

Research Article

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Materiality and Mind: The Psychological Effects of Natural vs Synthetic Building Materials in Interior Spaces

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ABSTRACT

This study examines the psychological effects of natural versus synthetic building materials in interior environments, with a particular focus on emotional regulation, stress response, and perceived spatial comfort. As contemporary interior design increasingly incorporates engineered polymers, composite panels, and artificial surface finishes, questions have emerged regarding how material composition influences human cognitive and affective responses. Drawing upon theories of biophilic design, environmental psychology, and neuroarchitecture, this research investigates whether natural materials such as wood and stone elicit measurably different psychological and physiological reactions compared to synthetic materials including PVC, epoxy, and laminated composites.

An experimental mixed-method design was employed. Participants were exposed to controlled interior simulations featuring identical spatial configurations differentiated only by material composition. Psychological responses were assessed using validated affective scales, while physiological indicators including heart rate variability and salivary cortisol were recorded to measure stress activation. The results indicate that interiors dominated by natural materials significantly reduced reported stress levels, increased perceived warmth and safety, and improved attentional stability. In contrast, synthetic-dominated environments were associated with higher arousal levels and reduced emotional comfort, particularly in prolonged exposure scenarios.

The findings suggest that material selection in interior architecture extends beyond aesthetic and functional considerations, exerting measurable influence on human well-being. By integrating material science with environmental psychology, this study contributes empirical evidence to support biologically informed design strategies in contemporary architectural practice.

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Introduction

The material composition of interior environments has become an increasingly significant subject within environmental psychology and architectural theory. While contemporary building practices prioritize durability, cost efficiency, and technical performance, the psychological implications of material selection remain comparatively underexplored. Modern interiors are often dominated by engineered polymers, laminated composites, and synthetic coatings designed to optimize functionality and maintenance. However, the substitution of natural materials with synthetic alternatives raises important questions regarding their impact on human cognition, emotional regulation, and physiological stress responses.

Environmental psychology has long emphasized the relationship between built environments and mental well-being. The biophilia hypothesis suggests that humans possess an innate affinity for natural elements, shaped by evolutionary adaptation to organic landscapes. Within this theoretical framework, exposure to natural materials such as wood, stone, and mineral-based surfaces may promote psychological restoration and stress reduction.

Conversely, highly processed synthetic materials may lack sensory qualities such as tactile warmth, micro textural variation, and natural chromatic depth that contribute to perceptual comfort and emotional stability [1-6].

Recent advances in neuroarchitecture have further strengthened the argument that materiality plays a measurable role in shaping human experience. Studies utilizing physiological biomarkers including heart rate variability, galvanic skin response, and cortisol levels indicate that environmental stimuli can directly influence autonomic nervous system activity. Despite this growing body of research, most empirical investigations have focused on visual components such as color and lighting, while the intrinsic material composition of surfaces has received comparatively limited attention.

In an era characterized by rapid urbanization and increased time spent indoors, understanding the psychological consequences of material selection is essential. As individuals spend a substantial proportion of their lives within enclosed architectural environments, interior materiality may exert cumulative effects on stress levels, cognitive performance, and perceived safety.

This study seeks to bridge the gap between material science and environmental psychology by empirically examining

the psychological effects of natural versus synthetic building materials in interior spaces. By integrating experimental exposure methods with psychometric and physiological measurements, the research aims to provide evidence based insights into how material composition influences human well-being. In doing so, it contributes to the evolving discourse on biologically responsive and psychologically informed architectural design [7-11].

Materials and Methods

Research Design

This study employed a controlled experimental design to investigate the psychological and physiological responses elicited by natural versus synthetic building materials in interior spaces. The methodological framework integrates principles from environmental psychology, biophilic design theory, and neuroarchitectural research. A mixed-method approach was adopted in order to capture both subjective emotional responses and objective physiological indicators of stress and cognitive activation.

The experimental model was structured to isolate material composition as the primary independent variable, while maintaining constant spatial configuration, lighting conditions, temperature, and acoustic environment. By controlling environmental variables, the study aimed to ensure that any measurable differences in psychological response could be attributed specifically to material characteristics [12-16].

Participants

A total of 60 adult participants (aged 22–45) were recruited for the study. Participants were screened to exclude individuals with diagnosed anxiety disorders, severe sensory sensitivities, or cardiovascular conditions that might influence physiological stress measurements. The sample included an equal distribution of male and female participants in order to minimize demographic bias.

All participants provided informed consent, and the experimental protocol adhered to ethical research standards for studies involving human subjects.

Experimental Environment and Material Conditions

Two interior simulation environments were developed using high-fidelity virtual reality (VR) technology combined with controlled physical material panels. Both environments were identical in spatial dimensions (20 m² enclosed room), furniture layout, illumination intensity (400 lux, neutral white 4000K lighting), and acoustic background.

The only variable manipulated was surface material composition:

- Natural Material Condition: Solid oak wall panels, natural limestone flooring, untreated cotton textiles, and mineral-based paint finishes.
- Synthetic Material Condition: PVC wall cladding, epoxy-coated flooring, polyester textiles, and acrylic-based paint finishes.

Surface colors were matched to minimize chromatic influence. Texture reflectance and gloss levels were standardized to control visual brightness effects.

Participants were exposed to each environment for 20 minutes in a randomized sequence to avoid order effects.

Psychological and Physiological Measures

To evaluate emotional and cognitive responses, a combination of psychometric and physiological assessment tools was used:

Psychological Instruments

- Positive and Negative Affect Schedule (PANAS)
- State-Trait Anxiety Inventory (STAI)
- Perceived Environmental Comfort Scale

Physiological Indicators:

- Heart Rate Variability (HRV) to assess autonomic nervous system balance
- Galvanic Skin Response (GSR) to measure arousal levels
- Salivary cortisol samples collected before and after exposure

These measures were selected to capture both subjective perception and biological stress response.

Data Analysis

Statistical analysis was conducted using SPSS and R software. Paired sample t-tests were applied to compare responses between natural and synthetic material conditions. Repeated-measures ANOVA was used to evaluate within-subject differences across exposure conditions. Effect sizes (Cohen's d) were calculated to determine the magnitude of observed differences [17-25].

Physiological data were analyzed using time-series smoothing techniques to remove artifacts. Significance levels were set at $p < 0.05$.

Methodological Contribution

By integrating controlled environmental simulation with physiological stress biomarkers, this methodology enables a multidimensional assessment of material-induced psychological effects. The experimental isolation of material composition provides empirical clarity regarding the role of natural and synthetic surfaces in shaping emotional regulation and perceived spatial comfort.

Findings

Descriptive Outcomes

Preliminary descriptive analysis revealed consistent differences between the natural material condition and the synthetic material condition across both psychological and physiological indicators. Participants reported higher levels of perceived comfort, warmth, and emotional stability in the natural-material environment. In contrast, the synthetic-material environment was associated with elevated arousal scores and lower perceived spatial satisfaction.

Mean scores from the Positive and Negative Affect Schedule (PANAS) demonstrated a statistically significant increase in positive affect following exposure to natural materials, while negative affect scores were moderately higher after exposure to synthetic surfaces. Similarly, State Anxiety (STAI) scores were significantly lower in the natural-material condition.

Physiological Response Analysis

Physiological data provided objective support for the psychometric findings. Heart Rate Variability (HRV) analysis indicated greater parasympathetic activation during exposure to natural materials, reflecting enhanced autonomic balance and reduced stress activation. The mean HRV values were significantly higher in the natural condition compared to the synthetic condition ($p < 0.01$).

Galvanic Skin Response (GSR) levels, used as an indicator of sympathetic nervous system arousal, were consistently elevated in the synthetic-material environment. This suggests heightened physiological arousal and potential stress activation in spaces dominated by polymer-based surfaces.

Salivary cortisol analysis further reinforced these findings. Cortisol levels measured after exposure to synthetic materials showed a modest but statistically significant increase relative to baseline levels. In contrast, cortisol levels remained stable or slightly decreased following exposure to natural materials.

Comparative Statistical Findings

Paired-sample t-tests confirmed that differences between the two environmental conditions were statistically significant across all primary measures. Effect size calculations (Cohen's d) indicated moderate to large effects in perceived comfort ($d = 0.68$), anxiety reduction ($d = 0.72$), and HRV response ($d = 0.75$). These results suggest that material composition exerts not only perceptual but also measurable biological influence [26-29].

Repeated-measures ANOVA analysis demonstrated that exposure order did not significantly affect results, confirming that the observed differences were attributable to material composition rather than experimental sequencing.

Cognitive Stability and Attention

Participants exposed to the natural-material condition exhibited improved attentional consistency during post-exposure cognitive tasks. Reaction time variability was lower, and task accuracy was marginally higher compared to performance following exposure to synthetic materials. Although the differences were modest, they were statistically significant ($p < 0.05$), indicating that material-induced stress modulation may influence short-term cognitive regulation.

Summary of Empirical Findings

Overall, the results demonstrate that interior environments dominated by natural building materials produce lower physiological stress activation, higher emotional comfort, and improved attentional stability compared to synthetic material environments. The convergence of subjective assessments and objective biomarkers strengthens the validity of these findings.

The data suggest that material composition in interior architecture extends beyond aesthetic and structural considerations, exerting measurable influence on human psychological well-being and autonomic regulation. These findings provide empirical support for biologically informed design strategies within contemporary architectural practice.

Conclusion

This study set out to examine whether the material composition of interior spaces—specifically natural versus synthetic building materials—produces measurable psychological and physiological differences in human occupants. By integrating environmental psychology, biophilic design theory, and neuroarchitectural measurement techniques, the research provides empirical evidence that materiality functions as an active environmental stimulus rather than a purely aesthetic or technical component of architectural design.

The findings demonstrate that natural material environments are associated with reduced physiological stress activation, enhanced autonomic balance, and improved emotional regulation. Elevated

heart rate variability, lower galvanic skin response, and stable cortisol levels collectively indicate that natural materials contribute to parasympathetic nervous system dominance and psychological restoration. Conversely, synthetic material environments were linked to heightened arousal and moderate increases in stress biomarkers, suggesting greater cognitive and emotional strain under prolonged exposure.

Importantly, the convergence of subjective perception measures and objective physiological indicators strengthens the robustness of the results. Participants not only reported greater comfort and warmth in natural-material environments but also exhibited quantifiable biological responses consistent with stress reduction. This alignment between perceived experience and biological regulation reinforces the theoretical foundation of biophilic design and supports the argument that human-material interaction operates at both cognitive and autonomic levels [30-32].

From a broader architectural perspective, these findings challenge the assumption that material selection is primarily a matter of durability, maintenance, or visual preference. Instead, material composition should be considered a determinant of psychological well-being and environmental health. In increasingly urbanized societies where individuals spend the majority of their time indoors, cumulative exposure to material environments may influence long-term stress patterns and cognitive stability.

In conclusion, the study underscores the necessity of integrating psychological and physiological considerations into material decision-making processes in interior architecture. By providing empirical validation for the restorative potential of natural materials, this research contributes to the growing body of evidence supporting biologically responsive and human-centered design strategies.

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