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Effect of Indoor Wall Wood Coverage on the Elderly Group—A Case Study of Activity Rooms in Old-Age Buildings

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Abstract: Wood finds extensive utilization in the design of indoor environments due to its natural and visual weighty characteristics. However, the visual perception of the elderly group towards their surroundings differs from that of other age groups, resulting in distinct requirements for the visual environment. Taking the activity room of an old-age building as a case study, this research employs a focus group to identify the factors and levels that influence the acceptance of wood among older individuals, subsequently designing various simulation scenarios. The semantic differential method and physiological monitoring enable the collection of psychological and physiological evaluations. The findings reveal that the increases in wood coverage significantly impact the psychological and physiological perceptions of older individuals, with acceptance of the environment increasing initially and then decreasing. In terms of physiology, the incorporation of wooden wall designs in indoor spaces assists in regulating essential physiological indicators such as heart rate and blood pressure. In conclusion, the implementation of indoor wood design positively influences the psychological and physiological perceptions of older individuals, thereby providing valuable guidance for the design of healthy indoor environments.

Keywords: wood coverage; elderly population; psychological evaluation; physiological evaluations

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1. Introduction

1.1. The Difference in Visual Environment Acceptance in the Elderly Population

Vision plays a crucial role in more than 80% of human perception of spatial surroundings [1,2]. Advancing age often leads to issues such as diminished vision and reduced visual processing speed, which consequently results in older individuals exhibiting distinctive acceptance patterns of visual environments compared to the general population [3]. Notably, investigations focusing on the evaluation of indoor light environments have revealed that older individuals typically express a greater need for enhanced indoor lighting and light backgrounds compared to their younger counterparts [4–7]. Lu et al. examined four kinds of indoor living behaviors among older individuals and assessed variations in these behaviors in response to differing light environment qualities. The study demonstrated that high-quality lighting significantly improves the environmental observation ability of older individuals and effectively reduces the risk of falls [8]. Exploring the impact of visual environments on cognitive performance and emotional regulation among older individuals in activity spaces, Heerwagen et al. compared indoor and natural lighting conditions [9]. St-Jean et al. found that the utilization of blue-rich light enables older individuals to engage in more activities, despite the common perception that blue light diminishes work efficiency [10]. Furthermore, research has expanded to encompass more specific indicators of indoor lighting, such as illumination [11–14], color temperature [15–17], and light source location [18]. Research studies have shown that while illumination has minimal impact on

the physiological rhythms of the elderly, it significantly influences their psychological state. Higher color temperatures can stimulate the physiological functions of older individuals, leading to a positive psychological response. Elderly individuals tend to prefer versatile indoor lighting positions that can be adjusted based on their current activities. Furthermore, the relationship between improvements in illuminance and color temperature and enhancements in lighting evaluations within elderly care facilities is not linear.

Color visual elements have been observed to impact cognitive differences among the elderly [19–21]. Torres et al. conducted a study examining the psychological perception of older individuals in old-age care facilities with regard to different indoor color choices. Their findings indicated that color preferences for interior spaces have a significant influence on the arousal level associated with expected activity [22]. Moreover, Schlangen's investigation revealed that warm-toned decoration enhances the cognitive ability of older enhance in memory tasks [23], which contrasts with outcomes observed in the general population [24,25]. In addition, the elderly have higher requirements for indoor color saturation and brightness, such as lower saturation and brightness selection, which will provide a natural and comfortable feeling.

The elderly population also exhibits distinctive visual tendencies compared to other age groups when exposed to diverse indoor and outdoor landscape environments. Dong's research proves that older individuals possess a more pronounced affinity for the space created by natural outdoor landscapes in comparison to other age groups [26]. Chung et al. also corroborated that a positive landscape visual environment has the potential to decrease interference and obstacles among older adults [27,28]. Furthermore, relevant studies have confirmed the positive impact of well-designed landscape space on the well-being and quality of life of older individuals from a visual environment standpoint [29–33].

1.2. The Influence of Wooden Visual Environment on Psychological Perception

Wood is a widely utilized material in architectural design due to its lightweight nature, high strength, carbon storage, and various other commendable qualities. Moreover, it significantly influences individuals' subjective assessment of their surroundings as it is associated with visual attributes such as naturalness, greenery, and warmth [34–37]. Masuda conducted an evaluative experiment involving diverse indoor wood coverage images and discovered that as the extent of wood coverage increased, people's positive descriptions of the indoor environment followed an inverted U-shaped pattern, initially escalating and subsequently declining [38]. Furthermore, a closer examination of positive descriptors such as 'natural' and 'novel' revealed a substantial correlation with the quantity of wood coverage. Notably, spaces with nearly zero or 100% wood coverage were perceived as novel [39]. Subsequent investigations have focused on various indoor settings, such as bedrooms [7], wards [40,41], offices [42], etc., to further refine the relationship between changes in wood coverage and human perception evaluations.

The arrangement of wood elements also constitutes a crucial visual aspect that influences people's psychological perception. Sakuragawa et al. explored the psychological perceptions generated by different application positions of indoor wood and determined that the positioning of wood on walls and floors instilled a sense of tranquility in individuals [43]. Nyrud maintains that wood elicits the most favorable subjective perception when applied to vertical walls, prompting further investigations into detailed placement areas such as indoor skylights, fences, and furniture [44]. In addition to the aforementioned factors, elements such as wood color [45,46], surface texture [47,48], and the choice of wood product type [49] are recognized as contributors to the psychological perception of individuals from a visual environmental perspective.

1.3. The Influence of Wooden Visual Environment on Physiological Perception

Tsunetsugu and colleagues conducted a study to investigate the impact of a wooden visual environment on physiological indicators. They found that the presence of wooden beams and column decoration in a room led to an increase in the subjects' heart rate, with a

statistically significant difference observed when compared to the subjective evaluation results [50]. Moreover, as the wood coverage varied, the heart rate exhibited an initial increase followed by a subsequent decrease. This pattern corresponded to the outcomes obtained from psychological evaluation [51]. In addition, other relevant studies have compared the effects of a wooden visual environment with decorative settings involving materials such as steel and green plants, revealing that wood elements exert a positive influence on heart rate regulation [41,52]. Harumi Ikei's comprehensive review of the physiological effects of wood further demonstrates that related research has expanded to encompass additional areas, such as the electrical skin index, blood pressure, and alterations in autonomic nervous activity [53].

1.4. Existing Research Limitations and Contributions of This Study

Research has demonstrated variations in the perception and assessment of the visual surroundings among elderly individuals compared to other age cohorts. Additionally, the wooden visual environment exerts a certain influence on the psychology and physiology of the human body.

Although previous studies have confirmed that the elderly experience distinct perceptions and responses when exposed to different light, color, and landscape settings, there are certain shortcomings in the research conducted on the elderly population. Specifically, the chosen survey methods lack specificity, as the questionnaire design poses reading comprehension challenges for older individuals and improperly employs evaluation weights from other age groups. Furthermore, the research methods employed are relatively simplistic, necessitating further investigation combining principles from psychology and physiology. It should also be noted that the indoor environment, when manipulated with color and light, is artificial, and it remains unclear whether there are disparities in understanding and evaluating the environment in a more natural indoor setting. Regarding the evaluation of the wooden visual environment, minimal investigation and research have focused on the elderly population, rendering the findings from other age groups inapplicable to the elderly, who possess weakened visual judgment ability. Moreover, the experimental design generally lacks control over other interference factors. Additionally, due to the challenges associated with constructing physical wooden spaces influenced by multiple factors and horizontal changes, a stronger emphasis on multi-space comparative analysis is warranted.

Therefore, the objective of this study is to employ a virtual environment and adopt the psychological evaluation survey and physiological index monitoring, which are more suitable for the elderly population. By doing so, we aim to establish a cognitive relationship between the elderly population and the wooden visual environment, providing guidance for the optimal design of indoor wooden environments catering to older individuals. The main contributions of this paper can be summarized as follows:

- To elucidate a comprehensive set of psychological and physiological survey methods that are well-suited for evaluating the visual environment within the elderly population.
- To ascertain the quantitative perspective on the relationship between changes in indoor wall wood coverage and the psychological and physiological perception of the elderly population.
- To clarify any disparities in the acceptance of indoor wooden visual environments between older individuals and other age groups.

2. Materials and Methods

This paper takes scenes of wooden indoor spaces as the object of research, and the research details are shown in Figure 1.

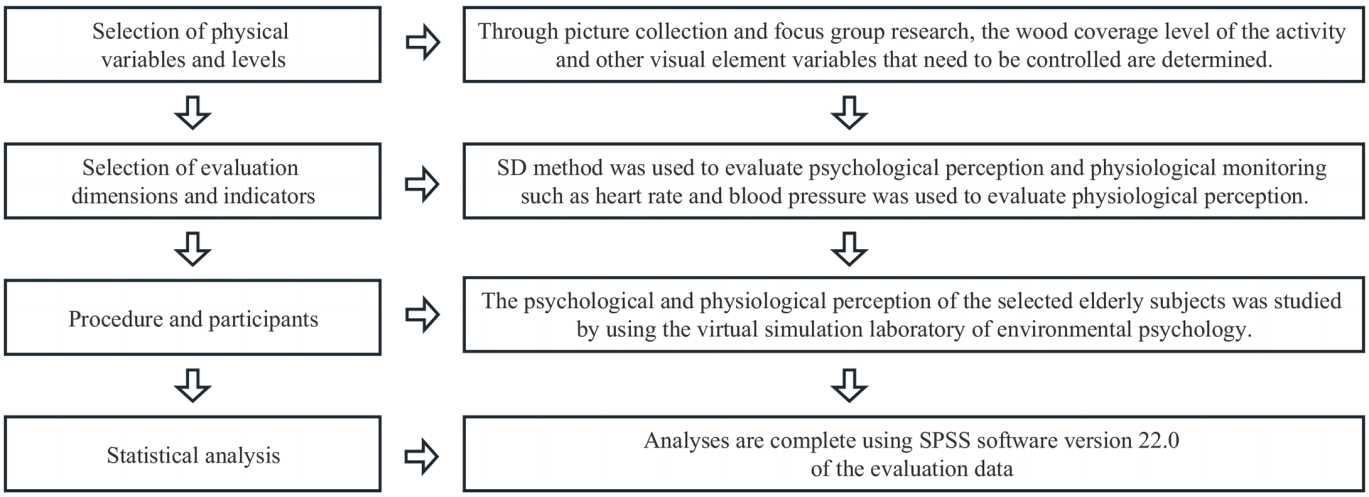


Figure 1. Research Framework.

2.1. Variable Control

Studying the visual environment of wood coverage necessitates the controlled manipulation of various visual elements. The methodology employed in this research involves focus group discussions. Prior literature shows that an effective focus group discussion should comprise a participant range of 6–12 individuals [54]. In order to conduct the experiments, ten graduate students possessing significant expertise in wood design and a research background in environmental psychology among the elderly population were selected (including one conference moderator, one recorder, five males, and five females), with ages ranging from 18 to 28 years. The host guides the participants in engaging in discussions on predetermined topics. For this study, the focus group selected the physical variables as the foundation. Drawing upon existing literature, the primary factors affecting the acceptance of wood in the activity room of the senior building were identified: wood texture, color, and layout. Due to the declining visual acuity of older individuals and its impact on texture recognition, wood texture was not included as a controlled variable. In terms of wood color, a low-brightness wood shade, which is favored by older people, was utilized. Regarding the layout, Xu's research shows that the difference in the wood layout does not significantly affect human perception [55]. However, considering the subjects' empirical judgments of wood layouts in indoor environments, the use of randomly arranged wood layouts would raise concerns about the authenticity of the setting, consequently influencing the experimental outcomes. The pre-experiment phase involves comparing different layout samples derived from the three most common wall wood application forms, namely 'wall skirt type', 'grid distributed type', and 'surface centralized type', to determine the layout selection that best aligns with the audience's acceptance of a single coverage rate.

2.2. Experimental Model Design

The research uses SketchUp 2019 as the modeling software to depict the scene. The scene represents a cuboid measuring 10.8 m × 7.2 m × 3.9 m, which corresponds to one of the standard dimensions of the typical activity room found in old-age buildings in China. This dimension is also a multiple of the designated modular unit of 300 mm [36]. In order to ensure consistent evaluation results and minimize the potential impact of material and decoration variations, the floor was uniformly covered with warm gray tiles, while the ceiling was painted white. Regarding indoor lighting, the simulated space adhered to the area ratio of window to floor specified in the 'Standard for the Design of Care Facilities for the Aged' for public activity rooms in elderly care facilities, which is 1:4. The indoor illumination level was set at 500 lx. Additionally, a cohesive depiction of the actual indoor environment of an elderly building's activity room was achieved by incorporating a unified natural landscape picture outdoors [56].

In order to achieve a viewpoint that aligns with the seated viewer's eye level (according to ergonomic data, sitting eye height = height × 0.703), the virtual camera was positioned at the midpoint of the wall opposite the window sill. The viewing angle was established at a height of 1.20 m to match the seated human body's eye height. The scene was rendered using Enscape 2.0. Table 1 provides a comprehensive overview of the positive viewing angles observed in all scenes.

All 17 visual images were compared and selected through an investigation into the authenticity evaluation of three layout methods with the same coverage rate among elderly individuals in Harbin. In light of the challenges associated with recruiting older participants and the need to collect more than 30 random questionnaires [57], 40 questionnaires were distributed and subsequently retrieved, resulting in 40 valid responses. In order to establish formal experimental scenarios featuring different coverage ratios, a reference is made to Table 2.

2.3. Perception Survey Method

The psychological perception of the audience is examined using the semantic differential method, which entails two crucial aspects: determining the adjective pairs and the evaluation scale [58]. Osgood developed the semantic differential to gauge connotative meaning [59]. To select evaluative adjective pairs, Osgood established the selection library [60], which was subsequently expanded to encompass different age groups [61]. In response to the requirements for 'sensory', 'emotional', and 'trait' items in the indoor environment questionnaire, we initially selected 15 pairs of opposite meanings. Through the expert questionnaire, experienced psychologists working with the elderly were consulted to identify and replace inappropriate word pairs that could lead to adverse effects such as cognitive ambiguity and irritability. Finally, nine pairs of opposing meanings were chosen to describe the elderly's evaluation of the indoor space of the activity room under varying levels of wood coverage. These pairs include 'Succinct-Sophisticated', 'Quiet-Impetuous', 'Natural-Artificial', 'Familiar-Offish', 'Warm-Cool', 'Bright-Dim', 'Secure-Insecure', 'Discernible-Indiscernible', and 'Aesthetic-Drab'. The evaluation scale of the SD questionnaire selects seven levels represented by degree adverbs: 'very, quite, general, fair, general, quite, very'. These levels are assigned values ranging from −3 to +3, where positive values indicate positive evaluations and negative values represent the opposite. Subsequently, the questionnaire was determined.

Given the varying influence weights of different semantics on spatial psychological evaluation, it becomes necessary to calculate the weight of each semantics. This study calculated semantic weights based on Yaahp software and expert questionnaires [62]. The weight calculation results of each evaluation semantics are shown in Table 3.

2.4. Test Room Setup and Equipment

Comparative analysis of subjects' evaluation between real and virtual environments has been conducted using virtual reality [63–65] and a hemispherical screen [66,67]. The results show minimal disparities in evaluation, with consistent trends observed in the assessment of changing environments. Consequently, virtual equipment demonstrates the potential to substitute real environments in comparative studies pertaining to environmental analysis.

The experiment took place at the environmental psychology virtual simulation laboratory, situated within the Harbin Institute of Technology. The hemispherical screen with a resolution of 1920 × 1200, a height of 4.7 m, and a maximum radius of 4.5 m. This device offered a horizontal angle exceeding 170° and a vertical angle surpassing 160°, ensuring comprehensive visual coverage and effectively replicating the visual stimulation experienced within physical scenes. The laboratory maintained a controlled temperature of 22 °C, considered comfortable for elderly individuals residing in cold regions. Moreover, the permissible range for temperature and humidity fluctuations was ±5%. Figure 2 presents an overview of the laboratory layout and scene.

Table 1. Test Scenes.

Test No.	Wood Coverage	Scenes	Test No.	Wood Coverage	Scenes
1	15%		10	60%	
2	15%		11	60%	
3	15%		12	60%	
4	30%		13	75%	
5	30%		14	75%	
6	30%		15	75%	
7	45%		16	90%	
8	45%		17	90%	
9	45%		18	Control group--0%	

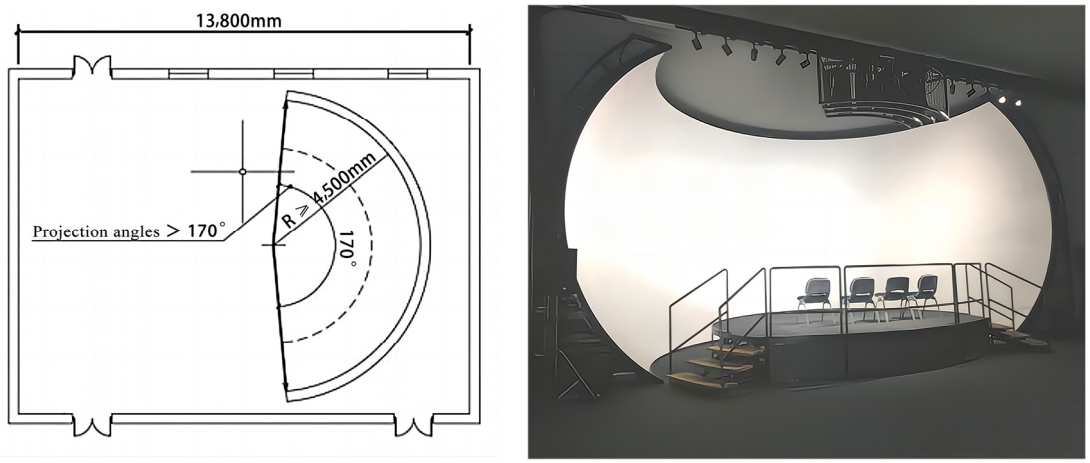
The control group was the picture observed before the visual stimulation of the wood.

Table 2. Formal Test Scenes.

Test No.	Wood Coverage	Scenes
1	15%	
2	30%	
3	45%	
4	60%	
5	75%	
6	90%	

Table 3. Semantic differential weight calculation results.

SD	Succinct	Quiet	Natural	Familiar	Warm	Bright	Secure	Discernible	Aesthetic
Weight	0.1425	0.1172	0.1110	0.0933	0.079	0.2142	0.1468	0.0588	0.0372



(**a**) (**b**)

Figure 2. Environmental psychology virtual simulation laboratory: (**a**) Plan graph of the laboratory; (**b**) Laboratory scene picture.

2.5. Participants

The study recruited a total of 30 elderly volunteers, comprising 16 males and 14 females, with an age range of 65–75 years (M = 69.64, SD = 1.26). Previous research has demonstrated that a sample size of 30 individuals is sufficient to yield statistically significant results in experimental investigations involving psychological and physiological monitoring of the population [68–70]. This sample size has also been found suitable for psychological assessments pertaining to wood evaluation [49,55], physiological monitoring experiments [71], and experimental studies for the elderly population [72,73]. The participants possessed satisfactory visual acuity and cognitive abilities, exhibited a willingness to cooperate with laboratory protocols, and reported no physical discomfort on the day of testing. Prior to the experiment, informed consent was obtained from all participants, who willingly agreed to partake and were briefed on the experimental procedures. It is important to note that the findings of this study were exclusively intended for scientific purposes, and participants retained the right to terminate their involvement at any given point.

2.6. Procedure

Considering the potential impact of completing the psychological questionnaire on monitoring physiological indexes, it is recommended to conduct the two experiments separately. In the psychological evaluation experiment, participants were instructed to rest for 15 min upon reaching the designated area in the laboratory in order to stabilize their emotions. The experimenter provided a detailed explanation of the experimental process and the method of filling out the Semantic differential questionnaire while also collecting primary personal data from the participants for their involvement in the study. Once inside the experimental room, the subjects were initially instructed to listen to a 15 min recording of the real activities and observe the control group's images to create an authentic environment.

Due to the limited endurance of older individuals for prolonged testing, the six sets of scenes were randomly divided into three experimental groups. Each experimental group comprised four segments. Following a preparatory period, participants were tasked with observing the first set of scenes for 5 min. Upon completing the observation, they were provided with 2.5 min for semantic investigation, followed by a 5 min period of rest and

adaptation. The process for the second set of scene experiments mirrored that of the first set. Participating in subsequent group tests required a rest period of at least 24 h. In order to prevent any undesirable effects resulting from the experience order, the order of scenes during the test was randomized [36]. After participants had completed all six scene experiments, the experimenter archived the experimental data. The research flow chart for the psychological evaluation experiment is depicted in Figure 3.

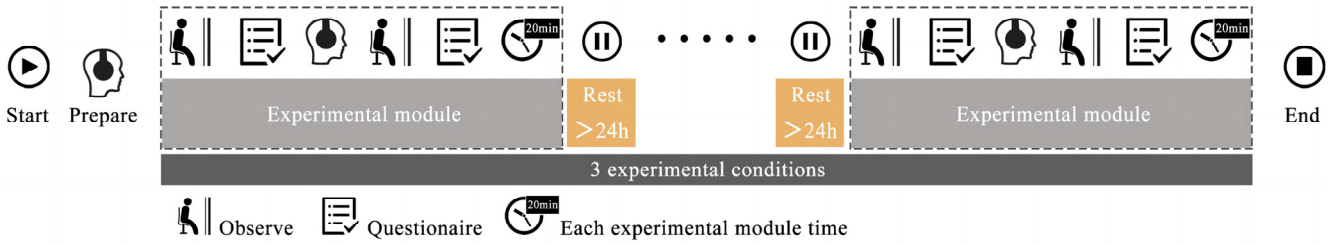


Figure 3. Research flow chart of the psychological experiment.

The physiological and psychological experiments exhibit similarities. However, during the preparatory phase, elderly individuals in the resting area are required to utilize physiological monitoring equipment. The equipment facilitates the monitoring of heart rate and blood pressure index, with specific emphasis on systolic and diastolic blood pressure. Given that systolic blood pressure offers a more comprehensive representation of blood pressure fluctuations, subsequent analysis will primarily focus on systolic blood pressure and heart rate physiological values [74]. Physiological indicators were monitored from the preparation stage when observing the control group, enabling a comparison of the effects of wood stimulation on these indicators. Additionally, completion of the questionnaire was not mandatory, thus ensuring that each experimental group only consumed 15 min. Figure 4 illustrates the research process of physiological testing.

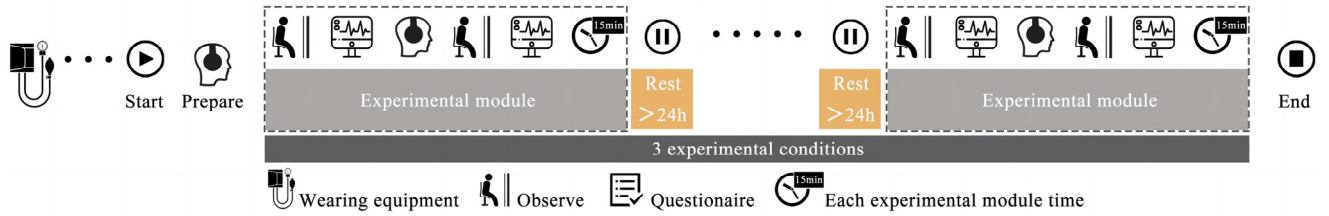


Figure 4. Research flow chart of the physiological experiment.

2.7. Statistical Analysis

The experimental statistical results were analyzed using SPSS 22.0. In order to examine the relationship between changes in wood coverage and individuals' perception, the Pearson correlation was employed to assess the psychological evaluation outcomes. The Pearson correlation determines the linear association between two variables (x and y) by treating the wood coverage degree as the x variable and the psychological evaluation result as the y variable, forming two linear vectors. In order to compute the Pearson correlation, the following formula is employed:

$$r = \frac{\sum(x - m_x)(y - m_y)}{\sqrt{\sum(x - m_x)^2 \sum(y - m_y)^2}}$$

m_x—The mean value of coverage vector x

m_y—The mean value of the evaluation result vector y.

When determining the correlation coefficient, the degree of freedom is df = n − 2. The variable lengths, denoted as 'n', represent the x and y variables. Additionally, the significance p-value is calculated to assess the level of significance.

In order to test the correlation between coverage and changes in physiological indicators, the paired sample *t*-test is employed. It is important to establish the correlation between paired samples as a prerequisite for the *t*-test. A significance probability (*p*-value) of less than 0.001 is required to determine the correlation between the paired samples, indicating a significant correlation between the two variables. This fulfills the requirement for conducting a paired sample *t*-test. In order to evaluate whether there is a correlation between the measurement values of physiological indices in each pair of groups, a comparison is made between the differences in the measurement values under the influence of a 0% wall wood coverage rate and other groups with varying wall wood coverage rates. The formula for the paired sample *t*-test is as follows:

$$t = \frac{m}{s/\sqrt{n}}$$

m—The mean value of the difference in physiological index changes
n—Number of samples selected
s—The standard deviation of physiological index change difference

The determination of significance is achieved by conducting a comparison between the *p*-value at a given degree of freedom (df = n − 1) and the t-distribution table.

Drawing from the statistical findings within the realms of psychology and physiology, variables can be considered significantly correlated at a level of 0.01 if the significance coefficient $p < 0.01$. If the significance coefficient falls between 0.01 and 0.05, variables can be considered significantly correlated at 0.05. Conversely, if the significance coefficient $p > 0.05$, the correlation between the variables is considered to be insignificant.

3. Results

3.1. The Effect of Wood Coverage on the Psychological Perception of the Elderly

3.1.1. Semantic Evaluation Analysis

The semantic differential evaluation results were utilized to determine the highest and lowest scores for each semantic differential questionnaire. Average scores of each semantic category were then comprehensively calculated across different levels of wall wood coverage. The semantic category 'succinct' exhibited the highest and lowest values at 30% and 60% wood coverage, respectively. Within the coverage range of 15–60%, the 'succinct' semantics showed a slight increase followed by a decrease with the rise in wood proportion and continued to exhibit a slight increase and subsequent decline beyond 60% coverage. The semantic score for 'quiet' reached its highest and lowest values at 15% and 60% wall wood coverage, respectively. It decreased as the wood coverage increased within the range of 15–60% and then experienced a slight increase upon reaching 75% coverage, followed by a subsequent decline. The 'nature' semantics reached achieved its highest value at 30% wall wood coverage, declined to a negative value at 75% coverage, and reached its lowest value at 90%. An increase in wood coverage showed a fluctuation law of rising, falling, rising, and then falling. The 'familiar' semantics attained its highest value at a coverage ratio was 15% and its lowest value at 90%. Although there was a slight increase from 60% to 75% coverage, the overall trend in semantic evaluation exhibited a decline. The lowest value for the semantic score of 'warm' was observed at 15% coverage, while the highest value was recorded at 90%. It exhibited a slight decline within the range of 45% to 75% coverage, but the overall trend in semantic evaluation increased. The 'bright' semantics gradually increased from 15% to 30% coverage, reaching its peak at 30%, and then gradually decreased. The 'security' semantics peaked at a coverage rate of 45%, indicating a positive overall evaluation. The 'discernible' semantics attained its highest value at a coverage rate of 45%, became negative within the range of 75% to 90% coverage, and reached its lowest value at 90%. The overall trend initially increased and then decreased. The semantic score for 'aesthetic' was highest at 60% coverage and lowest at 15%, with a general pattern of rise and fall.

Considering the weight assigned to each semantics category determined by the expert score, the weighted evaluation scores are calculated using the nine semantic weights, as presented in Table 4. This analysis allows us to observe the overall trend in the psychological perception evaluation of wood coverage rate. Notably, the highest weighted score was obtained at a wall wood coverage of 30%, whereas the lowest score was recorded at 90%. The difference between the weighted evaluation scores for 15% and 45% wood coverage on the wall was a mere 0.06 points. Gradual score decreases were observed as the coverage ranged from 60% to 90%, with all scores turning negative. These findings demonstrate that the psychological evaluation value of the elderly in the activity space is highest at 30% wall wood coverage, while it is lowest at 90% coverage. The overall trend initially exhibits an increase followed by a decrease.

Table 4. Semantic evaluation weighted score.

Coverage	15%	30%	45%	60%	75%	90%
Weighted score	0.84	1.49↑	0.78	−0.26	−0.48	−0.71↓

'↑' represents the highest value; '↓' means the lowest value.

3.1.2. Correlation Analysis

The scatter plot depicting the relationship between 'wall wood coverage' and 'evaluation semantic weighted score' is illustrated in Figure 5. Upon examining the association between these two variable groups, it is evident that a certain level of correlation exists; however, this correlation is only partially linear in nature.

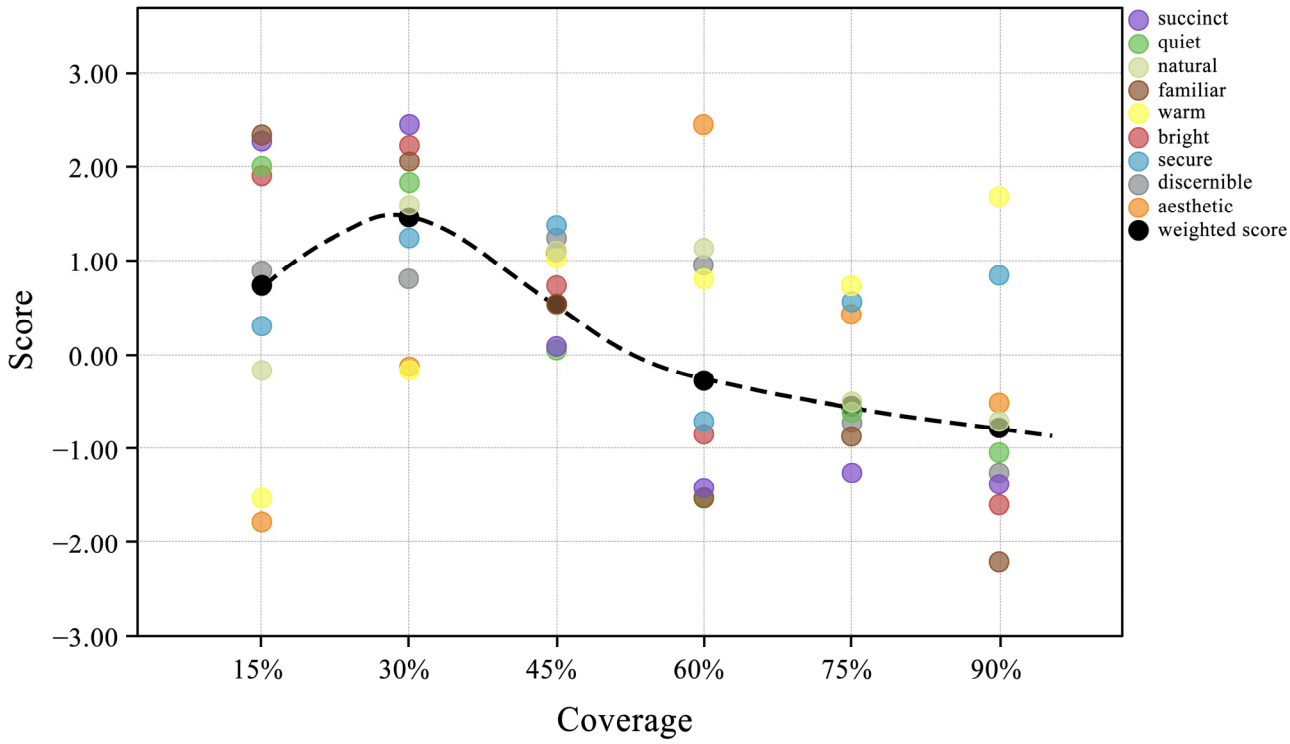


Figure 5. Scatter plot of 'wall wood coverage'—'evaluation semantic weighted score'.

The Pearson correlation coefficient and its corresponding test results revealed a significant correlation between the wall wood coverage rate and the evaluation semantic weighted score at a 0.05 significance level (sig. coefficient = 0.017, $p < 0.05$). However, it is important to note that the relationship between these two variables is not strictly linear. In order to account for this nonlinearity, additional correlation analyses were conducted using the Kendall and Spearman correlation coefficients. The sig. (two-tailed) values were

0.015 ($p < 0.05$) and 0.005 ($p < 0.01$), respectively, indicating significant correlations between the wall wood coverage rate and the evaluation semantic weighting score at the 0.05 and 0.01 levels, as presented in Table 5. The three correlation coefficients collectively demonstrated a significant correlation between the wall wood coverage rate and the evaluation semantic weighted score. Specifically, a positive correlation was observed between 15% and 30%, while a negative correlation was found between 30% and 90%. These findings suggest that the evaluation semantic weighted score reaches its highest value when the wall wood coverage rate is approximately 30%, and it decreases as the wood coverage exceeds 30%.

Table 5. The correlation coefficient of 'wall wood coverage'—'evaluation semantic weighted score'.

			Wood Coverage	Weighted Score
Pearson	Wood Coverage	correlation coefficient	1.000	−0.892 *
		Sig. (2-tailed)	-	0.017
		N	6	6
	Weighted score	correlation coefficient	−0.892 *	1.000
		Sig. (2-tailed)	0.017	-
		N	6	6
Kendall	Wood Coverage	correlation coefficient	1.000	−0.867 *
		Sig. (2-tailed)	-	0.015
		N	6	6
	Weighted score	correlation coefficient	−0.867 *	1.000
		Sig. (2-tailed)	0.015	-
		N	6	6
Spearman	Wood Coverage	correlation coefficient	1.000	−0.943 **
		Sig. (2-tailed)	-	0.005
		N	6	6
	Weighted score	correlation coefficient	−0.943 **	1.000
		Sig. (2-tailed)	0.005	-
		N	6	6

*. The correlation was significant at 0.05 level (two-tailed); **. The correlation was significant at 0.01 level (two-tailed).

3.2. The Effect of Wood Coverage on the Physiological Perception of the Elderly

3.2.1. Physiological Monitoring Statistics

Table 6 presents the variations in the impact of wall wood coverage on the heart rate of elderly individuals. It is noteworthy that the average heart rate of the elderly subjects was consistently lower following visual stimulation with wood, irrespective of the extent of wall wood coverage. Notably, the heart rate of older individuals experienced the greatest reduction when the wall wood coverage reached 90%. The overall pattern reveals that as the wall wood coverage increased, the heart rate exhibited an ascending pattern, peaking at 30% before subsequently declining. Although a slight upward trend was observed at 75%, it did not substantially impact the overall downward trend.

Table 6. Statistics on the influence of wood coverage on the heart rate of older people.

Coverage	15%	30%	45%	60%	75%	90%
Heart Rate (Pre)	75.50	75.50	75.50	75.50	75.50	75.50
Heart Rate (Post)	75.06	77.60↑	74.81	74.13	74.25	72.94↓

Table 7 presents the effects of wall wood coverage on systolic blood pressure in older individuals. The presence of wood visual stimulation resulted in lower systolic blood pressure compared to the absence of stimulation. Notably, the smallest decrease in systolic blood pressure was observed when the wall wood coverage was 30%, while the largest decrease occurred with a coverage of 60%. The overall pattern exhibited a gradual increase in systolic blood pressure as the wall wood coverage ranged from 15% to 90%. At a coverage

of 30%, the systolic blood pressure reached its peak value of 126.20 mm Hg. Subsequently, a downward trend was observed from 30% to 60%, reaching its lowest point at 120.94 mm Hg. Beyond 60%, the blood pressure value displayed a significant upward trend once again.

Table 7. Statistics on the influence of wood coverage on systolic pressure of the elderly.

Coverage	15%	30%	45%	60%	75%	90%
Systolic pressure (pre)	128.86	128.86	128.86	128.86	128.86	128.86
Systolic pressure (post)	124.75	126.20↑	123.50	120.94↓	123.25	124.31

3.2.2. Correlation Analysis

Table 8 presents the results of the paired sample correlation test between heart rate and systolic blood pressure. The correlation test for heart rate demonstrated a significance value of 0.009 ($p > 0.001$) for the 0–30% group, while the remaining groups exhibited a significance probability P of 0.000 ($p < 0.001$). These findings align with the prerequisite for the paired sample *t*-test. Analyzing the paired sample correlation test for systolic blood pressure revealed a significant probability P of 0.000 ($p < 0.001$) for groups 1–6, indicating a substantial correlation between the two variables within each group pair. Consequently, this outcome satisfies the prerequisite for the paired sample *t*-test.

Table 8. Paired sample correlation test results.

Comparative Group	N	Heart Rate		Systolic Pressure	
		Correlation Coefficient	Sig.	Correlation Coefficient	Sig.
0–15%	30	0.969	0.000	0.947	0.000
0–30%	30	0.566	0.009	0.928	0.000
0–45%	30	0.813	0.000	0.866	0.000
0–60%	30	0.860	0.000	0.815	0.000
0–75%	30	0.863	0.000	0.849	0.000
0–90%	30	0.907	0.000	0.848	0.000

After excluding samples that do not meet the prerequisites of the paired sample *t*-test, Table 9 presents the outcomes of the paired sample *t*-test conducted on the variable "heart rate". Only when the wall wood coverage is 90% is there a significant change in heart rate, as indicated by a two-tailed significance value below 0.01 when compared to the non-wood configuration. Consequently, a notable difference in heart rate is observed. The two-tailed significance values for the remaining group pairings exceeded 0.05. This observation is further supported by the statistical analysis of effect sizes, where group six exhibits a larger effect size compared to the other groups, except for group one and group five, which have effect sizes below 0.2. These findings provide empirical confirmation of the experiment's reliability. It is evident that older individuals experience a significant reduction in heart rate when the wall wood coverage rate reaches 90%. Heart rate measurements for wall wood coverage rates of 15%, 60%, and 75% were lower than those for a 0% coverage rate, although the reductions were not statistically significant. Moreover, the heart rate measurement for a 45% wall wood coverage rate was higher than that for the non-wood configuration, yet the increase is insignificant.

Table 9. Paired sample *t*-test results of 'heart rate'.

	Avg	Standard Deviation	95% Confidence Interval of Difference		T	Sig.	Cohen's d
			Lower Limit	Upper Limit			
0–15%	0.40	1.95744	−0.51611	1.31611	0.914	0.372	0.204
0–30%	−1.40	7.69415	−5.00097	2.20097	−0.814	0.426	0.182
0–45%	−0.20	4.75284	−2.42440	2.02440	−0.188	0.853	0.042
0–60%	0.40	3.95235	−1.44976	2.24976	0.453	0.656	0.101
0–75%	1.00	3.89331	−0.82213	2.82213	1.149	0.265	0.257
0–90%	2.10	3.22653	0.58994	3.61006	2.911	0.009	0.651

The findings from the paired sample *t*-test on 'systolic blood pressure' are presented in Table 10. The statistical analysis reveals that only when the wall wood coverage reaches 30%, there is a significant change in systolic blood pressure compared to the non-wood layout is 0.011 ($0.01 < p < 0.05$). In other words, the degree of shrinkage under the two coverage environments exhibits a noteworthy difference at a significance level of 0.05. Similarly, the sig. (two-tailed) values for the remaining group pairs are below 0.01. Hence, it can be inferred that there is a significant distinction between the variables in groups one, three, four, five, and six, with a significance level of 0.01. Specifically, when the wood coverage rate is set at 15%, 45%, 60%, 75%, and 90%, the systolic blood pressure significantly deviates from that observed in non-wood settings, with a significance level of 0.01. These conclusions are further supported by the analysis, which consistently falls within the reliable effect size range. Consequently, it can be concluded that wood coverage exhibits a significant correlation with blood pressure, and varying wood coverage rates can effectively reduce systolic blood pressure among older individuals.

Table 10. Paired sample *t*-test results of 'systolic blood pressure'.

	Avg	Standard Deviation	95% Confidence Interval of Difference		T	Sig.	Cohen's d
			Lower Limit	Upper Limit			
0–15%	3.85	4.92336	1.54580	6.15420	3.497	0.002	0.782
0–30%	3.65	5.82440	0.92409	6.37591	2.803	0.011	0.627
0–45%	6.50	8.59314	2.47829	10.52171	3.383	0.003	0.756
0–60%	7.30	9.83602	2.69660	11.90340	3.319	0.004	0.742
0–75%	6.50	8.41990	2.55936	10.44064	3.452	0.003	0.772
0–90%	5.65	8.89870	1.48528	9.81472	2.839	0.010	0.635

4. Discussion

4.1. The Effect Mechanism of Wood Coverage on the Psychological Perception of Older People

The analysis presents the influence mechanism of coverage change on the psychological perception of the elderly population, as depicted in Figure 6. The figure illustrates various curves representing the semantic evaluation results of each simulated space, while the thick red line represents the average psychological evaluation value of all subjects. The figure effectively portrays the alterations in psychological evaluation among different simulated spaces, considering variations in wall wood coverage.

The psychological evaluation of wall wood coverage varies across different semantic dimensions. In the "succinct" and "quiet" semantics, a positive evaluation is observed when the wood coverage ranges from 15% to 30%. At a coverage rate of 45%, the evaluation aligns with the average value. However, when the coverage exceeds 45%, the score decreases below the average value, indicating a negative psychological evaluation. This suggests that a lower wood coverage rate, in conjunction with physical walls, non-wooden elements, and pristine white wall surfaces, is utilized to cultivate an atmosphere characterized by

minimalism and tranquility. In the 'natural' semantics, the wall wood coverage rate higher than the average evaluation of 30–60% is preferred. Conversely, scores below the average value and even below zero are recorded at coverage rates of 15%, 75%, and 90%. This negative psychological evaluation indicates that excessive or insufficient use of wood on the walls diminishes the natural ambiance experienced by users in the space. Regarding the 'familiar' semantics, higher scores are observed when the wood coverage is 15%, 30%, and 45%, suggesting a greater sense of intimacy when the amount of wood is below 45%. In the 'warm' semantics, lower scores are recorded only at wood coverage rates of 15% and 30%, while the highest score is obtained at a coverage rate of 90%. This indicates that a higher wood coverage enhances the perception of warmth in the space. In the 'bright' semantics, the scores show a clear polarization. The highest score is obtained at a wood coverage rate of 30%, followed by 15% and 45%, all scoring above zero. However, scores turn negative when the wood coverage reaches 60% to 90%. It shows that a moderate wood coverage range provides a brighter ambiance for elderly users. However, excessive wood consumption gradually diminishes indoor brightness, resulting in a visually dim psychological experience for older individuals. The 'secure' semantics only show a lower evaluation score at a wood coverage rate of 60%. In contrast, the 'aesthetic' semantics record the highest score at a coverage rate of 60%. Thus, the same coverage rate exhibits significant differences in evaluation across different semantics dimensions. This disparity arises due to the decentralized wood application method used at a coverage rate of 60%, which offers greater flexibility and a wider range of application types. The decentralized wood application creates a visually dispersed experience for older individuals, enhancing the sense of spatial design while also generating a slightly insecure atmosphere. In the 'discernible' semantics, a wall wood coverage of 90% is almost equivalent to full wall coverage with wood. However, the wood application characteristics are less distinct compared to the medium proportion of 45% in the space.

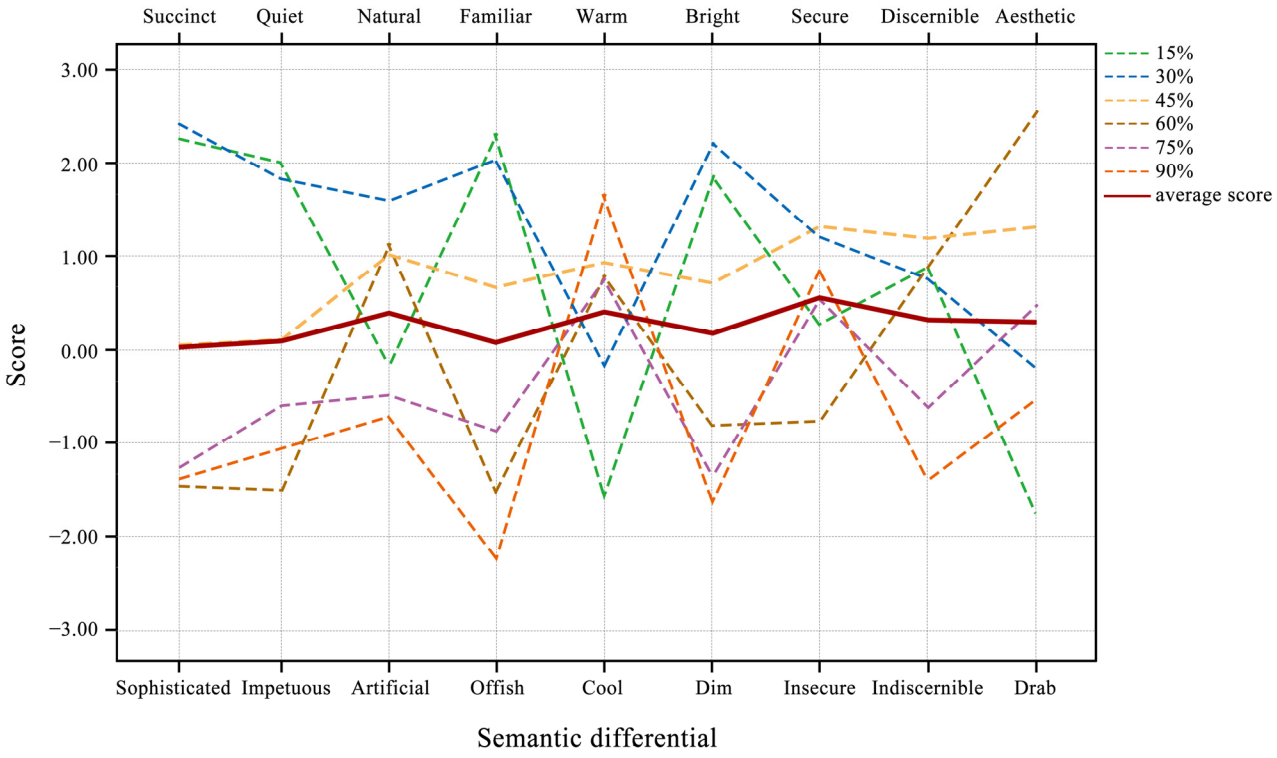


Figure 6. SD evaluation line chart of different coverage.

The study reveals that the 30% wood coverage wall exhibits the highest level of acceptance among the elderly population, whereas the wall with 90% wood coverage shows the lowest acceptance. These findings deviate from Tsunetsugu's study, which identifies

45% wood coverage as the most preferable outcome. The variance can be attributed to dissimilarities in the age composition of the participants, resulting in distinct spatial requirements. Specifically, elderly individuals prioritize luminous and uncluttered indoor environments due to visual impairments and concerns for safety. Consequently, their inclination for wood is slightly lower compared to the general population. However, excessively minimal use of wood can evoke sensations of coldness and insecurity, thereby rendering 30% wood coverage as the optimal choice for the elderly demographic.

4.2. The Effect Mechanism of Wood Coverage on the Physiological Perception of Older People

The alteration in the physiological perception of wood is related to the influence of psychological mechanisms [75]. For the elderly population, positive emotions and well-being are paramount. Emotional states such as tension and excitement serve as stimuli for human physiology. These stimuli gradually propagate to the cerebral cortex, leading to an elevation in heart rate and blood pressure. Consequently, we amalgamate the results of psychological evaluations to examine the mechanism through which wood coverage influences physiological perception.

Figure 7 illustrates the comparison between the trend of the weighted score obtained from psychological evaluation and the variation in heart rate. The abscissa represents the percentage of walls covered with wood, while the ordinates represent the average heart rate and the value of psychologically weighted evaluations, respectively. The observed trend is as follows: within the 15–30% range of wood coverage, the psychologically weighted evaluations value and heart rate exhibit a gradual increase; however, within the 30–90% range, they decreased gradually. Notably, when the wood coverage ratio reaches 30%, older individuals express the highest subjective evaluation. This is also accompanied by the highest heart rate, as the presence of wood in the activity space of the wall induces a positive psychological change, leading to a natural increase in heart rate among the elderly. Nevertheless, this increase remains within the range of heart rate control for maintaining good health, thanks to the positive regulatory effect of wood. The alteration in heart rate further corroborates that the psychological evaluation value is highest among older individuals when the wood coverage rate of the wall reaches 30%.

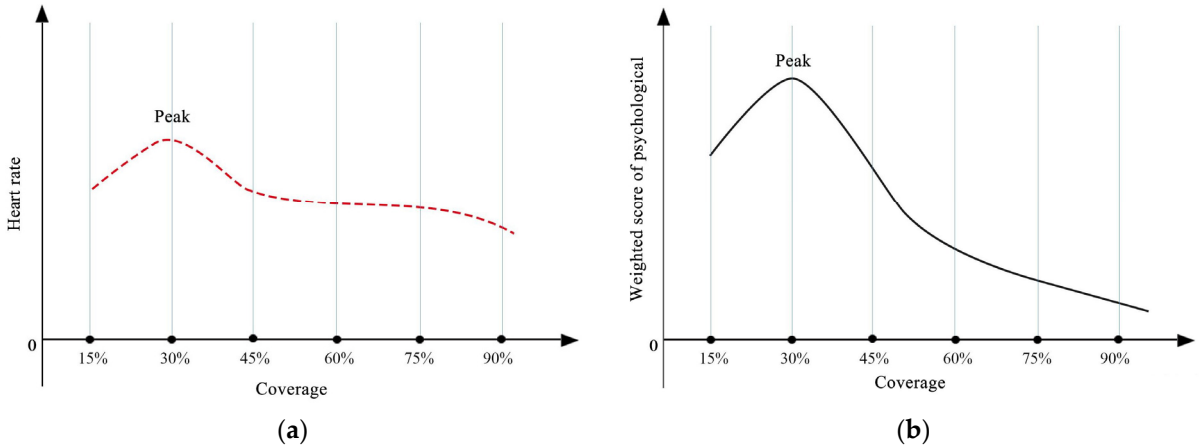


Figure 7. Comparison of the changing trend of heart rate and the weighted score of psychological: (**a**) Heart rate affected by wood coverage; (**b**) Weighted score affected by wood coverage.

The effect on blood pressure changes is shown in Figure 8, where the abscissa represents the wood coverage rate of the wall, while the ordinate represents the average systolic blood pressure value and the psychologically weighted evaluation value, respectively. The observed trend is as follows: within the 15–30% range, there is a gradual increase in the psychologically weighted evaluation value, accompanied by an increase in systolic blood pressure. In the 30–60% range, both the psychologically weighted evaluation value and systolic blood pressure experience a decrease. Moving further into the 60–90% range, the

psychologically weighted evaluation value decreases while the systolic blood pressure gradually increases. Notably, the highest psychological evaluation among older individuals is observed when the wall wood coverage rate reaches 30%, coinciding with a positive impact on blood pressure. However, despite its higher systolic blood pressure compared to other wall wood coverage rates, it remains lower than the blood pressure value recorded when the wall coverage rate is zero. Conversely, the lowest psychological evaluation among the elderly occurs when the wall wood coverage reaches 90%, with systolic blood pressure still being high. This outcome indicates that both positive and negative psychological emotions contribute to a certain extent to the increase in systolic blood pressure, while positive emotions can also alleviate high systolic blood pressure. Consequently, the visual environment featuring wood coverage results in lower blood pressure for older individuals compared to an indoor environment without wood coverage.

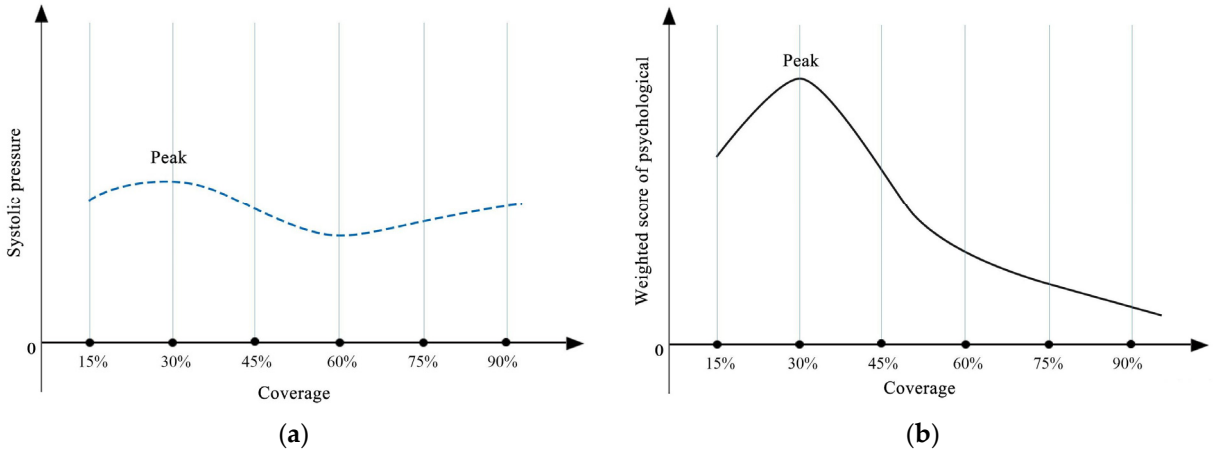


Figure 8. Comparison of the changing trend of systolic pressure and the weighted score of psychological: (**a**) systolic pressure affected by wood coverage; (**b**) weighted score affected by wood coverage.

4.3. Design Suggestions for Old-Age Buildings

In the context of old-age buildings, an appropriate wood coverage of 30% is recommended for spaces where the creation of a distinctive atmosphere is not necessary. Moreover, considering the diminished adaptability to light among older individuals, bright colors may appear gray to them. Statistical findings indicate that a wall wood coverage of approximately 30% provides the highest level of brightness. Therefore, it is advisable to select a wall wood coverage of close to 30% for activity rooms that have higher requirements for space illumination.

For other types of spaces, a wood coverage ranging from 15% to 30% is recommended to create a concise and visually vibrant environment suitable for senior care rooms. On the other hand, a wood coverage of 30–45% is ideal for spaces such as elderly libraries and calligraphy rooms, where a tranquil, warm, and bright spatial visual experience is desired. A wood coverage of 45% can also be employed in room designs that aim to enhance spatial discernibility. In order to achieve a rhythmic aesthetic atmosphere, an elderly gym can consider utilizing approximately 60% wood coverage.

It is important to note that when the wall wood coverage approaches 60%, elderly individuals may experience psychological sensations of restlessness and insecurity. This may be attributed to the grid distribution pattern of the wood application form. Therefore, employing low-tech design methods to create a simple and natural indoor space environment is recommended.

5. Conclusions

This study examines the psychological and physiological changes experienced by elderly individuals in an activity room of an old-age building in response to variations in wood coverage on the walls. The specific conclusions can be summarized as follows:

In old-age buildings, specifically the activity room, alterations in wood coverage on the walls influence the psychological perception of the elderly towards their environment. Initially, an increase in wood coverage leads to an elevation in psychological acceptance among the elderly, followed by a subsequent decline. The highest psychological perception evaluation by the elderly is achieved when the wood coverage reaches 30%.

Furthermore, the rate of wood coverage on the wall of activity rooms in old-age buildings impacts the physiological indexes such as heart rate and blood pressure among the elderly population. The heart rate index initially increases and then decreases with the increment in wood coverage rate, with the maximum value significantly lower than that of non-wood spaces. The systolic blood pressure index shows an upward trend, followed by a downward trend, and then another upward trend with an increasing wood coverage rate. Overall, the systolic blood pressure remains lower compared to non-wood spaces.

The changes in acceptance of the elderly individuals towards indoor space, as influenced by variations in wood coverage on the walls, follow a similar overall trend observed in other age groups, characterized by an initial rise followed by a decline. However, there are some differences specific to the elderly population. Notably, older individuals tend to favor a lower proportion of indoor wood coverage.

Although this paper presents significant findings, there are areas for improvement. Firstly, the pre-experiment issuance may have had a limited sample size, affecting the selection of the formal experiment's setting. The subsequent study will involve a larger sample size. Additionally, the experimental design stage only considers the influence of a single factor, namely wall wood coverage, while overlooking other factors such as color, texture direction, and materials that may influence the perception of the elderly population. For instance, consider common natural wood colors such as light yellow and red. Their warm hues might either augment the positive associations evoked by wood or potentially heighten aversion towards it. Furthermore, investigating whether different texture directions can alter research outcomes based on the elderly population's preferences requires further verification. Finally, the geographical location of the elderly subjects and its potential influence on the study results remain unclear since the study was conducted in cold areas where wood is appreciated for its warmth and brightness. However, if conducted in other climatic regions, the study results may vary, necessitating revisions to address the relevant limitations in subsequent studies.

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