive literature review of the last 15 years, it is clear that there are significant health benefits associated with the presence of these natural elements in an indoor setting. Some of these benefits include reduced stress, increased pain tolerance, improved task performance, increased sense of well-being and attentional focus recovery, and heightened natural killer activity. Due to low awareness, these findings could be integrated into the marketing strategies of forest companies and their total product concept could be expanded to include health benefits. Additionally, the application potential is seemingly limitless and a look at hospitals and schools shows cost saving benefits as well. As this is a relatively young field of study, there are also areas for further research including long-term and large-scale studies.

Keywords – physical and psychological health benefits, stress reduction, pain tolerance, phytoncides, attentional focus, task performance, forest product marketing, total product concept

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Introduction

The average person in North America spends 80-90% of their time indoors (Qubulus, 2010). As a result, air quality, sunlight, view, temperature, and the presence of plants and wood are all important considerations. Architectural and environmental psychology, among other things, looks at the relationships between humans and wood. Psychologists have known since 1960 that environments can have positive and negative effects on an individual (Ittelson, 1960). Further studies on the material have been sporadic and have varied from the views of hospital beds to plants in the workplace (Bringslimark et al., 2009; Ulrich, 1983). In the past 15 years, there has been an increase in research on the health benefits of wood used in interior finishing from physical to psychological benefits at home or in the workplace (Rice et al., 2006; Sakuragawa et al., 2005; Tsunetsugu et al., 2002).

With the majority of the population spending nearly all of their time indoors, whether an interior environment is natural, modern, stressful or restorative is an important consideration. With this in mind, an extensive literature review, of the last 15 years, regarding the health effects of wood, plants and views of nature in the human environment has been conducted in order to look at what can be learned and how public and private indoor settings can benefit from this information. The review of literature covers research conducted on the effects of wood finishing in the interior to views of a wooded environment and everything in between. In the discussion, after the background information

has been analyzed, there will be a brief insight into the integration, application and limitations of this material.

Literature Review

Before I begin, I would like to clarify a few terms. When referring to the “health benefits” of wood, I am referring to a broad variety of health related benefits including pain tolerance, improved immune system and psychological benefits. Psychological benefits are equally as encompassing including changes in emotion, stress, cognition, effectiveness and adaptive capacity. Overall, the term health benefits refers to anything positive that may come from wood, plants, the natural landscape or scenes of nature.

Researchers have known for half a century that environments play an important role in human lives. In 1960, Ittelson found that human environments could have positive and negative effects on an individual (Ittelson, 1960). In 1982, Balling and Falk pointed to an inherent preference for natural scenery (Balling and Falk, 1982). Ulrich took these findings one-step further in 1984 when he discovered that post-surgery patients assigned to rooms with views of a natural scene required less pain medication and less recovery time (Ulrich, 1984). These findings eventually paved the way for the majority of research done on the subject of the health benefits of wood and nature in the interior human environment over the past 15 years.

In 1995, Kaplan underwent research to determine the restorative benefits of nature. He discussed how directed attention plays an important role in effectiveness. There is also a need to reduce the fatigue related to directed attention as a means of restoring effectiveness. Sleep is one such method, however, it is highly impractical, especially if it were used throughout the day to restore effectiveness. Thus the use of a restorative environment is much more logical and common place. There are four components of restorative environments: being away, fascination, extent and compatibility. The sense of being away does not require a distant setting and easily accessed natural environments play the part in an urban context. Nature offers soft fascination with its multitude of processes and requires an effortless attention allowing for thought to be on other things. An area does not need to be large to have extent and trails can be designed to give smaller areas a feeling of vastness. A human often uses less effort to function in the natural environment and is experienced as high in compatibility. So although urban environments may contain some or all of these four components, natural settings have ample amount of all of them. Kaplan also proposed a framework that places stress and directed attention in a broader setting of human-environment relationships (Kaplan, 1995).

Herzog et al. (1997) built off of Kaplan's Attention Restoration Theory (ART). They simplified Kaplan's key benefits from cleansing the mind of cognitive noise and recovering from directed attention fatigue to "attentional recovery" and time to think of immediate personal problems and an opportunity to ponder life's bigger questions to "reflection." For the experiment, settings were broken into

three levels of restorative potential: ordinary natural, sports/entertainment and everyday urban. Ordinary natural were seen as places of both reflection and attentional recovery. Everyday urban were seen as poor for both reflection and attentional recovery. Sports/entertainment were seen as places for attentional recovery, but poor for reflection. To test these theories, participants were given scenarios and asked to rank which setting they would prefer and why. The results of the study support their initial hypotheses and the importance of ordinary natural settings in an urban context (Herzog et al., 1997).

Herzog et al. (2002) choose to expand upon their earlier research and developed another study that had participants rate 40 activities ranging from nature-related to chores to drugs. The purpose of this study being to determine peoples' knowledge of the restorative potential of a natural setting and compare that to the ideals suggested in ART. Some of the more interesting contextual findings included that participants rated nature much higher for restorative properties than entertainment while for the likelihood of choosing activities this was not true. Also, individuals tended to rate nature higher for a best friend than they did for themselves (Herzog et al., 2002).

So, although it has been established that being in a natural setting can reduce stress levels and be restorative, what about nature viewed through a window? Ulrich began to answer for this question in 1984 and Kaplan (2001) and Parsons et al. (1998) picked up where he left off (Kaplan, 2001; Parsons, 1998; Ulrich, 1984). Kaplan focused on apartment communities and used both verbal (description) and visual (ranking photographs of views from their apartment

building) approaches to determine participant's view preferences. What was found was that views of natural settings could contribute highly to aspects of an individual's sense of well-being and their sense of satisfaction. On the other hand, views of built elements have significant effects on satisfaction, but less so on well-being (Kaplan, 2001). Parsons et al. (1998) took a different approach and used videos to simulate driving through various outdoor environments. The test consisted of 4 phases: baseline period, stressor 1, drive video and stressor 2. The stressors in this study were active (serial addition or PASAT) and passive (video tape of workplace injuries known to cause stress). PASAT (Paced Auditory Serial-Addition Task) is a pre-recorded audiotape where participants are tasked with listening to a series of single-digit numbers and say aloud the sum of every two digits. PASAT, like the workplace injury video, is a known method of inducing stress. Throughout the study, test subjects were hooked up to a variety of equipment that records skin conductance, facial EMG, and cardiovascular measures. From these measurements, stress level and recovery time could be determined and analyzed. What was found was that individuals viewing nature-dominated environments had lower stress levels than those viewing urban-dominated environments. They also found that participants who viewed the natural environments had a quicker recovery rate from stress and a lower stress level when exposed to subsequent stressors (Parsons et al., 1998).

The majority of the literature, at this point, had been focused on being in or viewing the natural environment. With this in mind, research began to look at the effects of nature in the interior human environment. Lohr and Pearson-Mims,

inspired by Ulrich's results, sought out to find if interior plants would have the same pain implications that Ulrich found in his report (Lohr and Pearson-Mims, 2000; Ulrich, 1984). To test this, they set up three different rooms and had participants submerge their hand in ice water for up to 5 minutes. What was discovered was people in the room with indoor plants would hold their hand in the ice water for a longer time than the other two rooms; one was a plain control room and the other contained colorful objects to get participant's attention. This indicates that simply having something to draw the eye is not enough, but the presence of interior plants is required to see the increase in pain tolerance. Additionally, the research points to an improvement of mental well-being for people in a room with plants (Lohr and Pearson-Mims, 2000).

Pain tolerance is not the only thing that researchers have found interior plants to influence; mood and task performance were found to be affected by the presence of an interior plant. In one particular study, researchers found that plants improved the results of certain tasks and that plants tended to affect males more so than females. In this experiment, participants were given two types of tasks (association and sorting) and overall the presence of plants improved both association and sorting task performance, however, the association task saw the greater improvement. Furthermore, female participants collectively scored more consistently on tasks with and without plants and scored higher than males in settings lacking plant life. Males, on the other hand, scored significantly higher with interior plants than in rooms where there were not any. As a result, it was suggested that gender might play a role in the effects of plants in the indoor

environment. This same study also found evidence that interior plants could affect creative work positively (Shibata and Naoto, 2002). This study was conducted over a short period of time and its main focus was on task performance. Therefore, further research specific to the affects on mood could be conducted.

Not everyone is convinced of the health benefits of interior plants. As a result, Bringslimark et al. (2009) conducted a critical review of all the experimental literature surrounding the psychological benefits of indoor plants. Their review consisted of a large variety of literature published over the last 30 years. They found that after a critical examination of the literature they were able to agree with studies showing that indoor plants can provide health benefits, including a high pain tolerance and stress-reduction. However, they said this with strong reservation as they had issues with heterogeneity in many methods and results (Bringslimark et al., 2009). As for the subject, it is still in its infancy and therefore there is still an abundance of research that can be done and several avenues remain unexplored.

Interior wood finishing and wood products have shown to cause similar physiological and psychological responses that interior plants create. Sukuragawa et al. (2005) first began to look at these effects with the influence of wooden wall paneling. Subjects were exposed to two wall panel types (full-sized hinoki wood wall panels and white steel wall panels) after a brief control exposure to a curtain covering the walls. In order to measure physiological responses, continual blood pressure measurements were taken. To record

psychological responses, after exposure, evaluation by the SD (semantic differential) method and the POMS (profile of mood states) test were performed. This experiment found that psychologically hinoki wood panels produced natural impression and reduced feelings of depression or dejection. What was also discovered was that white steel panels had the opposite effect and increased depression and dejection while reducing vigor. For subjects, who liked the wood panels, there were significant decreases in blood pressure and for those who did not like them showed no change in blood pressure. Additionally, those who disliked the steel wall panels had a significant increase in blood pressure (Sukuragawa et al., 2005). This study marks the beginning of research on the responses of humans to interior wood finishing.

Up until this point, the health benefits (physical, psychological, physiological) of wood and plants in the human environment had been studied, yet few researchers had ventured to apply this knowledge beyond implications. Rice et al., in a 2006 study, designed a three-part experiment to examine people's perception of interior wood. Their findings not only point to preferences and positive feeling towards wood but also to never before used marketing applications of their results. Each participant in this experiment underwent a q-sort experiment, a personal interview and a self-administered questionnaire. The q-sort portion consisted of individuals being given 25 numbered cards of images of living rooms and asked to rank them. Initial ranking had participants put cards into three categories (rooms that they liked, rooms that they disliked and rooms that they felt indifferent towards) and then they were asked to fill the 25 spots on

a normal distribution (ranging from -4 to +4). The results of the q-sort remarkably showed that the top rated living rooms were significantly different from the bottoms rated and that the top six rooms had a lot in common. Each six had windows with views of nature or plants within the room and were bright. The two top rated rooms were almost entirely wood and had few synthetic materials. The interview section of the study posed five questions to subjects who were given one of three images of living rooms. These questions focused on the positive/negative elements of the room, the first word that came to mind when seeing it and subject's assessment of the room's atmosphere and feeling. Of all the rooms, participants disliked the modern living room the most, while the most liked room was the rustic living room. Words used to describe the modern room revolved around cold, uncomfortable and modern while words used to describe the rustic rooms consisted of warm, relaxing and comfortable. The more positive elements of the rustic living room consisted of its natural lighting, view of nature and use of materials. The final portion of the experiment was the self-administered questionnaire that was designed to gain insight into demographics, furniture preferences and feelings towards the use of certain materials. Wood, as it did in the two previous sections, scored higher and was more frequently associated with attributes like homey, warm and relaxing. After the completion of their research, Rice et al. (2006) discussed implementations of this information including expanding the framework for healthy housing to incorporate psychological benefits as well as a call for wood products companies to innovatively market their products for their health benefits (Rice et al., 2006).

Tsunetsugu et al. (2007), also interested in the application of psychological and physiological ramifications of interior wood finishing, conducted research to determine the responses of humans stimulated by interiors with different percentages of wood quantity. Participant's physiological indices were continually recorded from the beginning of the test. Each subject was exposed to three rooms (with wood quantities of 0, 45, and 90%) after a control period to stabilize their psychological indices. In the 0% wood room, diastolic blood pressure decreased significantly. The same was true for the 45% room in addition to an increase in pulse rate. The 45% room also had the highest rankings in comfort and restfulness. The 90% room caused the largest decreases in both diastolic and systolic blood pressure (Tsunetsugu et al., 2007). There are wide reaching implications from this study because this study suggests that varying percentages of wood covering have significant responses in diastolic blood pressure, systolic blood pressure and pulse rate. So, although the results show changes in physiological responses, further research on this subject with more participants could indicate patterns or optimal percentages.

One aspect of wood that many researchers had overlooked was whether or not it actually contained any chemicals that brought on some of the health benefits previously described. Li et al. (2006), originally starting research in this field to explore the effects of forest bathing on the immune system, looked at phytoncides (wood essential oils) and their effects on natural killer activity. Although this experiment was done *in vitro* (outside of a living organism), the tests showed that phytoncides enhance human natural killer activity. Natural

killers are an important part of the immune system and defend the host from infections by other organisms. This is not only important for flues but an increased activity in natural killers could increase the body's ability to prevent cancer generation and development (Li et al., 2006). A later study by Li et al. (2007) tested the same effects of forest baths and found the same increase in natural killer activity that their previous research tested (Li et al., 2007). The significance of these findings is that wood in the built human environment contain phytoncides and has the same potential to increase natural killer activity.

The final and most recent study, by Fell (2010), researched the restorative properties of interior wood. Such questions as to the restorative properties of nature and indoor plants had previously been answered but no research had studied wood in the built environment or the combination of wood and plants. Four test room environments were constructed (no plants, no wood / no plants, wood / plants, no wood / plants and wood) and subjects were fitted with electrodes to measure skin conductance and inter beat interval (Fell, 2010). After a baseline period, participants were administered a PASAT test (the same mild stressor as in Parsons et al., 2008) in one of the four test rooms and, upon completion, were given a recovery period. Test subjects in the wood and plant office showed lower levels of stress activation in all phases of the study. This study also found that plants had no effect on stress and therefore cannot differentiate the stress-reducing health effects of interior wood against indoor plants (Fell, 2010).

Discussion

The purpose of research is to test a hypothesis and once tested, to apply that gained knowledge. In the case of wood and plants in the human environment, there is sufficient evidence and learning surrounding the research and yet little to none of that new understanding is being applied. These studies highlight a multitude of health benefits (psychological and physiological) that could have far reaching effects from work place productivity to performance in public schools. Thus, I intend to discuss the integration and application potential surrounding these health benefits. Additionally, I will emphasize the limitations of research in this field and propose areas of further research.

Integration

There are many institutions, businesses and practices that would benefit from the adaptation of these experiment's finding. Two in particular include forest product companies and government, using the Wood First initiative as an example.

In order to compete effectively in a growing, competitive global marketplace, a forest company needs to be innovative and market their products accordingly. Rice et al. (2006) had it right when they said "there is a need to market wood products in an entirely new manner, focusing on the multitude of positive attributes that wood products possess, including the potential to increase

the psychological health and well-being of people who buy and live with appearance wood products (Rice et al., 2006).” No other product exists that can claim the same health benefits and yet wood product marketing hasn’t changed over the years. It is still primarily a “word of mouth” industry that needs to start focusing on a better means of informing the public. There are many ways to market this but one such way would be for forest products companies to band together to start a generic advertising campaign that promotes the health benefits of wood because the public simply is not aware. The most famous generic advertising campaign is the “Got Milk?” campaign by milk producers in the United States. The campaign was launched in 2004 and after just two years it had achieved a 91% awareness rating. It didn’t end up driving sales up substantially but in fact stopped the steady yearly decline of 2-3% and caused consumption to more or less plateau (Marketing Case Studies, 2008). If forest companies were to come together and take a similar approach or develop an innovative marketing campaign, there could be comparable success. There are also new ways that individual companies could market their product and expand their total product concept. The total product concept is the combination of physical product attributes and non-product attributes such as customer service, delivery, perceived values and intangible associations. Wood producers are neglecting the health benefits from their total product concept and missing out on an attribute that has the potential reach new clients. Personal sales is the primary form of marketing in the forest industry; presentations could be tailored to specifiers like architects and interior designers to include the health benefits of wood.

Specifiers may then request wood products, materials and finishes for their next projects and promote it as a healthy choice.

A second avenue of integration is in government initiatives. In British Columbia, the government is promoting its forest sector through the Wood First Initiative. The basic premise is to change attitudes surrounding wood and to have wood viewed as the first choice for construction. The focus of this campaign is on the cost-effectiveness, durability and environmentally friendly properties of wood (Ministry of Forests, Lands and Natural Resource Operations, 2011). Although these are all important aspects of wood, integrating health benefits into the initiative could cater to those interested in more than just an eco-friendly substitute. It would also add something to the list of reasons to support the use of wood first that steel and cement competitors could never provide. Such integration is another method of spreading awareness and promotion that wood has not historically received. I believe that spreading awareness is the key and once the word is out, everything else will come together.

Application

The application of these findings is seemingly limitless: homes, schools, offices, hospitals, senior residences, libraries and many more. Therefore, for the sake of this discussion I will only focus on two public institutions: schools and hospitals. School, a place where the 86% of the Canadian public spend 12 years of their life, has enormous potential for the integration of wood and plants into the

classroom (Conference Board, 2007). Lets consider the stress reducing qualities of wood and plants. High school is a highly stressful time for many students (Robinson et al., 1995). It is a time where teachers ask more of everyone and when most teenagers begin planning for the rest of their life. If students were exposed to stress reducers on a daily basis in the interior environment, this could potential lead to lower rates of dropout, bullying and even suicide. Furthermore, stress reduction is only one of the many tested health benefits of wood and plants in the human environment. Consider the ramifications if schools were purposely fitted with wood products, interior plants, views of nature and finished with wood. The benefits of improved creativity, mood and sense of well-being, increased attentional recovery and task performance could simply improve a student's day or go as far as to improving their test scores. The benefits of wood in schools are completely untested, however, with so many studies indicating an array of positive outcomes then why should it be any different in a school setting? The unemployment rate of individuals who did not graduate from high school is 12.2%. The rate for those who did graduate is nearly half of that at 6.8% (Statistics Canada, 2006). This has huge cost saving potential if wood in schools were to reduce the number of dropouts who end up unemployed and on welfare.

Hospitals are another costly public institution where the implementation of a healthy interior could save money and benefit those using the institution. Ulrich (1984) proved that individuals, recovering from surgery, with a view a nature required less pain medication, fewer recovery days and had less post-surgery complications. Lohr and Pearson-Mims (2000) also found that the presence of

interior plants increased an individual's pain tolerance. These findings alone should be enough to advocate for the use of interior plants and rooms with views of nature. In Ulrich's case study, patients with a view of nature were discharged on average one day earlier (or requiring 8.5% fewer post operative days) than those with views of other buildings. The daily cost for a patient recovering from surgery in a hospital in Lower Mainland, British Columbia averages \$3,065 CND (David Cummings, 2009). On a yearly basis over 400,000 surgeries are performed in the province of British Columbia (Ministry of Health Services, 2011). If the number of recovery days were reduced by 1 for 1/20 of these patients, that would save the government \$61 billion CND. This is not the only cost saving aspect of this implementation of wood, plants and views of nature. Other cost savings would include lower drug costs and fewer repeat surgeries due to complications.

This does not mean that this concept of improving the interior environment should only be integrated into schools and hospitals. Public, private and residential buildings alike could equally benefit. 20% of Canadians experience an illness related to stress every year. If you were to convert that to the cost of work time lost it would total \$12 billion CND (Statistics Canada, 2010). There is enormous cost saving potential for businesses across Canada and there is application potential for nearly all aspects of a society that spends 80-90% of its time indoors.

Limitations

One of the most common arguments against this subject is the lack of research. Although that was true 10 years ago, the research has doubled since then and looks as though it will continue to grow. Even so, it is still in its infancy and there are several areas for furthered research; there has been little repetition of some experiments, most studies have only a few participants and there have been virtually no long-term studies.

A lack of repetition of previous experiments is a problem that can lead to further problems; this is especially true in a small field such as this where there are few new entrants. If a study was designed based on previous research, then it is assuming a repeatable truth so if that experiment, it is based on, were repeated, then it would produce similar results to that of the original. So, if an experiment is unrepeated, then its original findings may have been anomalies and not representative. In the majority of my research, I found a large amount of research that did in fact repeat earlier studies and developed them further. However, there are studies that remain unrepeated and further experiments using similar design methods could assume accuracy in methods, rationale and results that are in fact untested.

After my literature review, I became aware that a large amount of the existing data is based on experiments conducted on only a handful of participants from a similar background. Understandably university students are often the most sought after test subjects because of their abundance, readiness

to participate and often obligation to participate to receive class credit. This, however, neglects many demographics and wood and/or plants may have different effects or levels of impact depending on many factors including age. In recent years, the number of participants in studies has been increasing (Fell, 2010; Rice et al., 2006). This is a healthy trend and one that I hope will continue.

Finally, there is a need for long-term studies. Nearly all existing research has come from 20 minute experiments on participants. The need for long-term studies is not only for exploring more areas of research but such studies, I believe, are what the public needs to be convinced of the benefits of wood and plants in the built interior. An example of long-term research would be a comparison between three classes at a public school in three differing indoor environments; a natural, wooded interior classroom with indoor plants, a modern interior classroom that is lacking wood finishing and indoor plants and a control classroom that has a blend of the wood and modern rooms elements. Identical content would be covered, identical assignments and indicators of performance would be issued and similar teaching methods would be used to teach the students. Consequently, after a year in these three environments, a comparison could be made about the effects of a student's environment on their learning. A similar example would be in an office setting and testing employ performance in similar office environments to those described for the school classrooms.

Conclusion

The health benefits (psychological and physical) of wood, plants and views of nature in the human environment is a relatively new field of study where little attention has been paid. After an extensive literature review of the last 15 years, it is clear that there are significant health benefits associated with the presence of these natural elements in an indoor setting. These benefits include reduced stress, increased pain tolerance, improved task performance, mood, sense of well-being and creativity, increased attentional focus recovery, heightened natural killer activity and several others. As a result of the low levels of awareness surrounding these health benefits, there are many ways these findings could be integrated and applied. Forestry companies and government initiatives market the use of wood based on its structural and environmentally friendly properties and neglect the multitude of health benefits. Furthermore, public schools and hospitals are two examples of public institutions where designing and building with wood, plants and views of nature could be applied and even save costs. Additionally, there are limitations to the current research that include experiment repetition, longevity and the number of participants used in each study. These limitations, however, do not take away from the importance of these studies and their current/future implications.

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