

# Study on the Visual Cognition of Laminated Bamboo Furniture

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## Abstract

Laminated bamboo furniture is high in ecological value and low in overall cost, exhibiting broad prospects for industrial development. Studies have been conducted on human visual cognition of wood and textiles but not of glue-laminated bamboo materials. This study employed a subjective questionnaire and eye-tracking technology to explore the effect of the laminated bamboo furniture surface characteristics on human visual cognition. The results indicate that the fixation count and total fixation duration of caramelized glue-laminated bamboo materials were higher than those of natural colors; participants tend to pay more attention to the colors of glue-laminated bamboo surfaces than to their textures. Although no significant differences have been identified between the overall evaluations attributed to various types of glue-laminated bamboo, within specific cognitive dimensions, participants evaluate natural and caramelized colors differently. Natural glue-laminated bamboo furniture is associated with a greater sense of usability and cultural design in participants' visual cognition, whereas caramelized glue-laminated bamboo furniture is associated with a greater sense of beauty. Total fixation duration and fixation count for the surface characteristics of laminated bamboo furniture are positively correlated with participants' subjective visual appraisals. The longer it takes for participants to notice a laminated bamboo furniture product and the more frequently they fix their gaze on it, the more favorable their evaluation of the product is. These research findings provide a reference to designers for the design of laminated bamboo furniture.

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As a kind of natural biomass material, bamboo has excellent material mechanical properties, is economically friendly, and has environmental protection value. People have used bamboo timber to make furniture since ancient times. With the development of modern bamboo processing technology, furniture made from glue-laminated bamboo has gradually come into the view of consumers today. Laminated bamboo furniture is a kind of furniture made from glue-laminated bamboo, which has many types, such as frame-type furniture, panel-type furniture, and bend furniture. With its excellent performance in structure and design, laminated bamboo furniture has a broad development space and huge market potential and is favored by consumers all over the world (Xing and Wenjin 2012, Lei et al. 2014).

Studies have indicated that cognition plays a major role in aesthetic experience (Hekkert 2006). The material characteristics viewed from this perspective are described as intangible characteristics (Karana et al. 2009). Visual cognition facilitated through the surface colors and textures of materials has been examined to clarify consumers' cognitive impressions of products; however, previous studies have rarely focused on such visual cognition (Zuo et al. 2016). Studies on the material characteristics of glue-laminated bamboo have focused on its physical properties, such as gluing performance (Mahdavi et al. 2012), thermal

treating (Rosa et al. 2014), basic mechanical properties (Veermaa et al. 2014), and preservative treatment (Li et al. 2015), but have ignored perceptions of its surface characteristics. Application studies have addressed the use of glue-laminated bamboo in building structures (Sharma et al. 2015, Li et al. 2016), but few have examined its use in furniture making. The homogenization of modern furniture modeling has revealed the importance of material applications. Huffman and Kahn (1998) stated that consumers' visual perceptions of the surface characteristics of furniture

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materials significantly influence their overall evaluation of furniture. Consumers' preferences for specific products depend on combinations of materials and shapes and their intent to purchase specific furniture on the basis of its surface materials. Therefore, research should be conducted on visual cognition in relation to laminated bamboo furniture to achieve improved cognitive product evaluation and laminated bamboo furniture design quality.

Currently, visual cognition studies have been conducted primarily through subjective evaluation and physiological measurement, both of which exhibit their respective advantages. Subjective evaluation involves in-depth interviews, questionnaire surveys, user observations, and focus groups (Kuze and Ukai 2008, Upenik et al. 2016, Alahmadi and Drew 2017), enabling researchers to discover problems, clarify various phenomena, and generalize research participants' subjective cognitive information to acquire considerable research data and abundant scope for interpretation. However, subjective evaluation relies on researchers' research capacities and their familiarity with a specific field; the process is labor intensive and can be affected by researchers' own subjective emotions (Kim et al. 2013, Bergstrom and Schall 2014). Following the evolution of research theories and technology, methods for physiological measurement have become increasingly diverse. Physiological measurement involves instruments that incorporate infrared imaging, virtual reality, electroencephalograms, and eye-tracking technology to detect the changes in participants' physiological indicators, such as heart rate, neural excitation, breath, and expression, thereby identifying their potential intuitive physiological feedback information. This research approach enables objective observation of participants' immediate emotions and intuition, but it requires complicated operational procedures and elimination of irrelevant factors in the measurement of indices. In this study, both subjective evaluation and physiological measurement were conducted to provide a rich scientific reference for cognitive appraisals of laminated bamboo furniture. For physiological measurement methods, eye-tracking technology was employed to record participants' eye movements to objectively observe the physiological aspects of their visual cognition, thereby enabling easy and intuitive analysis of psychological changes. In previous studies, eye-tracking technology has been employed in web page design appraisals (Luan et al. 2016), in the visual aesthetic evaluation of artwork (Wallraven et al. 2009), and in appraisals of indoor decoration and furniture designs with satisfactory results (Song et al. 2016, Wan et al. 2018). This study incorporated eye-tracking technology to expand on other studies examining the visual cognitive effects of the surface characteristics of glue-laminated bamboo materials.

The characteristics of consumers' visual cognition were investigated through both physiological measurement and subjective evaluation. An eye tracker was applied to track participants' eye movements, and semantic differences were examined to identify participants' subjective cognitive evaluation. The surface characteristics of laminated bamboo furniture were processed in this study in order to facilitate the examination of the effects of its colors and textures on participants' visual cognition and preferences. In addition, the correlation between eye movements (physiological data) and subjective visual cognitive evaluation (psychological data) was investigated to further clarify consumers'

preferences for the surface characteristics of laminated bamboo furniture, thereby providing a reference for laminated bamboo furniture designs. This study focused mainly on the effect of changes in the surface textures and colors of laminated bamboo furniture on eye movements and subjective visual cognitive evaluation as well as the correlation between eye movement (physiological data) and overall subjective visual cognitive evaluation (psychological data).

## Materials and Methods

### Participants

Forty-two healthy students (14 males and 28 females with a mean age of 22.5 yr,  $SD = 2.118$ , range 19 to 27 yr) were recruited as participants. No color blindness (including local and full color blindness), anomalous trichromatism, or night blindness was found in all participants. All participants signed written consent forms to participate before the experiment and received a gift worth about \$4 as compensation.

### Apparatus

The eye tracker was an Ergo-LAB man-machine environment synchronization platform of eye movement module Tobii PRO×2 (<http://www.tobiiipro.com>). This instrument supports the computer composition optical recording pupil and corneal reflection principle; the line of sight of the participant can be accurately collected when the participant's head moves or the ambient light changes. Participants were watching the stimuli on a 15-inch liquid crystal display (resolution 1,920 by 1,080 pixels, 60 Hz) during the test, and the process was controlled by eye-movement software in the computer.

### Stimuli

According to literature reviews and market research, the surface texture of glue-laminated bamboo is divided mainly into plain pressure and side pressure. Plain pressure refers to the combination of gluing on the radial surface of bamboo splits, with the chord surface outward, and the bamboo fibers on the surface of the material are strip-shaped. The side pressure is to glue each tangential surface of the bamboo; the radial surface of each bamboo split forms the surface of glue-laminated bamboo, and the surface of the material is the radial microstructure of bamboo, which is in the form of a multipoint. The color of glue-laminated bamboo can be divided into natural (color refers to the color of bamboo itself) and caramelized. Caramelized refers to the color of bamboo after waterproofing, dust prevention, and anticorrosion; after carbonization treatment, the bamboo chip can show a brown effect (Li et al. 2020). This study selects four kinds of laminated bamboo furniture surface materials that are the most common in factory processing and the furniture market: caramelized plain pressure, caramelized side pressure, natural plain pressure, and natural side pressure. After 3D scanning, they were treated with uniform size (1,200 by 1,600 pixels, 300 dpi) (Fig. 1).

In order to make the participants observe the surface characteristics of glue-laminated bamboo more clearly and reduce the influence of furniture modeling structure, the best-selling glue-laminated bamboo furniture on Taobao ([www.taobao.com](http://www.taobao.com)), according to the collected market survey results, was chosen to be the stimuli in this test.

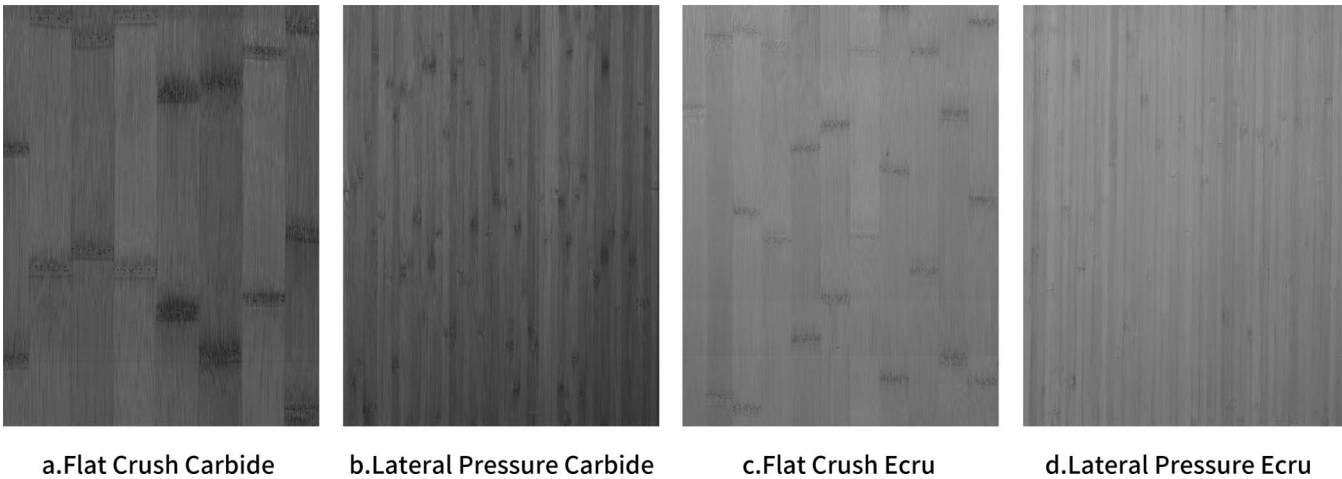


Figure 1.—Four kinds of experimental materials of glue-laminated bamboo.

After being evaluated by experts, a glue-laminated bamboo cabinet with a relatively simple form was used as the eye-movement experimental material in this experiment. 3Dmax software was used to construct the 3D model of the furniture, and V-Ray3.0 software render was used to attach the 3D model with four surface characteristic materials. After rendering, the laminated bamboo furniture model can be restored more realistically in the furniture market (Fig. 2).

Stimulus of different materials were arranged in pairs, and left and right positions were exchanged to form new stimulus pictures to eliminate the influence caused by the change of stimulus position. A total of eight stimulus pictures (1,600 by 900 pixels, 300 dpi) were obtained for the experiment, in which the size of each laminated bamboo cabinet was 400 by 400 pixels (Fig. 3).



Figure 2.—Experimental materials of glue-laminated bamboo furniture.

### Questionnaire design

A number of in-depth studies have examined the relationship between material and human emotions. The use of wood in the design can improve consumers' sense of beauty (Shuli et al. 2013), and the functional properties of materials are of vital importance in consumers' cognitive preferences (Manzini 1989, Manzini and Petrillo 1991), including the material's performance, application range, and environmental friendliness (Karana et al. 2015). Manzini (1986) points out that the application of materials should be adapted to the social environment and cultural background of consumers. Moreover, researches have shown that consumers are greatly affected by economic efficiency when evaluating materials. Therefore, we developed a five-dimensional scale (usability, beauty, environmental friendliness, economic efficiency, cultural) to assess the participants' visual cognitive preference for materials in this study.

Two pairs of Kansei adjective words are chosen to reflect the characteristics of each aspect, and then 10 pairs of Kansei words are selected in the scale (Table 1). A 7-point Likert scale (1, totally agree with the positive description, to 7, totally agree with the negative description) was used. Since each pair of the Kansei adjective words has a strong preference tendency, materials with a higher score mean that participants have a higher visual preference among them. The scores of each dimension of the material's visual cognitive preference can be obtained by adding the scores of two pairs of Kansei adjective words belonging to this dimension. The Kansei adjective word scale used in this study has passed the reliability test with Cronbach's  $\alpha = 0.93$  (Field 2009).

### Procedure

The experiment was conducted in a quiet and uniform light environment. Before the formal experiment, the participants were asked to sit on a seat and adjust to a comfortable sitting posture so that the eye-movement apparatus could capture and calibrate the data of both eyes. After participants fully understood the experimental requirements and procedures, the computer screen started to play the stimuli. The participants watched eight contrast pictures randomly appearing by eye-movement software (Ergo Lab man-machine environment synchronization platform). During the watching process, the participants



Figure 3.—Experimental materials in eye-movement experiment.

made a cognitive response after each picture appeared and then jumped to the page by clicking the mouse. Before each stimulus appeared on the computer screen, there was a blank page shown with a “+” symbol located at its center that lasted for 5,000 ms, and then it entered the next picture automatically. After completing the eye-movement experiment, the participants conducted a subject evaluation questionnaire experiment on four kinds of glue-laminated bamboo surface characteristics of the material (Fig. 4).

### Data analysis

The glue-laminated bamboo cabinets on the left and right sides of a picture were divided into different areas of interest (AOI) for statistical analysis. The main eye-movement indexes were the first fixation duration, time to first fixation, total fixation duration, and fixation count. First fixation duration is the time for participants to stay in a specific AOI for the first time. Time to first fixation is the time from the display of the information interface to the time when the eye stays at the first fixation point. Total fixation duration is the sum of the fixation time of participants staying in a specific AOI. Fixation count is the total number of fixation points left in an AOI for the participant. These are commonly used as the main indicators of eye-movement data in contrastive experiments (Buscher et al. 2009).

This experiment was a 2 by 2 (two variables and two categorical types) within-subjects design. There were two independent variables in this experiment, each with two categorical types. The first variable was “texture,” and the subsets were “plain pressure” and “side pressure.” The second variable was “color,” and the subsets were “natural” and “caramelized.” The dependent variable was the subjective evaluation of visual cognition. Subjective evaluation dimensions of visual cognition include usability, beauty, environmental friendliness, economic efficiency,

and cultural. The primary objective of the analysis was to test the differences of the eye-movement index (first fixation duration, time to first fixation, total fixation duration, and fixation count) within each independent variable of texture and color. In this study, multiway analysis of variance and Pearson correlation analysis was used to calculate the correlation between eye-movement data (physiological data) and subjective evaluation of visual cognition (psychological data). An alpha level of 0.05 was set for statistical tests. All statistical analyses were performed using Microsoft Excel 2019 and SPSS 22.0.

## Results

### Eye-movement data

The eye-movement data of the glue-laminated bamboo cabinet is shown in Table 2. According to the data in Table 2, there was no significant difference in the first fixation duration and the time to first fixation of laminated bamboo furniture with different surface characteristics ( $P > 0.05$ ). However, in the color dimension, the total fixation duration and the fixation count showed significant differences ( $F = 4.164, P < 0.05, R^2 = 0.030$ ), and the mean value of natural color (0.692) was lower than the mean value of caramelized color (0.926). The color dimension showed significant difference in the fixation count ( $F = 5.832, P < 0.05, R^2 = 0.036$ ), and the mean value of natural color (4.489) was lower than the mean value of caramelized color (5.563).

### Behavior data

The texture and color variables were studied in the five dimensions of visual cognitive subjective evaluation indexes and overall evaluation by multiway analysis of variance (Table 3). According to the data in Table 3, the interaction effect of texture variable and color variable was not significant ( $P > 0.05$ ). The main effects of texture variable on usability, beauty, environmental friendliness, economic efficiency, cultural, and overall evaluation were not significant ( $P > 0.05$ ), indicating that the subjective evaluation of visual cognition of the participants on the glue-laminated bamboo was almost not affected by the texture variable. For the color variable, there were main effects for usability ( $F = 6.254, P < 0.05, R^2 = 0.053$ ), beauty ( $F = 28.872, P < 0.01, R^2 = 0.152$ ), and cultural ( $F = 7.580, P < 0.01, R^2 = 0.059$ ). According to the data in Table

Table 1.—10 pairs of Kansei words chosen in the scale.

Aspect	Kansei words	
Usability	Firm-Fragile	Easeful-Afflictive
Beauty	Ugly-Artistic	Elegant-Raffish
Environmental friendliness	Environmental-Infertant	Harmless-Harmful
Economic efficiency	Rare-Cheap	Top grade-Low end
Cultural	Civilized-Insolent	Modern-Uncultured

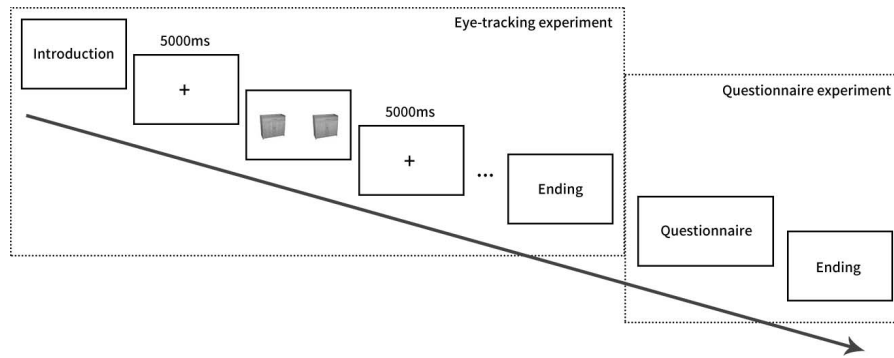


Figure 4.—Process of experiment.

4, the main effect of usability showed that the mean value of natural color (10.548) was higher than the mean value of caramelized color (9.869) in the different color samples. The main effect of cultural showed that the mean value of natural color (10.036) was higher than the mean value of caramelized color (9.369).

### Relationship between eye-movement data and subjective overall evaluation

Pearson correlation analysis was used to analyze the relationship between eye-movement data (physiological data) and subjective overall evaluation (psychological data) of visual cognition (Table 5). According to the data in Table 5, the results showed that the subjective overall evaluation of visual cognition was positively correlated with the total fixation duration and fixation count ( $r = 0.175, P < 0.05; r = 0.184, P < 0.05$ ).

## Discussion

### Eye-movement data analysis

According to the eye-movement data from this study, surface textures caused no significant differences in participants' first fixation duration, time to first fixation,

total fixation duration, and fixation count. Accordingly, the textures exerted no significant effects on participants' cognitive processes. This was because the effect of plain pressure and side pressure on the materials' surface textures was relatively minor. However, color variations significantly affected participants' total fixation duration and fixation count. The participants fixated their gaze on surface characteristics of caramelized glue-laminated bamboo furniture for a longer time and more frequently than they did on its natural counterpart. According to studies, longer fixation duration and more frequent fixation indicate that consumers require a higher level of cognitive ability to process the information conveyed by an object (Just and Carpenter 1978, Senders et al. 1976, Lin and Lin 2014). Because caramelized glue-laminated bamboo materials are rarer than unprocessed natural glue-laminated bamboo materials and consumers respond to unfamiliar objects with caution, longer duration and greater fixation frequencies are required for the observation and recognition of caramelized glue-laminated bamboo materials.

### Behavior subjective data analysis

The surface textures of glue-laminated bamboo materials exerted no significant effects on participants' subjective

Table 2.—Comparison of glue-laminated bamboo Materials in the eye-movement data.

Variable	First fixation duration (s)	Time to first fixation (s)	Total fixation duration (s)	Fixation count
Texture				
Mean (SD)				
Plain pressure	1.071 (1.062)	0.14 (0.054)	0.758 (0.460)	4.991 (2.687)
Side pressure	0.850 (0.381)	0.141 (0.049)	0.860 (0.952)	5.061 (3.132)
<i>F</i>	3.231	0.011	0.794	0.025
<i>P</i>	0.074	0.915	0.374	0.875
Color				
Mean (SD)				
Natural	0.886 (0.469)	0.141 (0.048)	0.692 (0.479)	4.489 (2.649)
Caramelized	1.034 (1.033)	0.141 (0.056)	0.926 (0.930)	5.563 (3.071)
<i>F</i>	1.435	0.001	4.164	5.832
<i>P</i>	0.233	0.991	0.043*	0.017*
Texture × color				
Mean	0.743	0.003	0.016	2.270
<i>F</i>	1.170	0.948	0.029	0.273
<i>P</i>	0.281	0.332	0.866	0.602
<i>R</i> <sup>2</sup>	0.034	0.006	0.030	0.036

<sup>a</sup> \* =  $P < 0.05$ ; \*\* =  $P < 0.01$ .

**Table 3.—Comparison of the five dimensions of subjective evaluation indexes of visual cognition and overall evaluation data.<sup>a</sup>**

Variable	Texture	Color	Texture × color	R <sup>2</sup>
<b>Overall evaluation</b>				
Mean	0.720	28.339	15.482	0.007
F	0.019	0.734	0.401	
P	0.892	0.393	0.527	
<b>Usability</b>				
Mean	9.054	19.339	0.149	0.053
F	2.928	6.254	0.048	
P	0.089	0.013*	0.827	
<b>Beauty</b>				
Mean	0.482	108.482	1.339	0.152
F	0.128	28.872	0.356	
P	0.721	0.000**	0.551	
<b>Environmental friendliness</b>				
Mean	0.214	2.881	4.667	0.019
F	0.088	1.182	1.915	
P	0.767	0.278	0.168	
<b>Economic efficiency</b>				
Mean	0.292	3.720	10.006	0.029
F	0.101	1.290	3.471	
P	0.751	0.258	0.064	
<b>Cultural</b>				
Mean	1.929	18.667	4.667	0.059
F	0.783	7.580	1.895	
P	0.377	0.007**	0.171	

<sup>a</sup> \* =  $P < 0.05$ ; \*\* =  $P < 0.01$ .

evaluations in this study, but significant differences were noted for color variations. Moreover, consumers displayed different color preferences in different subjective evaluation dimensions.

In terms of usability evaluation, significant effects by different surface colors were observed on participants' subjective visual cognitive evaluation. The participants indicated that the natural materials visually conveyed a greater sense of usability than the caramelized materials did. This was possibly because the participants were unfamiliar with processing technology; they were also influenced by the relatively higher proportion of natural products available on the market compared with caramelized ones and by the belief that “unprocessed, natural materials make for the highest-quality products.” This led them to consider that the natural products possessed higher usability than did the caramelized products. From the professional perspective, however, the caramelized glue-laminated bamboo outperformed the unprocessed natural materials in mechanical strength, bonding performance, and insect and corrosion resistance. Furthermore, glue-laminated bamboo processing involves steam cooking and charring, which effectively enhance insect and mold resistance, thereby prolonging the life span of bamboo materials (Jiang et al. 2008).

The colors of the material significantly affected the subjective visual cognitive evaluation of the participants. The participants favored the caramelized materials over the natural ones aesthetically. This was possibly because caramelized color highlights the contrasts between bamboo knots and fibers in glue-laminated bamboo materials, forming decorative textural patterns on the surfaces. Thus,

**Table 4.—Effect of color of glue-laminated bamboo on usability, beauty, and culture.**

Variable	Mean (SD)	
	Natural	Caramelized
Usability	10.548 (1.638)	9.869 (1.881)
Beauty	9.143 (2.196)	10.750 (1.620)
Cultural	10.036 (1.807)	9.369 (1.297)

caramelized glue-laminated bamboo is visually more pleasing than is natural glue-laminated bamboo. Moreover, the color of the caramelized materials is darker than that of the natural materials and is closer to the traditional Chinese colors of mahogany and hardwood furniture; laminated bamboo furniture with darker colors is considered by consumers to be more elegant and refined. Accordingly, consumers tend to choose caramelized glue-laminated bamboo products over natural ones for aesthetic reasons.

In terms of cultural evaluation, surface colors had a significant impact on participants' subjective visual cognitive evaluation, with participants favoring the natural materials over the caramelized materials. Bamboo is associated with traditional Chinese culture, and consumers tend to regard unprocessed bamboo as true bamboo. This is possibly because natural colors create a closer resemblance to the visual characteristics of original bamboo than do caramelized colors and are more evocative of bamboo cultural associations. Furthermore, the natural bamboo materials evoke a greater psychological sense of freshness, naturalness, purity, simplicity, and mellowness than do caramelized bamboo materials (Fang and Yan 2015) and more readily satisfy modern cultural needs.

No significant differences were noted between participants' subjective environmental and economic appraisals for the plain pressure and side pressure textures or for the natural and caramelized colors. This was possibly because bamboo is ingrained in consumers' minds as economical and environmentally friendly materials (Nath et al. 2020) and because processing methods do not affect consumers' impressions of bamboo.

### Relationship between eye-movement data and subjective overall evaluation

The glue-laminated bamboo surface characteristics were found to exert no significant effects on participants' overall subjective evaluations. However, the total fixation duration and count were demonstrated to be positively correlated with the overall subjective visual evaluation. This indicates that a greater duration and frequency of eye fixation on the surface characteristics of a specific glue-laminated bamboo material yields superior visual cognitive evaluation.

**Table 5.—Pearson correlation analysis between eye-movement data and subjective overall evaluation of visual cognition.<sup>a</sup>**

Variable	First fixation duration	Time to first fixation	Total fixation duration	Fixation count
<b>Subjective overall evaluation of visual cognition</b>				
r	-0.044	0.012	0.175	0.184
P	0.573	0.882	0.023*	0.017*

<sup>a</sup> \* =  $P < 0.05$ ; \*\* =  $P < 0.01$ .

The results of this study reveal that the surface characteristics of laminated bamboo furniture greatly affect consumers' visual cognition and evaluation of it. In daily life, visual cognition is the primary means for consumers to evaluate the surface textures of materials. Someone's initial fixation occurs at the most prominent point within one's visual range, and the subsequent visual point will remain in the area where information is maximized (Henderson 2003, Itty 2005, Tseng and Howes 2008). The area with the most prominent information directly determines first fixation points, triggers consumers' memory associations and expectations regarding the location of specific information, and affects their subsequent visual tracks critically (Oliva et al. 2003). The longer and more frequently a laminated bamboo furniture product captures consumers' gaze, the more favorable their visual perceptions are, causing them to subsequently become more curious regarding the respective product and pay more attention to it. Furthermore, consumers are required to reflect before decisions to purchase furniture products and therefore tend to favor glue-laminated bamboo materials that capture their gaze for long durations and at high frequencies. Eye-movement data and cognitive appraisals for the viewing of glue-laminated bamboo materials can be used to assess the preferences of potential customers and to provide a theoretical reference for understanding their consumption tendencies in greater depth.

### Conclusion

In this study, the effect of glue-laminated bamboo's surface characteristics on consumers' visual cognition was explored to promote designers' understanding of the complex relationship between material textures and visual cognition. Designers should also actively consider the visual cognitive differences for various materials' surface characteristics. The results of this study provide a reference on the effects that glue-laminated bamboo's surface characteristics exert on consumers' visual cognition. The conclusion is as follows:

1. Unlike the plain pressure and side pressure textures, the natural and caramelized colors exerted significant effects on the participants' cognitive processing. They tended to pay more visual attention to the colors of laminated bamboo furniture than to its textures. Improving the surface color of furniture products therefore significantly enhances consumers' preference for them.
2. The participants' subjective evaluations of the colors of glue-laminated bamboo differed significantly according to the cognitive dimensions. The natural laminated bamboo furniture products were associated with a greater usability and stronger cultural associations in the participants' subjective visual evaluation than the caramelized glue-laminated bamboo products, but the participants considered the caramelized glue-laminated bamboo products to be more aesthetically pleasing than the natural glue-laminated bamboo products. Therefore, laminated bamboo furniture products should be designed according to different design goals; appropriate colors should be selected for the product design intentions.
3. The overall subjective visual cognitive evaluation is positively correlated with total fixation duration and fixation count. As such, the greater the duration and frequency of consumers' attention to a laminated

bamboo furniture product, the more favorable their evaluation of the product. Accordingly, surface characteristics that capture consumers' visual attention for long durations and at high frequencies should be adopted in laminated bamboo furniture design to improve overall visual cognitive evaluation.

This study has the following potential limitations: (1) In consideration of the operability of the number of experimental materials, only one furniture shape was selected. Therefore, the results of this study may not be applicable to all laminated bamboo furniture products. (2) Because of time and budget constraints, only current university students were selected as study participants. Future studies will include participants with a broader range of backgrounds.

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