

## **EYE MOVEMENT EVALUATION OF DIFFERENT WOOD INTERIOR DECORATION SPACE**

SHA SHA SONG, QIAN WAN, GE GE WANG

BEIJING FORESTRY UNIVERSITY, KEY LABORATORY OF WOOD SCIENCE AND ENGINEERING  
BEIJING, CHINA

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### **ABSTRACT**

In order to improve people's living quality and ameliorate their living environment, making the full use of the environmental characteristics of wood materials in the building and interior decoration become more and more important. In this paper, the development and application of eye tracking technology is summarized, and the development trend of eye movement research in the field of wood environment is reviewed. Through an eye tracking experiment research on indoor wood decoration space to explore if different specialty, the sex, the wooden interior proportion factor have significant effect on people's judgment on the picture preference or not. Make exploration of people for different wood interior decoration environment preference and visual cognitive style, providing new ideas and methods for room decoration design. On the other side, through the study of the eye movement to explore the wood interior decoration environment has an objective and effective and scientific significance.

**KEYWORDS:** Wood materials; interior decoration; visual environment; eye movement characteristics.

### **INTRODUCTION**

With the rapid development of science and technology and economy, people's standard of living has been rising as well. While focusing on the quality of life, people pay more attention to their own living environment. The living environment not only includes the outdoor environment for public, but also includes people's own indoor living environment. The quality of the indoor environment has greatly influence on people's psychological and physical health, and the interior decoration and furnishings which are important for beautifying the indoor environment play a significant role in improving people's living environment. As the wooden material is an important part of indoor decoration, different species of wood and the different proportions of wood in the indoor space can make differences in people's visual perception and their evaluation of psychological and physiological.

Usually, people obtain message through the eye movement. The movement of eye is closely related to the human's perception and information processing which are two-directional relationship between them (Jacob and Karn 2003). We can study how people observe the outside world through eye movement to analyze their psychological activities and cognitive processes. Researchers tried to treat the eye movement data as the indicators of human mental life in 1878 (Epelboom et al. 1995). With the help of eye tracker, we can obtain the real-time data of participants in their processes of watching visual information, finding the participants' judgment on specific information and selected processing model of cognitive characteristics. As a result, we can analyze and explain some fact of visual evaluation at the view of participants' psychology and spirituality. Using the technology of eye-movement to analyze people's eye movement track, while observing a picture, is an objective research method of psychology study. Researcher used eye movement analysis in their study of advertisement layout, they found that participants' fixation point firstly focused on the informative area (Wedel and Pieters 2002), and found that participants gaze at important area longer in his study of advertisement layout through eye movement analysis (Duchowski 2002, 2003). Further summarized the applications of different emotional physiological signals in the field of human-computer interaction design, and pointed out the significance of emotional physiological signal in usability evaluation part of interactive system (Yusoff and Salim 2010). Therefore, using people's visual physiology characteristic to study eye movement in related disciplines can obtain people's saccade choice and gazing process when they observing various information, so that we can study human's visual perception and integrated process of mental judgment. Meanwhile, people's fatigue, preference, sensitivity, etc. can also be clearly understood through the eye movement indexes such as the fixation time and the pupil diameter, etc.

At present, the research on the visual evaluation of interior decoration environment is still not systematic, and the research in the field of wood environment is also very little. In the eye movement research, a large number of experiments focused on advertising, reading, psychology and other related fields. In recent years, there are some scholars trying to extend the application area. For example, there are people making some eye movement research attempts of the chair, cabinet, sofa shape, Ming furniture. But overall, there are still some improvements and many worth exploring aspects. The technology of eye tracking can offer a clear-eyed view and a more scientific evaluation method for the public to consider the evaluation of wood materials and wood environment. The successful examples of eye movement technology in graphic design and psychological research tell us that the introduction of eye movement technology in the interior decoration environment may bring new breakthrough in design and innovation. Moreover, studies showed that after different professional training, people's brains have different development (Fan and Wang 2011). As the eye movement reflect the activities of our brain directly, study of the people in different background may reveal the difference of their esthetic preference in wood environment. Therefore, using the technology of eye movement tracking to study the field of wooden environment and analyzing the subjects with different background objectively and quantitatively is benefit for creating and extending the space of wood interior decoration in various aspects, even making these studies visually, accurately and scientifically.

This study attempts to treat the eye movement technology as a research method of the new attempt in the field of wooden environment, to explore the different factors on the indexes of eye movement and visual preference differences, influence, and information processing mode of human visual information on the wood decoration indoor environment.

## MATERIAL AND METHODS

In the comparison of the eye movement index, we chose the following parameters:

The number of fixation time: A sign of regional importance. The more important the area is, the more the number of fixation time is.

Average number of fixation point: Average number of times the participant fixates on an AOI (count).

Average pupil diameter: Pupil size is sensitive index in the study.

### Subjects

The subjects were randomly selected from a university in Beijing. Including 16 males, 21 females and 19 professional people with the background in wood science and technology, 18 with others. In the experimental process, some participants due to the head, eye fatigue or other physiological reasons, the eye movement instrument cannot be logged to the eye movement data or the data is not accurate enough so that it is not able to use, so after the final screening, get effective subjects of 28 people, 14 males, 14 females, 14 wood science and technology professional people and 14 non wood science and technology professional people. The average age of the participants was 22 years old. Subjects were uncorrected visual acuity or their corrected visual acuity is above 1.0 (including 1.0), no color blindness (including local color and full color blindness), anomalous trichromatism or night blindness.

College students are a special consumer group, which is a new generation of young, energetic, open-minded, as a reason, their consumption idea exists rational factors and emotional factors, becoming considerable autonomy. Study of College Students' wooden interior environment of visual evaluation of the eye movement characteristics, just can reflect the development tendency of future interior design and popular direction of decoration market. Therefore, college students, as the object of study, have practical significance.

### Experimental apparatus

Experiment studied at the furniture design laboratory of Beijing Forestry University, Materials Science and Technology College. The experimental instrument is ErgoLAB man-machine environment synchronization platform of eye movement module Tobii x2\_60 and supporting computer composition, using optical recording pupil and corneal reflection principle to design. The experimental apparatus is used to record the eye movement data when the test is used to see the different wood interior decoration environment. The data sampling frequency is 60 Hz and the experimental material is presented by a 19 inch liquid crystal display (resolution 1024 x 768 pixels), and the distance between the two is 0.8 meters.



*Fig.1: Eye tracker Tobii X2-60.*

### Materials

Four proportion of wooden interior spaces were chosen, respectively, about 90 % of the wooden interior space (log structures house), about 50 % of the wooden interior space (glued

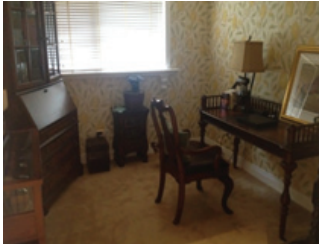
timber structure house), about 25 % of the wooden interior space (light wood frame house), no wood (0 %) of interior space (steel and concrete structure house) 4 kinds of indoor environment of 20 photos (Fig. 2-5). In order to carry out the investigation on wooden interior proportion factor, 5 pictures were selected of each indoor environment from different angles and 5 groups in total, 4 in each group. And their specifications are unified.



*Fig. 2: Log structures house (90 % wooden decoration).*



*Fig. 3: Glued timber structure house (50 % wooden decoration).*



*Fig. 4: Light wood frame house (25 % wooden decoration).*



*Fig. 5: Steel and concrete structure house (0 % wooden decoration).*

Photograph: Different wood indoor space pictures from the houses of the Suzhou Royal overall residential Systems Co. Ltd. demonstration, using a digital camera for photographing, shooting control conditions of consistency and balance the effect of independent variables. After the shooting, using the Photoshop software for image processing, image resolution of 1024 x 768 pixels.

### Procedure

The experiment is divided into two parts. First of all, the eye movement experiment is carried out, and then the questionnaire is completed.

Eye movement experimental procedure includes four parts: After entering the laboratory, sitting in a distance of 0.8 meters in front of the display, implementing the experimental eye tracker calibration procedures, and then begin the formal part of the experiment. The main test of every subject gives unified instruction: Below to begin the formal experiment, now please assume you need for living space of the decoration, the screen in front of you will show you a photo. Please look at every piece of picture, according to right arrow into the next one. In determining the participants understand the experimental requirements, let subjects exercise experiment, then began formal experiment, experiment with pictures presentation order is randomization, experimental materials are presented by the subjects with the blank space key control, between every two pictures show a stay in 8 seconds "?", when subjects verbally caller should just watch

the picture, by the main subjects alongside records, followed by central screen will show a "+", lasts approximately one second, also need to pay attention to"? " and "+", so the data processing can be found usually in the first view of the picture is located in the center of the screen, the average time of each experiment is about 20 minutes.

The actual experiment will be divided into 2 groups, two groups of male and female equally, 20 pictures in group 1 and group 2 are the same, but the order of playing the pictures is different.

Questionnaire survey: After the end of the eye movement experiment, using self-made questionnaire survey subjects which were asked to just present different wood interior space decoration picture preferences and comfort of a five point rating, the higher score (maximum 5) said stronger preference. (Which are just finished each picture directly after the next number, experimental personnel records).

A five point rating: 1. Don't like (comfortable), 2. Not much like (not too comfortable), 3. General like (comfortable), 4. Prefer (comfortable), 5. Love (very comfortable).

### Experimental data processing and analysis

The recording and analysis of the eye movement data is recorded and using the feedback of the data analysis software that comes with the eye tracker. Including the first viewpoint, the fixation time, the number of fixation, the moving order of the fixation point, the diameter of the pupil, other test data are analyzed by SPSS 22.0 software at last.

In this experiment, three factors mixed experimental design of 2\*2\*4 measurement variables. 4 kinds of wood proportion of indoor space (90, 50, 25, 0 %) \* professional (wood science, not) \* gender (male, female). The variables include: The average fixation time, average fixation point number, average pupil diameter, and picture preference values. The factors, including professional, gender, wood trim ratio and data analysis before the first eye movement analysis software for each image into regions of interest, and first using Excel software to clear up all the data. Finally, using SPSS 22.0 software for multivariable multi factor analysis of variance.

## RESULTS AND DISCUSSION

Analysis of the selection of eye movement indicators including the average fixation time, the average fixation point number, and the average pupil diameter are basically be considered. On one piece of picture average fixation time is longer, the average gaze point more, the average pupil diameter is larger, the higher the extent of its preference for the picture. In addition, the rest of the analysis index is the five point evaluation of the measurement of picture preference value.

### The average fixation time difference of the proportion, specialty and gender of different wood interior trim

Tab. 1: The difference of the average fixation time of the subjects under different conditions.

Wooden decoration proportion	Profession	Gender	Mean (s)	Standard deviation
90 %	Wood science and technology	male	0.18	0.05
		female	0.21	0.05
	not	male	0.19	0.06
		female	0.17	0.03

50 %	Wood science and technology	male	0.19	0.06
		female	0.20	0.07
	not	male	0.17	0.05
		female	0.19	0.06
25 %	Wood science and technology	male	0.18	0.05
		female	0.20	0.06
	not	male	0.18	0.05
		female	0.18	0.03
0 %	Wood science and technology	male	0.18	0.05
		female	0.19	0.04
	not	male	0.16	0.05
		female	0.18	0.04

Tab. 2: The effect of the main body of the average fixation time is tested.

	Mean square	F	Significance
Wooden decoration proportion	0.01	2.02	0.11
Profession	0.02	6.73	0.01
Gender	0.01	4.31	0.04

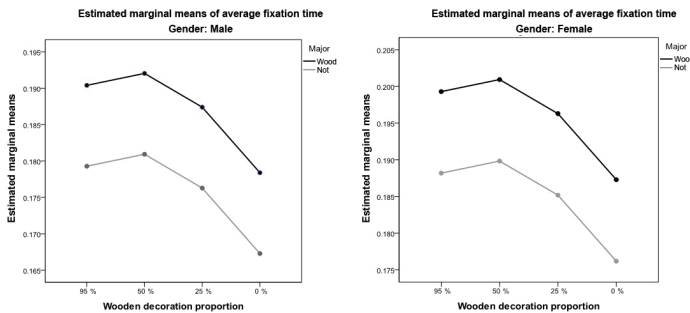


Fig. 6: The average fixation time of different conditions which is estimated by the mean of the marginal mean value of the broken line chart.

Through the variance of all data with multi variables and multi factors analysis, draw the chart, we can easy to find wooden interior proportions have a great influence on the professional average fixation time. From Tab. 2 we can determine there are significant differences between the major and gender factors on the average fixation time (significant  $p=0.01 < 0.05$ ,  $p=0.04 < 0.05$ ). For the proportion of wooden interior factors, the average fixation time from more to less respectively 50, 90, 25, 0 %, indicating that people more prefer the wooden interior proportions of the indoor environment.

### The average fixation number difference of different wood interior proportion, specialty and gender.

Tab. 3: The mean fixation number of the subjects under different conditions.

Wooden decoration proportion	Profession	Gender	Mean (s)	Standard deviation
90 %	Wood science and technology	male	13.37	7.59
		female	17.94	14.42
	not	male	13.86	7.67
		female	13.03	6.71
50 %	Wood science and technology	male	13.71	6.08
		female	18.71	16.04
	not	male	13.00	7.95
		female	13.60	7.11
25 %	Wood science and technology	male	14.23	7.47
		female	18.20	15.32
	not	male	13.77	8.07
		female	14.09	8.13
0 %	Wood science and technology	male	12.43	5.60
		female	17.80	13.76
	not	male	11.54	9.04
		female	10.74	4.82

Tab. 4: The test of the effect of the main body of the average fixation number.

	Mean square	F	Significance
Wooden decoration proportion	103.38	1.09	0.36
Profession	1134.30	11.90	0.00
Gender	724.59	7.60	0.01

From above, we can see professional and gender factors of each picture average fixation number exist significant difference ( $p < 0.05$ ,  $p = 0.01 < 0.05$ ). Chart comparing can easily find that the average fixation time of woodworking group is better than non-woodworking group, fixation number of girls is more than that of boys, with the average fixation time difference obtained similar results that professional background and girls were more nuanced. While analyzing Tab. 3 and Fig. 7, we can find that the proportion of wood trim on the average number of points of the impact is small, which in Tab. 4 the significance of 0.36 (greater than 0.05) can also be confirmed.

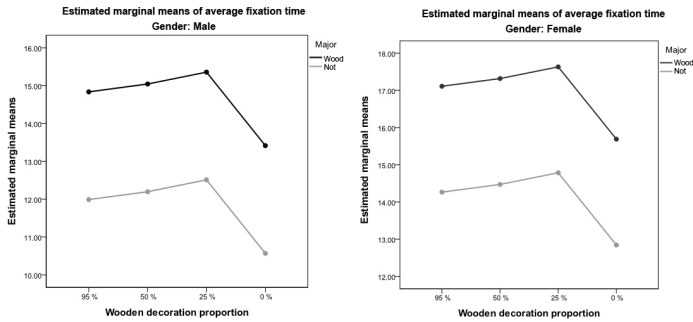


Fig. 7: The average gaze point of different conditions which is estimated by the mean value of the broken line chart.

### Difference of average pupil diameter of different wood trim ratios, majors and genders

Tab. 5: Mean pupil diameter difference under different conditions.

Wooden decoration proportion	Profession	Gender	Mean (s)	Standard deviation
90 %	Wood science and technology	male	4.02	0.56
		female	3.53	0.33
	not	male	3.40	0.39
		female	3.26	0.35
50 %	Wood science and technology	male	4.00	0.57
		female	3.53	0.35
	not	male	3.40	0.42
		female	3.23	0.34
25 %	Wood science and technology	male	3.98	0.62
		female	3.53	0.34
	not	male	3.35	0.39
		female	3.26	0.36
0 %	Wood science and technology	male	3.98	0.56
		female	3.52	0.34
	not	male	3.36	0.39
		female	3.16	0.33

Tab. 6: The inter – effect test of the average pupil diameter.

	Mean square	F	Significance
Wooden decoration proportion	0.06	0.32	0.81
Profession	29.29	158.20	0.00
Gender	13.48	72.82	0.00



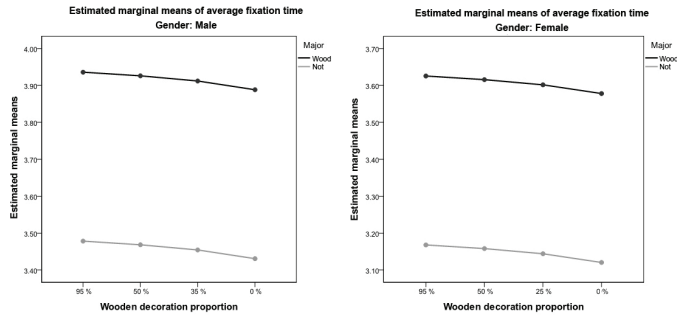


Fig. 8: The average pupil diameter of the mean value of the broken line chart was estimated at different conditions.

From the data above, we can find that professional and gender factors on each picture average pupil diameter exist significant difference ( $p < 0.05$ ), namely, different majors and sexes of average pupil diameter have significant difference, but wooden interior proportion about the impact is not significant ( $p = 0.81 > 0.05$ ), based on the former analysis, summary for the different proportion of wooden interior environment does not significantly affect the subjects of eye movement index changes.

**The analysis of the results of five point evaluation method in the questionnaire**

First, five point evaluation method in the evaluation of 1-5 points assignment, here respectively introduced 5 preference values of images, to represent the questionnaire subjects to evaluate each picture after the values obtained. So if the displayed picture preference value is larger, then it means the picture preference degree of the subjects is higher.

Tab. 7: Different conditions of the image preference values.

Wooden decoration proportion	Profession	Gender	Mean (s)	Standard deviation
90 %	Wood science and technology	male	3.97	1.04
		female	2.83	1.18
	not	male	3.26	1.15
		female	3.46	0.98
50 %	Wood science and technology	male	3.66	1.03
		female	3.49	1.07
	not	male	3.17	0.98
		female	3.63	0.91
25 %	Wood science and technology	male	3.40	1.06
		female	2.80	1.16
	not	male	2.86	0.81
		female	2.94	0.73
0 %	Wood science and technology	male	3.29	1.13
		female	2.89	1.08
	not	male	3.17	1.12
		female	3.46	0.98

Tab. 8: The inter subject effect test of the image preference values.

	Mean square	F	Significance
Wooden decoration proportion	6.35	5.69	0.00
Profession	0.30	0.27	0.60
Gender	3.62	3.24	0.07

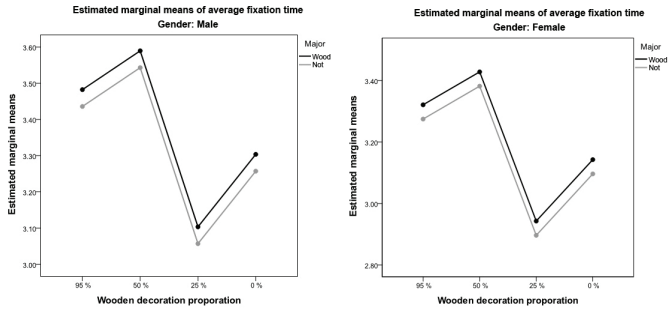


Fig. 9: The marginal mean value of the image preference which is estimated by the mean of the marginal mean value of the broken line chart.

By above knowable, wood trim and the proportion of gender factors of each picture preference value has a great influence and significant effect ( $p < 0.05$ ), from Fig. 9, it is easy to see that picture preference value by the corresponding wooden interior proportions were 50, 90 and 0, 25 %, namely subjects for wooden interior a larger proportion of the indoor environment is more liked. And from Tab. 7 we can find that same wooden interior proportion, in woodworking group girls' pictures preference value is higher than boys', so sex of indoor wood environment aesthetic preferences also have greater impact.

**Analysis of the moving sequence of the image's gaze point**



Fig. 10: Test to the picture B1 watching point move.



Fig. 11: Test to the picture B12 watching point move.

Since each image will stay about a second "+", the first viewpoints are usually located in the central screen and then it can be observed that subjects' gaze points often move along a predetermined order to observe a circle, keeping the sense of region of interest or getting more information of regional additional attention.

## DISCUSSION

### **The influence of different interior wooden decoration proportion on cognitive processing**

We discussed the influence of the esthetic preference and the cognitive process in different proportions of wood interior decoration from the perspective of subjects' average fixation time. The results showed that the average fixation time of girls usually slightly more than boys, fixation time of wood profession group is longer than that of non-wood profession group. Maybe the observation of professionals pay more attention to detail matters due to their professional training. Yabus (1967) pointed out that observers always paid more attention to their interested area. Therefore, we can assume that subjects are more interested in interior decoration with a modest proportion of wood, and mixed structure housing preferences is weak for wood structure building and steel. Although the subjects' cognitive process of the proportion of wood interior decoration has no significant difference in the number of the average fixation point, from the data, we could find that the subjects' preference on the space of the wooden decoration is slightly higher than the space of reinforced concrete structure. This indicate that improve the proportion of wood interior decoration can also increase the residents' satisfaction.

Firstly, the wood material has some unique features such as color, material, texture and so on. With the natural visual beauty on the surface of wood, this kind of material has the most outstanding material quality. Rice et al. (2006) said that the use of wooden products could create a more healthy environment and a warm, comfortable, relaxed, natural and attractive wooden interior environment. Then, the reinforced concrete interior space we people live daily make us feel repressive and restless, however, the wooden interior decoration space could bring people better feeling of visual psychological and relieve their stress of daily work.

### **The influence of different majors and gender on esthetic preference**

The pupil diameter is associated with the preference value of the pictures, general pupil diameter of the display picture preference is greater, so we believe that major and gender on subjects about the image of the preference degree have a greater impact. And the average pupil diameter of wood profession group is significantly larger than that of the non-wood profession group; professional background will put more attention and observation of the pictures, which is much more detailed. The average pupil diameter of the male group is larger than the female group, which may be related to the the experiment of seriousness and gender physiological factors.

For picture preference values, the difference between wood profession group and non-wood profession group is very small, that is, different professional subjects in this regard have similar aesthetic preference. This may be related to the subjects which are from the same college, accepted the basic education and cultural environment roughly similar, which make them have similar visual information processing. And professional background may make professional girls have more demanding requirements for pictures, and lower scores. But for non-professional girls, combined with life experience analysis, their preference of all kinds of pictures is usually to be higher than that of similar boys, perhaps can explain Tab. 7 phenomenon.

### **The influence of Region of Interest (ROI) in different interior decoration spaces on the cognition of the pictures**

Image analysis can be found that the boys' gaze points are usually less than girls', and the observing process of general girls is often in detail, and the girls often concerned about some of the decoration and furnishings details which boys pay less attention to this aspect, sometimes

boys' watching will stay on the wall or ground. Through the data analysis of gaze point order, the same results can be validated like the obtained results of variance analysis. This may due to the difference cognitive-psychological models between male and female.

## CONCLUSIONS

Through the above analysis and discussion, the following conclusions:

1. Different professional, different gender on the subjects of the average fixation time and number of average fixation point exist significant differences. The two data in wood group were significantly greater than the not wood group, female group's average fixation time and number of average fixation point more than the male group. Different gender subjects have different fixation point move order, focusing on the scope and content of the picture different because of the professional and gender. So that different professional and gender factors have significant difference on subjects watching pictures of aesthetic preference and visual information processing model.
2. Different professional, as well as different gender on subjects' average pupil diameter exists significant difference effect. Wood profession group is bigger than the average pupil diameter of non-wood profession group, boys wood profession group the average pupil diameter of boys is greater than of girls. And average pupil diameter also can reflect the aesthetic preferences of the subjects to images, so the combination evaluation method can get the conclusion: five major and gender factor has certain influence to the aesthetic preferences, but the effect is not significant difference.
3. Participants preference values exist significant differences for different wooden interior proportion of the interior decoration space. The data of wood profession group and non wood profession group has little difference, may be due to the participant has the long-term education with the same culture background and living environment, make subjects produce similar way of visual information processing in the experimental. Subjects more prefer to higher percentage wooden interior space (greater than 50 %). Therefore, in the indoor design, it is necessary for the indoor environment of the wooden interior proportion to purpose to choose, to improve the living environment.
4. As for the scientific contribution of this study for the wood research, the results of a series of experiments using eye tracking technology starting from a new research direction, in order to explore from different professional, different gender and different wooden interior proportion of the interior decoration space on the influence of aesthetic preference. It provides new ideas and new methods for the application of eye movement research in wooden environmental science, experimental conclusion can be very useful for the wooden interior proportion of the interior decoration space, as it provides a scientific and effective reference, it also develops wooden environment research field. And it is helpful for wood material in interior decoration, the living environment design and selection of application.
5. Different background of subjects have difference visual cognitions on wooden interior decoration space. However, the designers of the interior decoration space usually are not the users who will live in. Therefore, designer should consider the differences from the aspect of users, adjusting the proportion of wood in the interior decoration space and finally meet the needs of them.

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\*SHA SHA SONG, QIAN WAN, GE GE WANG  
 BEIJING FORESTRY UNIVERSITY  
 MATERIALS SCIENCE AND TECHNOLOGY  
 QING HUA EAST ROAD 35  
 P. O. BOX 25  
 HAIDIAN  
 BEIJING 100083  
 CHINA  
 PHONE: 86 010 62337192  
 Corresponding author: songrui\_1688@126.com

