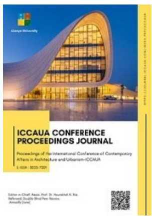


# ICCAUA Proceedings Journal

*Proceedings of the international conference of contemporary affairs in architecture and urbanism-ICCAUA*

*Volume 8 (December 2025), Pages 210-221*
Journal homepage: https://journal.iccaua.com/

ICCAUA Proceedings Journal

**DOI:** https://doi.org/10.38027/ICCAUA2025EN0350


# Mental Worlds Shaped by Neuroarchitecture: The Effects of Indoor Materials on Brain Activity and Emotional Well-Being


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**Received:** 17 January 2025
**Revised:** 6 May 2025
**Accepted:** 18 June 2025
**Available online:** 5 July 2025





This article has been selected and peer-reviewed for publication in this journal as part of the 8th International Conference of Contemporary Affairs in Architecture and Urbanism, held on 8–9 May 2025 in Alanya, Türkiye.



**Abstract**

This research explored how interior materials—natural wood, processed wood, concrete, and metal—influence brain activity, cognition, and emotional well-being in university environments. The study involved 35 participants, using EEG to monitor brain responses, the Stroop test to assess cognitive performance, and POMS test to evaluate emotions, with data analyzed via machine learning and statistical methods. Findings revealed natural wood yielded the best cognitive outcomes (93% accuracy, quick responses), boosted emotional calm (low negativity, high vigor), and fostered neural relaxation. Processed wood showed comparable benefits, whereas concrete and metal correlated with reduced cognition, elevated stress, and emotional disturbance. EEG analysis effectively identified material-specific effects. The study highlights wood's potential to enhance productivity and mental health in learning and work settings, urging a rethink of material choices in design to improve urban living standards.



**Keywords:** Neuroarchitecture; material textures; EEG; cognitive performance; emotional well-being; interior design; wood.


## 1. Introduction

Architecture is a multidimensional discipline that influences human life not only by creating physical spaces, but also by shaping individuals' cognitive processes, emotional experiences, and mental well-being. In today's societies, people spend more than 90% of their time indoors. For this reason, it has become extremely important to understand the interaction of spaces with the human mind by moving the design beyond aesthetic and functional concerns. Architectural material textures, elements such as wood, concrete and metal are the basic components that determine the sensory and perceptual atmosphere of the spaces. Neuroarchitecture, as a field that studies "the dynamics resulting from the interaction of the human brain with the environment by combining neuroscience, environmental psychology and architecture", aims to place these effects in a scientific framework. This study aims to investigate the cognitive and emotional effects of material textures used in university classroom and office environments, especially on wood (natural and processed), concrete and metal people, from a neuroarchitectural perspective. Experiments with tools such as EEG (electroencephalography), Stroop test and Mood Profile (POMS) deal with the relationship of these materials with perception, mood and neural responses with a multidisciplinary approach. (Klepeis et al., 2001) (Eberhard , 2008).

The study argues that the use of materials in interior design is not only an aesthetic or structural choice, but also a factor that directly affects the mental processes and psychological well-being of individuals. In this context, conscious planning of material selection can play a critical role in improving users' quality of life and spatial experience. As Alain de Botton puts it in The Architecture of Happiness, "the spaces we live in shape our moods and behaviors; We need places that will nurture and encourage the survival of the good parts that remain in the depths of the soul." This study aims to understand the mechanisms of neuroarchitecture and this formation and integrate it into design processes. (Alain de Botton , 2006).

The effects of architectural material textures on human beings have been comprehensively discussed by various disciplines in the past (Afara et al. 2024; Amen, Afara, and Muhy-Al-din 2024) . Research on biophilic design has shed light on the effects of natural materials on the human mind. While arguing that "organic textures, such as wood, satisfy people's need to connect with nature and therefore evoke positive emotional responses", his study revealed that "natural elements reduce mental fatigue and promote cognitive regeneration". While these findings point to the

neurological underpinnings of biophilic design, the perceptual effects of industrial materials present a different picture. Rice et al. argue that "hard surfaces such as concrete and metal are associated with a sense of coldness, distance, and modernity; wood is perceived as 'warm', 'natural' and 'relaxing'". (Rice et al., 2006a).
Noscientific approaches have made significant strides in investigating the neural traces of these effects. Harmony found that "natural visual stimuli trigger positive emotional processing in the gamma and beta frequency bands," while Tsunetsugu et al. have experimentally proven that "wooden surfaces physiologically produce stress-reducing effects and lower blood pressure." Studying the use of materials in healthcare settings, Nanda et al. found that "natural textures such as wood reduce anxiety levels in patient rooms and support the healing process"; This has demonstrated the therapeutic potential of material selection.( Harmony, 2013) Tsunetsugu et al., 2007) (Nanda et al., 2011).
On the other hand, there are more specific studies on the cognitive effects of material tissues. Kaplan's theory of attention restoration suggests that "natural elements renew attention by alleviating cognitive fatigue," while McMahan and Estes have confirmed through meta-analyses that "natural environments increase positive mood and facilitate coping with stress." Research on industrial materials, on the other hand, offers a different perspective; Pallasmaa criticizes that "hard and cold surfaces in modern architecture diminish sensory richness and weaken the emotional bond between man and space." However, these studies have often focused on the general perception of indoor space, while cognitive effects in specific functional areas, such as the university, have not been examined in sufficient depth. Systematic comparison of material tissues in the context of neuroarchitecture has also found a limited place in the literature. This study aims to expand on this rich foundation offered by previous research and to deepen the relationship between neuroarchitecture and architectural design. Thus, the optimization potential of material selection in interior design for the human mind is re-evaluated in the light of past developments.(S. Kaplan, 1995) (McMahan & Estes, 2015) (Pallasmaa , 2024).

## 2. Materials and Methods

This study aims to examine the effects of architectural material textures (natural wood, processed wood, concrete and metal) on the cognitive performance, emotional responses and neural activities of individuals in university classroom and office environments from a neuroarchitectural perspective. The research was carried out in a controlled laboratory environment and supported by neuroscientific measurement techniques (EEG), cognitive performance assessment tools (Stroop test) and emotional state analysis methods (POMS). Experimental design adopted a multidisciplinary approach to systematically evaluate the effects of material tissues on individuals; Data analysis was carried out with statistical tests and machine learning-based classification techniques.

### 2.1. Participants

Working Educated or in the office environment Employee 20-50 35 volunteers in the age range participated. The number of participants was considered to study with the optimum sample size to provide sufficient statistical power in EEG-based experiments. The sample size is too large Effects that were actually insignificant in studies sample It can be found to be incorrectly meaningful due to its large size. Therefore, as much as possible, the optimum sample size should be studied ( Sacco , 1982) , (Mazen et al., 1987) ( Coblick , 1998) (Jones & Sommerlund, 2007) (Balkin & Sheperis, 2011) .
Participants were selected from individuals who did not have a neurological or psychiatric disease and had normal or corrected vision and hearing. The gender distribution was balanced and the mean age was calculated as 28.6 years. Demographic characteristics of the participants (education level, occupation) were recorded and evaluated with a pre-experimental questionnaire. All participants signed the written consent form after being informed about the purpose, procedure and privacy policies of the experiment. Participants were asked to avoid factors that could affect cognitive performance, such as caffeine or drug use, for at least 24 hours before the experiment.

### 2.2. Materials

The materials used in the experiment represent four different material textures that are suitable for use in university classroom and office environments: natural wood, treated wood, concrete and metal. The choice of material was made on the basis of findings in the literature, both in terms of physical properties (hardness, roughness, warmth) and sensory perception (visual, tactile, emotional). The materials were placed on a standard office desk to allow visual and tactile interaction of the participants and prepared in panels in a U-shaped way to expose the material from three sides of the participant. (Figure 2.1-2.2-2.3-2.4).

**Concrete**: Exposed concrete panels have been chosen as a frequently used material in modern architecture with their hard, cold and monolithic structure. It has been reported in the literature that concrete is associated with neutral or distant perceptions, . The surface is designed in rough and gray tones. ( Heschong , 1979) (Jasmine Ariman , n.d .)

**Figure 2.1.** Concrete Material.

**Natural Wood**: Panels obtained from untreated wood were chosen for their organic texture and natural color (light brown tones). Studies showing that wood evokes a feeling of warmth, naturalness and peace ( Ulrich , 1984b) (Rice et al., 2006b) support this preference. The surface is characterized by rough and natural grain patterns.

**Figure 2.2.** Natural Wood Material.

**Processed Wood**: The panels obtained are prepared by varnishing and flattening. Treated wood offers a texture that is less organic but still aesthetically and positively perceived compared to natural wood. The surface has a smooth and shiny coating. (S. Kaplan, 1995).

**Figure 2.3.** Processed Wood Material.

**Metal**: Stainless steel panels were included in the experiment with their texture that evokes an industrial and cold feel. Studies in which metal surfaces are associated with a sense of modernity and distance have driven this choice.

The surface has a smooth and shiny appearance ( Zumthor , 2006).

**Figure 2.4.** Metal Material.

All these materials to be used in the experiment are placed on the table as shown in Figure 2.5.

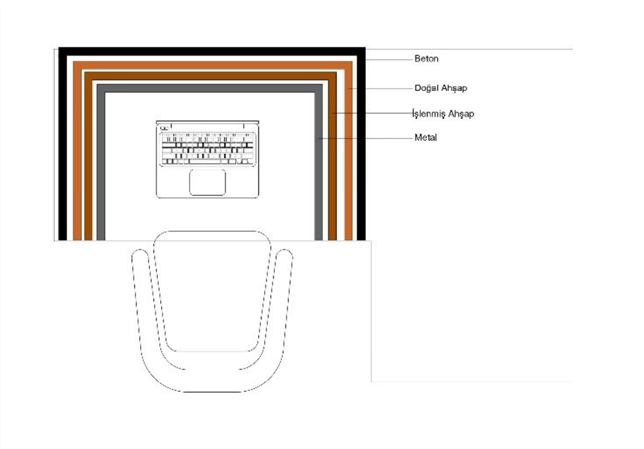


**Figure 2.5.** Layout of the Experiment Table.

### 2.3. Experimental Method

The experiments were carried out in a controlled laboratory environment based on the design of repeated measurements. Each participant was exposed to four material textures (natural wood, treated wood, concrete, metal) in random order, and EEG, Stroop test, and POMS measurements were taken in this process. This design aimed to isolate the independent effects of material textures by minimizing the impact of individual differences. ( Field , 2024).

#### 2.3.1. EEG Measurements

A 14-channel Emotiv Epoc EEG device was used to record brain activity (Figure 2.6.).

**Figure 2.6.** 14 Channel Emotiv Epoc EEG Device.

This device is capable of measuring brain waves (delta: 0.5-3 Hz, theta: 3-8 Hz, alpha: 8-12 Hz, beta: 12-27 Hz, gamma: >35 Hz) with its electrodes in the prefrontal (AF3, AF4), frontal (F3, F4, F7, F8), temporal (T7, T8) and occipital (O1, O2) regions. EEG is recognized as an effective method for analyzing the neural responses of architectural stimuli in neuroarchitectural studies ( Coburn et al., 2017) . Participants visually and tactile examined each material tissue for 2 minutes. During the experiment, participants were asked to be in a comfortable sitting position, keep their eyes open, and focus their attention on the surface of the material. External variables such as ambient light, noise, and temperature were kept constant.

**2.3.2. Stroop Test**

A three-stage Stroop test was applied to evaluate cognitive performance. (Figures 2.7.-2.8.-2.9.) This test is a classic neuropsychological tool that measures attention, cognitive control, and reaction time. This test was prepared by using PEBL software. Before the test started, the participant was informed about the test. While the participant was fully exposed to the material on the experimental table, the material was introduced to the participant and they were asked to touch it. The main purpose of this test is to measure the brain signals with the help of EEG by allowing the participant to focus while being fully exposed to the material. (Stroop , 1935) (MacLeod & Dunbar, 1988) (Mueller & Piper, 2014).


**Figure 2.7.** Stroop Test 1. Phase.


**Figure 2.8.** Stroop Test 2. Phase.


**Figure 2.9.** Stroop Test 3. Phase.

At each stage, the number of correct responses and reaction times were measured. The Stroop test was chosen to evaluate the effect of material tissues on cognitive processing because it has been proven in the literature that environmental stimuli can affect attention and cognitive performance (R. Kaplan & Kaplan, 1989a) . (Berman et al., 2008) ( Ohly et al., 2016) The test was performed immediately after exposure to each material tissue and repeated a total of four times. The Stroop effect has been analyzed as an indicator of cognitive load. (MacLeod & Dunbar, 1988).

**2.3.3. Mood Profile (POMS)**

The Profile of Mood States (POMS) questionnaire was used to measure emotional responses. POMS is a valid and reliable tool that assesses emotional state with six subscales: anger, tension, depression, vigor (energy), fatigue and confusion. The questionnaire consists of 65 items and each item is scored on a Likert scale between 0 and 5 The Total Mood Disorder (TRHB) score was calculated with the following formula: (Mcnair et al., 1971) (Terry et al., 2003)

TRHB=(Anger + Tension + Depression + Fatigue + Head
Confusion)−Vigor

POMS was chosen to measure the impact of indoor materials on emotional well-being, as previous studies have revealed differences in emotional responses from natural and synthetic materials ( Ulrich , 1984b) . ( Nanda et al., 2011) The duration of the questionnaire is approximately 5 minutes and it is aimed to reflect the instant emotional states of the participants. ( Tsunetsugu et al., 2007).

**2.4. Experimental Environment**

The experiments were carried out in the Digital Design Laboratory of Süleyman Demirel University. In the digital design laboratory where the experiments were carried out, there are two desks, two file folder cabinets and four chairs. The room is 2.75 meters high, 2.42 meters wide and 6.25 meters long. There are 2 windows measuring 108x102 on one wall of the room. The plan of the laboratory where the experiment was carried out is shown in Figure 2.10.

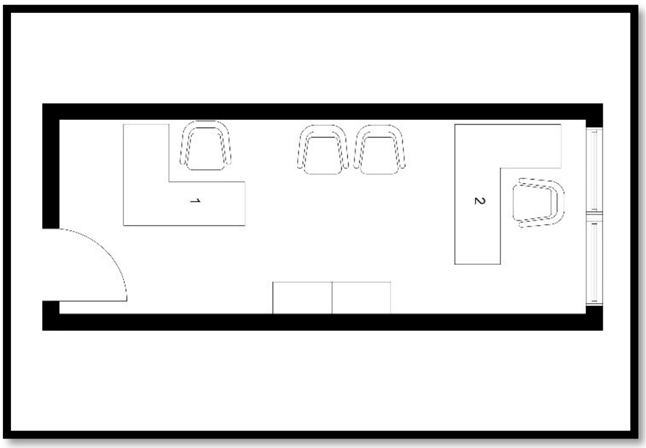


**Figure 2.10**. Plan of the room in which the experiment was carried out.

Participants were seated in an ergonomic office chair and the materials were presented at eye level (at a distance of approximately 60 cm) (Figure 2.11.). During the experiment, the room temperature was kept constant between 22-24°C and care was taken not to make the environment noisy. In addition, the minimalist design of the room made it easy for participants to focus their attention solely on the material textures.

**Figure 2.11**. View from the Experimental Environment.

**2.5. Application of Experiments**

During the experiment, 3 different measurements were applied to the participants. These; psychological tests (POMS Scale), physical measurements (EEG measurements), aptitude tests (Stroop Test).

Before starting the experiments, the participants were informed about the experiment. Afterwards, the participants were taken to table number 1 in the laboratory and asked to fill out the consent form. After filling out the necessary forms, the participant was taken to table number 2 where the experimental setup was located.

The experimental phase began after the participants were given a thorough explanation of the purpose of the study, its protocols, and the use of the equipment. Participants gave their signed consent to participate after receiving a thorough detail about the techniques. Participants were asked to sit in a chair while wearing EEG sensors and electrodes for physiological assessments. To test the reliability and stability of the electrode recordings, participants were instructed to open and close their eyes during the 1-minute cycle. In addition, participants were guided to limit their bodily movements (to reduce possible interference of irrelevant signals in EEG measurements) and to focus on the visual stimuli of a predefined blank scene. Participants were first asked to relax, then they were asked to see the materials.

The study was conducted on a subject-by-subject basis, and each subject was exposed to each material image. The total duration of the experiment for each participant lasted about 8 minutes. After the device was turned on, the ability test (stroop test) was started from the computer in front of the participant and he started to perform this ability test while being exposed to metal material. After the test was completed, the experimenter removed the metal material and the participant was asked to continue the aptitude test while being exposed to the natural wood material. After the stroop test was completed, the experimenter removed the natural wood material and the participant completed the stroop test again with the treated wood material. Finally, the experimenter removed the wooden material and the participant stroop with the concrete material completed the test again and the experiment was terminated. In this way, each participant completed a stroop test for four different materials. Material sequences were changed at the end of each experiment to make the experiment healthier. For example, the first participant was experimented with metal, processed wood, natural wood, and concrete material, respectively, while the other participant was experimented with concrete, natural wood, processed wood, and metal, which are the opposite of this order. In this way, the results of both EEG recordings and stroop test will be consistent. Because if each participant had been experimented with metal material first, the stroop test results of the metal material would have been more than possible in terms of time and true-false. Thanks to this ranking, this was prevented.

**2.6. Data Analysis**

The collected data were analyzed by statistical and machine learning-based methods and the cognitive, emotional and neural effects of material tissues were evaluated in a multifaceted way.

**2.6.1. Statistical Analysis**

**Stroop Test**: Cognitive performance data (correct response numbers and response times) were analyzed with one-way repeated measurements ANOVA using SPSS 22 software. In order to evaluate the differences between material types, F statistic was calculated and the significance level was determined as $\alpha=0.05$. The normal distribution of the data was checked by the Kolmogorov-Smirnov test. Effect sizes were reported with partial eta squares ($\eta^2$) and Bonferroni correction was used for post-hoc comparisons. ANOVA is recognized in the literature as a powerful method for analyzing the cognitive effects of environmental factors ( Pallant , 2020) . (Wickens & Keppel, 2004).

**POMS Data**: Emotional responses were analyzed with the Wilcoxon Signed Rank Test. This nonparametric test was chosen to evaluate the differences of POMS subscale scores and TRHB between material types because it gives reliable results when the data are not normally distributed. The significance level was accepted as $p<0.05$ and the effect sizes (r) were calculated. (Wilcoxon , 1992).

**2.6.2. EEG Data Analysis and Machine Learning**

EEG data was processed with a machine learning-based approach to discern patterns of neural responses to material tissues.

**Pre-Processing**: Raw EEG signals were cleaned by Independent Component Analysis (ICA) to distinguish between eye movements, muscle artifacts, and electrical noise (Jung et al., 2000) ( Makeig et al., 1995) . This method is standard practice in EEG analysis and is effective in improving signal quality. (Delorme & Makeig , 2004)

**Feature Extraction and Selection**: After preprocessing, the 15-second signal for each image was divided into 5 separate ranges, each 3 seconds long and with the same label. This segmentation allowed for a more detailed analysis of the patterns of brain activity associated with emotion recognition in response to different environmental stimuli. The strength of the EEG signal in each time interval was calculated for 5 frequency bands: Delta (1-4 Hz), Theta (4-8 Hz), Alpha (8-13 Hz), Beta (13-30 Hz), and Gamma waves (30-45 Hz). This frequency band analysis provided values for specific patterns of oscillatory activity associated with emotional processing. The extracted brain features were then subjected to k-fold cross-validation and the ReliefF feature selection algorithm was applied to select the top 15 features for each training set. ReliefF stands out in the literature as an effective feature selection method in multiclass problems and noisy data sets ( Kononenko , 1994) . (Robnik- Šikonja & Kononenko, 2003) Feature selection has been implemented to increase the model's generalization ability and prevent overfitting. (Guyon & Elisseeff , 2003)

**Classification: The** Support Vector Machine (SVM) algorithm was used to classify EEG data according to material types. The dataset was divided into 80% training and 20% testing, and model performance was evaluated with 5-fold cross-validation. The selected traits were used to train an SVM classifier, with each subject classified separately. During classification, a confusion matrix was calculated to assess the separation of brain activity for emotion recognition between different groups. In addition, the number of times each feature was selected during kfold cross-validation was counted and normalized to the total number of multiples in cross-validation. This procedure resulted in an amount for each of the force-based trait, demonstrating their importance in classification or discrimination between classes. The use of machine learning approaches, particularly the Support vector machine (SVM) classifier, allowed us to analyze complex patterns of brain activity and identify features that distinguish patterns of brain activity in response to indoor materials. The success of SVM in EEG classification has been proven in emotion recognition and neuroarchitectural studies. ( Lotte et al., 2018)

**3. Results**

**3.1. Stroop Test Findings**

The Stroop test was applied to evaluate the effect of material tissues on cognitive performance (attention, reaction time, cognitive control). Correct response percentages and response times measured after exposure to each material tissue were analyzed with one-way repeated measurements ANOVA. The findings show significant differences in cognitive performance between material types. The normal distribution assumption was confirmed by the Kolmogorov-Smirnov test ($p > 0.05$) and post-hoc analyses were performed with Bonferroni correction.

**Natural Wood**: When participants were exposed to natural wood, they exhibited the highest percentage of correct

answers (94.8% ± 4.1%). This finding supports that natural wood promotes attention restoration and reduces cognitive load (R. Kaplan & Kaplan, 1989b) . ( Berman et al., 2008)
**Treated Wood**: In the treated wood condition, the percentage of correct answers was recorded as 93.30% ± 5.6. A small decrease in performance compared to natural wood was observed. The cognitive performance supporting effect of treated wood can be perceived positively, similar to natural wood. (Nyrud & Bringslimark, 2010)
**Concrete**: The percentage of correct response after exposure to concrete texture was measured as 93.21% ± 5%. Concrete has led to a significant performance decrease compared to natural wood. This result supports that the perception of concrete as hard and cold can negatively affect cognitive processes. ( Heschong , 1979)
**Metal**: Metal texture was the material in which the lowest percentage of correct answers (90.4% ± 8.5%) was measured. The difference between metal and natural wood is statistically significant. Industrial and cold perception of metal surfaces can make attention and cognitive control difficult. ( Zumthor , 2006)
The Stroop effect was found to be the lowest in natural wood and highest in metal. This suggests that natural materials reduce cognitive load, while synthetic materials increase it ( MacLeod , 1991) . ( Ohly et al., 2016) The findings support the literature on the cognitive benefits of biophilic design. ( Kellert et al., 2011).

### 3.2. POMS Results

The POMS questionnaire was used to assess the effect of material textures on emotional responses. Subscale scores (anger, tension, depression, vigor, fatigue, confusion) and POMS scores were analyzed with the Wilcoxon Signed Ranking Test. The findings reveal that the differences in emotional state between material types are significant ($p < 0.05$).
The test results revealed a statistically significant difference in the POMS scores of the participants as they examined different materials (P<.01). The paired sample t-test between individuals' positive emotions also showed a significant increase, especially after watching natural wood material (P<.05, Mean-1=6.21, Mean-2=7.12) and treated wood (P<.05, Mean-1=6.12, Mean-3=5.98). However, no significant change in negative emotions was observed after watching concrete (P>.05, Mean-1=2.21, Mean-2=2.89). In contrast, there were significant changes in negative emotions after the metal material (P<.05, Mean-1=1.89, Mean-3=1.98).

### 3.3. EEG Results

EEG data were collected and processed with a machine learning-based approach to analyze neural responses to material tissues. Power spectral density (PSD) was calculated for frequency bands (delta, theta, alpha, beta, gamma) and classification was made with SVM (Support Vector Machine).
Using 15 features selected by the ReliefF algorithm, 80% training and 20% test datasets were created. Classification accuracy was calculated as 93%. The confusion matrix (Figure 3.1.) reveals that wood and have the highest distinctiveness, while metal shows lower distinctiveness.

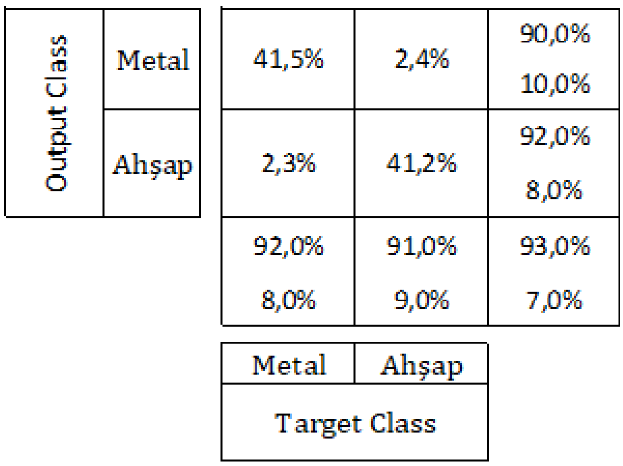


**Figure 3.1.** Confusion Matrix.

The EEG classification analysis aimed to distinguish between the associated patterns of brain activity of monitoring different materials. As the complexity matrix demonstrated, the results showed an overall accuracy of 93% for the classification algorithm. The algorithm had an error rate of 10% in estimating natural wood and 8.0% in estimating wood, resulting in accurate predictions of 90% and 92%, respectively. Trait importance analysis revealed that gamma power (frontal and temporal domains), delta power (distributed across all channels or domains), theta power (frontal domains), and beta power (frontal and temporal domains) contained the most information about emotional processing. These findings are in line with previous research highlighting the importance of gamma, delta, theta, and beta power in emotional processing. (Hirai et al., 1999) (Axmacher et al., 2008) (Demiralp et al., 2007) Gamma strength has been associated with positive emotional experiences, such as joy and love, and has been shown to play a role in the processing of complex visual stimuli, such as natural scenes ( Vialatte et al., 2009) , (Thomas & Vinod, 2018) Delta strength has been associated with the processing of basic emotional stimuli, including facial expressions, while theta and beta strength have been implicated in attention processes and the regulation of emotional responses. (Olejniczak, 2006) (Assenza & Di Lazzaro, 2015)

The second classification algorithm was aimed at distinguishing between all materials. The overall accuracy obtained is 60% and 65% precision values of metal, 40% concrete, 48.8% treated wood, 52.8% natural wood and 64.8%.
The feature importance analysis for the classification performed in this study showed that gamma power (frontal and temporal occipital) and beta power (frontal and occipital areas) contained the most information about psychological indices and physiological responses. The highest coefficient was observed in the frontal channels for gamma and beta power exceeding 0.25. These findings suggest that certain patterns of brain activity may be related to emotional responses to different types of indoor environments, especially areas with wood materials. The use of machine learning approaches, particularly the SVM classifier, has enabled the identification of features that differentiate patterns of brain activity in the response to wooden interior categories.

**4. Discussion**

The findings show that natural wood is superior in supporting cognitive performance and emotional well-being, with treated wood exhibiting a profile close to these effects, while concrete and metal increase cognitive load and emotional restlessness.

**4.1. Effects on Cognitive Performance**

The findings of the Stroop test revealed that natural wood supported cognitive performance with the highest percentage of correct answers and the shortest response time. This result is consistent with Kaplan and Kaplan's theory of attention restoration; It supports the idea that natural elements reduce cognitive fatigue and refresh attention. Berman et al. showed that exposure to nature improved Stroop performance; In this study, it was observed that natural wood had a similar restorative effect. Treated wood performed close to natural wood, suggesting that even processed forms of materials of organic origin may provide cognitive benefits. (R. Kaplan & Kaplan, 1989b) ( Berman et al., 2008) (Nyrud & Bringslimark, 2010)
Concrete and metal, on the other hand, negatively affected cognitive performance. This finding is consistent with the literature that synthetic and cold surfaces can increase cognitive load. In particular, the fact that metal underperforms indicates that the perception of industrial and distant can lead to a distracting effect. The observation of the lowest cognitive load in natural wood in the Stroop effect analysis highlights the potential of biophilic design to optimize cognitive processes. (Heschong , 1979) (Zumthor , 2006) (Kellert et al., 2011)

**4.2. Effects on Emotional Responses**

POMS results showed that natural wood was the material that most supported emotional well-being, with the lowest score and the highest energy score. This is in line with Ulrich's findings on the stress-reducing and emotional healing-promoting effects of natural elements. Tsunetsugu et al. reported that visual perception of wooden surfaces reduces physiological stress; In this study, this effect was confirmed as an increase in emotional peace and energy. Treated wood exhibited a positive effect close to natural wood, suggesting that treated wood retains its aesthetic and emotional value. ( Ulrich , 1984b) (Tsunetsugu et al., 2007) (Burnard & Kutnar , 2015)
Concrete and metal increased emotional restlessness with high negative emotion scores (e.g., anger, tension). The harsh and cold perception of concrete supports the feeling of emotional distance noted by Arıman and Hescong, while the industrial character of metal lends itself to Pallasmaa's work. The strong difference between metal and natural wood reveals the significant influence of material textures on emotional responses. These results highlight the importance of biophilic design in promoting emotional well-being in indoor spaces (Jasmine Ariman , n.d .) ( Heschong , 1979) ( Pallasmaa , 2024) (Wilson, 1986) . (Nanda et al., 2011)

**4.3. Effects on Neural Activities**

EEG analyses have shown that natural wood promotes relaxation and reduced cognitive load, while concrete and metal increase stress and distraction. The relationship of alpha waves with relaxation and mental serenity was confirmed by Bashar and Klimesch; In this study, it was observed that natural wood triggered this effect. (Basar, 1999) ( Klimesch , 2012)
The fact that machine learning classification distinguishes material types with 93% accuracy confirms that EEG is a powerful tool in analyzing material perception in the context of neuroarchitecture. (Djebbara et al., 2022) Higuera-Trujillo et al., 2021)
From a practical point of view, these results can guide architects and designers to opt for materials of natural or organic origin in their learning and working environments. Although the widespread use of synthetic materials such as concrete and metal provides aesthetics and durability in modern architecture, their negative impact on the mental and emotional health of individuals should not be overlooked. The high accuracy of machine learning analysis offers an innovative method by which material perception can be evaluated automatically and objectively in the future.

**5. Conclusions**

This study examined the effects of indoor materials (wood, concrete, metal) on brain activity and emotional responses with EEG-based classification analysis and offered new insights. The goal is to understand how material use affects individuals' psychological well-being and emotional experiences. The findings revealed that the choice of materials in interior design is a factor that directly affects the mental and emotional states of individuals, beyond an aesthetic and functional preference. In particular, wood-clad spaces evoked positive emotional responses (relaxation, peace, well-being), which were distinguished by high accuracy in EEG analysis; Hard surfaces, such as concrete and metal, on the other hand, have been associated with less positive or neutral responses. This suggests that the natural texture and warmth of wood trigger positive effects on the neural level, while synthetic materials create emotional distance.
The study assessed the emotional effects of material types by systematically analyzing patterns of brain activity

derived from EEG data. Wood has exhibited a stress-reducing and well-being enhancing effect in line with biophilic design principles. Although concrete and metal are favored for functionality and durability in traditional design, they should be re-evaluated due to their negative impact on emotional well-being. The EEG classification has concretely demonstrated the neural effects of the material by distinguishing material-induced emotional responses with high accuracy.

In the literature, the psychological effects of interiors are generally examined with elements such as color and light, while the choice of materials has received less attention. This study supports the work of Kaplan and Kaplan, showing that wood reduces mental fatigue and promotes positive emotions. The findings of Nanda et al., reporting that natural materials reduce anxiety in healthcare settings, reinforce this thesis' claim that the use of wood can also improve well-being in general indoor spaces. EEG results confirm that the sensory properties of wood (texture, temperature) trigger positive responses in the brain. (R. Kaplan & Kaplan, 1989b) ( Nanda meat al., 2011) The findings emphasize the contribution of material selection in interior design to the quality of life of individuals, drawing attention to the emotional effects that are often neglected in urban planning and design. The use of wood has the potential to offer new strategies in creating environments that promote positive emotional experiences and overall well-being. Future research may examine material effects in different spaces (e.g., patient rooms, playgrounds) and demographic groups. This work lays a foundation that encourages designers and planners to consciously address the choice of materials and integrate natural elements such as wood into interiors. Furthermore, this research was conducted in the laboratory in a controlled environment that may not fully reflect the diverse and dynamic nature of spatial environments. In future studies, all room surfaces can be covered with these materials and trials can be made.

### 5.1. Recommendations

Based on the findings of this study, it reveals some recommendations for designers, policymakers, and future research: Designing spaces based on materials and that this approach can significantly improve spatial livability and psychological well-being. The use of smart technologies allows for the collection of large-scale data on how people interact with the spaces in question. This data can inform evidence-based design improvements that directly address public health concerns, such as improving features that promote physical activity or relaxation. In addition, it can be optimized based on the data collected and the spaces can be adapted to public health needs and environmental benefits. Developing virtual reality (vr) prototypes for community engagement can be used to incorporate VR technology into the design process by allowing them to experience and interact with virtual prototypes of proposed spaces. This can help gather feedback and preferences before physical development, ensuring that the final designs resonate deeply with user needs and wants.

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