

**LICENTIATE THESIS**

***Computer visualization of wood  
– some important aspects***

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## Abstract

Research regarding the aesthetic features of wood and people's preferences for different appearances of wood has to date been rather limited. Today it is common to use computers to show how a room or product will look when or if it is produced. This thesis presents the results of a quest to learn which aspects are of importance when visualizing wood. The objective of the first two studies was to find and gather words and descriptions for aspects of wood visualization and to categorize them. The objective for the third study was to find a method for measuring peoples' preferences for wood on internet and to describe these differences in preference amongst the interviewed respondents. The objective for the fourth study arose in an attempt to use the descriptions found in the first studies to search for an experienced difference between an image on paper and the same image on a computer screen.

This thesis does not cover computer visualization in general or the differences between wood species.

The basis for the studies in this thesis is qualitative interviews based on the Grounded Theory method, focus groups and two-by-two comparisons. With the findings from the first studies, it was interesting to try to verify them and at the same time rank found aspects that seemed to be important and test a hypothesis regarding preferred exaggeration when visualizing wooden interiors. There are some bias risks involved in paper IV, and these are discussed openly.

Given the results from these four studies, it is easier too see the entirety of the complex topic *visualization of wooden interiors*. Since smart exaggeration (rather than merely correct photorealism) and being part of the whole (the context is critical) are more important than merely having a correct texture, it is time to start work with factors that make wood interact with its context. Light is a good example of this. The light gleam reflecting from the wooden surface tells us that this is not just a flat texture, but a topological and varying structure. The contrast and color of the wooden surface are also crucial.

*Keywords:* Wood, Visualization, Wood communication, Computer Graphics, Perception, Qualitative methods, Marketing.

## Preface

The work presented in this licentiate thesis was carried out at Luleå University of Technology, Division of Wood Technology at Campus Skellefteå. I would like to thank my supervisor, Dr. Olof Broman, and my examining professor, Dr. Anders Grönlund, for supervision and guidance, and especially Olof for pushing me forwards.

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I would also like to extend my thanks to Michael Dell and William Gates for making my life as a computer user extra interesting. Thanks to Ida for the carpet, to Carina for the critique and to my family for helping me do whatever is totally different from this writing and reading and writing and writing...

And finally—Maria, I love you:

I am crazy about you, Pretty Woman.

Skellefteå, May 2004.

Enar Nordvik

## List of papers

This thesis is based on work reported in the following papers, referred to by roman numerals:

- I. Nordvik, E and Broman N.O. (2003) Visualizing Wooden Interiors - What people react to and how they describe it. Submitted to Forest Products Journal.
- II. Nordvik, E and Broman, N.O. (2004) Visualizing the Qualities of Wood. Submitted to Forest Products Journal
- III. Broman, N.O, Fjellner, B-A and Nordvik, E (2003). A Method for Measuring of Peoples' Preferences for Visible Wood Using Internet. (Swedish). Technical report ISSN 1402-1536; 2003:21, Luleå University of Technology
- IV. Nordvik, E and Broman, N.O. (2004) Paired Comparison of Aspects of Digital Images of Wood. Submitted to Forest Products Journal

## Contribution to the included papers

The main part of the work in papers I, II and IV was conducted by the author. The study described in paper III was designed by Broman and Nordvik, but data analysis using PCA was handled solely by Broman and computer programming by Fjellner.



## Table of contents

|   |     |
|---|-----|
| ABSTRACT  | III |
| PREFACE   | IV  |
| LIST OF PAPERS  | V   |
| TABLE OF CONTENTS   | VII |
| 1. INTRODUCTION AND BACKGROUND                                      | 1   |
| 1.1. Wood   | 1   |
| 1.2. Visualization  | 1   |
| 1.3. Communicating and experiencing                                 | 2   |
| 2. OBJECTIVES AND LIMITATIONS                                       | 3   |
| 2.1. Research objectives  | 3   |
| 2.2. Limitations  | 3   |
| 3. MATERIALS AND METHODS  | 5   |
| 3.1 Gathering descriptions of wooden interiors on a computer screen | 5   |
| 3.2 Verifying descriptions of wooden interiors in a computer        | 5   |
| 3.3 Comparing different wooden interiors on the Internet            | 6   |
| 3.4 Comparing aspects of wooden interiors on a computer screen      | 6   |
| 3.5 Possible error sources  | 7   |
| 4. RESULTS  | 9   |
| 5. DISCUSSIONS AND CONCLUSIONS                                      | 11  |
| 5.1 Discussions   | 11  |
| 5.2 Conclusions   | 13  |
| 5.3 Practical implications of the results                           | 13  |
| 5.4 Future work   | 14  |
| 6. REFERENCES / LITERATURE CITED                                    | 15  |
| PAPERS I-IV   |     |
| Paper I   | 17  |
| Paper II  | 33  |
| Paper III   | 49  |
| Paper IV  | 81  |





# 1 Introduction and background

## 1.1 Wood

Wood is more than a material with technical characteristics to be weighed, measured and calculated. Wood is a material with aesthetic qualities, biological variations and different appearances dependent on wood species and treatment. The technical characteristics have been thoroughly investigated through years of research, but the *soft* or qualitative questions regarding attitudes and feelings towards wood are sadly not as well documented. This situation is, however, starting to change. Wood as an interior material offers warmth (as compared to stone), a never-repeating pattern (as compared to wallpaper) and treats light differently depending on how the wood is treated.

CEI-Bois, the European confederation of woodworking industries, states “living with wood” as their main end-use area in their vision to make wood-based products the leading solution in interior system products (CEI-Bois 2004). Research regarding aesthetic features of wood and people's preferences for different appearances of wood has to date been rather limited.

Although some studies have been carried out both in Europe and Japan (Marchal and Mothe 1994, Mazet and Janin 1990, Nakamura et al. 1993) the lack of knowledge in this field is still very evident. Also, knowledge of the final customers' preferences is still poor in the wood product chain, especially when it comes to the aesthetic features of wood (Swearingen et al. 1998, Hansen and Weinfurter 1999, Marchal and Mothe 1994), even though recent studies are oriented towards this subject (Jahn et al. 1999, Bumgardner et al., 2001, Donovan and Nichols 2003).

The industry must become better at communicating wood and its advantages and disadvantages throughout the wood-processing chain (from forestry to housing and recycling). Communicating the whole material, even the softer qualities, such as visual impressions, has become increasingly important when trying to reach new customers and to keep existing ones in times of harder competition. This communication is what is here called *wood communication*. Pakarinen (1999) states that it is important not only to put emphasis on design; the manufacturers also have to sell wood by its aesthetic features. The computer could be a useful tool in this communication, but do we have knowledge about which properties of wood we want to communicate and how we should do it?

## 1.2 Visualization

Today it is common to use computers to show how a room or product will look when or if it is produced. In communicating the aesthetic properties of wood in such cases, the ways people experience wood are of interest, as are what is important to focus on and what is best to avoid.

The efficacy and validity of using the computer for visualization is well known and has been documented by Sheppard (2000), among others. It has become more common to use computer-generated images to show how a room or a product will look when produced, or for marketing purposes.

The entire field of digital imaging and scientific visualization (Cox 1990) is becoming more reliable, and substantial advances have been made in computer capabilities and

graphic software, which has made visualization easier and more accurate, but the research is still somewhat limited (Daniel and Meitner 2001). However, some results have been achieved. Results indicate that aspects of computer visualizations (e.g., resolution and color fidelity) may significantly affect observers' perceptions, understandings and judgments. Some features of visualizations are known, for example, to affect attention and interpretation and to arouse positive and/or negative emotions (Mitchell 1983, Broudy 1987, Cox 1990). Daniel and Meitner (2001) are involved in discussions about the validity of visualization, but as applied to forest landscapes, not to wooden interiors. The studies mentioned above deal with visualization in general or of trees, not of wood and/or wood interiors.

### 1.3 Communicating and experiencing

Work concerning wood and visual impressions is presented in articles by Broman (1995a, 1995b), which contain qualitative interviews, but focus on methods of interrogation. Broman (1995b) also investigates people's attitudes towards wood and shows that it is possible to draw adequate conclusions about real, live wood experience from computer experiments. By comparison to Broman (1995a), the studies described in this thesis are more oriented towards conceptions about computer-visualized wood interiors.

Architectural scientific discussions about *experiencing beauty* are nothing new. During the course of years, considerable work has been done (Hesselgren 1987, Rasmussen 1962) and still is being done. A study of the perceived color of paint (Fridell Anter 2000) is an interesting example, but it is directed more towards color and painted façades.

To communicate the essence of wood—the *soft* or *qualitative* features (such as visual, tactile and *mental* qualities of wood)—expressed and visualized by a computer is both an interesting opportunity and a challenge because of the medium's limited means of communication. Vital knowledge is missing about what factors are important when visualizing wooden interiors. There is always a difference between what we look at and what we see, i.e., between the physical reality and the experienced reality (Fridell Anter 2000). The overall aim of this thesis is to study human descriptions and perceptions of computer visualizations of wood interiors. If it is possible to discover and map what people react to and how they describe it, it should be possible to know (or study) which factors are to be given extra consideration in computer visualizations of wood.

## **2 Objectives and limitations**

### **2.1. Research objectives**

This thesis presents the results of a quest to learn which aspects are of importance when visualizing wood and of an attempt to rank these aspects in order of importance. The objective for papers I and II was to find and gather words and descriptions of aspects of wood visualization and to categorize them. The objective for paper III was to find a method for measuring peoples' preferences for wood and to describe the differences in taste and preference amongst the interviewed respondents. This was done using digital images on the Internet.

The objective for paper IV arose in an attempt to use the descriptions found in papers I and II to search for an experienced difference between an image on paper and the same image on a computer screen (paper IV). Here, the image on paper represented the physical reality, and the image the respondents chose represented the experienced reality. The hypothesis derived from the first three studies was that most people would prefer a computer image that was slightly exaggerated (compared with the physical reality), i.e., *hyperrealistic*, in order to experience the image as realistic.

### **2.2. Limitations**

This thesis does not cover computer visualization in general or the difference between wood species. This thesis concerns wood qualities involved when wood interiors are computer visualized. This means wood as a part of the whole image, in a context, and does not include nonvisual qualities (such as tactile or sound features). Many of wood's competitive advantages will be missed in such a visualization. Also, this thesis deals with the general problems of computer visualization to the extent of its adequacy for the experience of interior wood. The first three studies (papers I–III) are oriented towards preferences, i.e., what people like, while the fourth study (paper IV) concentrates on more objective judgments.



Figure 1. Images 1-7c used in papers I-II, 8a-b in paper III and images 9a-b in paper IV.

### **3. Material and methods**

The basis for the studies in this thesis is qualitative interviews (although paper III and IV uses quantitative methods, it relies on qualitative results from earlier studies). All studies also concern digital images in a two-by-two comparison on a computer (albeit with a projector in paper II). The images (Figure 1) were gathered from outside sources (except for images 9a and 9b in Figure 1) to avoid bias, and were all in digital format. Some were photographs (Figure 1, images 4 and 9a and 9b), some modeled in a computer (Figure 1, images 8a and 8b). However many of the variations (papers I, II, IV) of the images were constructed by the researchers. Images 1-7c were used in papers I-II, images 8a-b in paper III and images 9a-b in paper IV (see Figure 1).

#### **3.1 Gathering descriptions of wooden interiors on a computer screen**

The study in paper I aimed at exploring and gathering descriptions of computer-visualized wood interiors through qualitative interviews. The Grounded Theory method (Glaser and Strauss 1967) was used to get a map of what people react to in such images. The principle is to sort interview data into groups consisting of aspects of a certain quality, all this to find out which aspects that might be of importance when visualizing wood interiors.

Eighteen pictures of interior surroundings with visible wood elements were produced in the computer. See Figure 1, images 1–7 for examples. To avoid biased results and to avoid a situation wherein the researcher is measuring responses to his own pictures, the seven originals were collected from outside sources such as architects and CAD companies. Each original was varied so as to obtain three versions of each picture with wide variations in light, shadows, color, contrast, etc. (see images 7a–c for examples). A system was prepared on a laptop computer for viewing the pictures two at a time for comparison in pairs. The two-by-two comparison strategy was used because it is considered a good way to provoke opinions where respondents have to choose and then motivate their choices (Silverstein and Farrell 2001).

The respondents were instructed to point out which picture they liked less in a two-by-two comparison. The respondents were chosen at the Stockholm Central Station in order to get as wide a variety as possible regarding age, sex and background, all according to theory. Twenty-one persons were interviewed for approximately 20 minutes each. All interviews were recorded on a minidisc recorder, and the interviews were later transcribed onto paper before the grouping and regrouping started.

#### **3.2 Verifying descriptions of wooden interiors in a computer**

To verify the results from the first study, another similar study was conducted using the same image material (Figure 1, images 1–7). Inspired by the methods used in focus groups (Krueger 1994, Morgan 1998), we divided the respondents into three groups. The first group consisted of people between 20 and 30 years old, the next of people between 40 and 60, and the third of professionals (architect, visualizer, constructor, etc.). A relaxed atmosphere was created with discussions or dialogues instead of conducting formal interviews. The interviews took place in Skellefteå. They lasted approximately one hour and were recorded on a minidisc

recorder. Supporting notes were also taken on paper. The researcher led the discussion and passed the word. The main question was “*Which picture do you think is better?*” Altogether, this led to a richer material (as compared to paper I). This study used pictures projected on a projector screen, but the sorting criteria were the same as in the first study. This study was also recorded and the data were thoroughly analyzed and grouped into categories.

### **3.3 Comparing different wooden interiors on the Internet**

At the same time as the first study was conducted, the first steps were taken towards an internet-based study, paper III. The idea was to find a method for measuring consumer preferences as to interior wood and also to verify some earlier findings (Broman 1995a, Broman 1995b). A room was modeled by a professional visualizer using computer software. Seven texture pictures gathered from a wooden floor vendor were used for changing the floor material. The species were alder, birch, cherry, oak, oak plank, maple and walnut. See images 8a and 8b for examples of the evolution of the room. The images were used in a two-by-two comparison competition, and the respondents were asked to describe in words the picture they liked the most and the one they liked the least. The result was automatically written into a computer log that was easily transferred into a spreadsheet. A balanced binary tree (Silverstein and Farrell 2001) was used to reduce the amount of choices, and Principal Component Analysis, PCA (Anon 2002, Eriksson et al. 2001), was used to interpret the data. The context of the room was varied during the three interview rounds, as seen in Figures 8a and 8b.

### **3.4 Comparing aspects of wood interiors on a computer screen**

With the findings from earlier studies (papers I–II), it was interesting to try to verify them and at the same time rank aspects that seemed to be important and test a hypothesis regarding preferred exaggeration when visualizing wood interiors.

The hypothesis was derived from earlier studies (papers I–II) and was concerned with the idea that photo realism (to look as correct as a photograph) is not enough; to create a picture that most respondents would accept as a fair visual representation, properties such as light, color and contrast have to be slightly exaggerated in the image.

Six of the properties (that also were possible to control technically) were chosen: light, color, contrast, shadow, gleam and texture scale. An interior context with a wooden table was set up, and a photographer took pictures that later were varied in the properties named above using a computer. An original picture was also ordered from a photo lab.

Image 9a is the original, and 9b is one of the variations (decreased contrast).

First, the paper copy was shown and put away. Then two steps of two-by-two comparisons were executed on a computer screen, with the original picture incorporated in the latter step. The respondents were instructed to choose the picture that was most like the picture on paper they saw first. The results were logged into a computer and easily transferred into a spreadsheet, where the analyses were performed.

### 3.5 Possible error sources

This thesis describes attempts to make a map of the unexplored landscape of wood visualization. When reaching for knowledge in an interdisciplinary area, it's inevitable to end up with some biases and errors, both in fact and mind. The researcher has tried to describe all known error sources, but has no doubt that some still remain uncommented.

When it comes to experiencing wood, one of the greatest biases for papers I and II is perhaps that it is very hard for viewers to differentiate between what the respondents understood from the picture and what they liked in it. The term *understand* here means understanding what the respondent sees in the picture—the perspective, the furniture and the material, etc. This means that it might be easier to understand what kind of wood the picture is supposed to communicate and how it looks in one picture, but because of other factors, such as the aspects in the category *Spirit* (paper I—*Light, Warmth, etc.*) and the picture composition, it might be easier to like another picture. Naturally, practical matters such as viewing angle and lighting situation during the interview are also important. However, this was managed by allowing the respondents to try different views.

In paper III, one bias risk is the risk that the respondent will succumb to the sheer number of choices and answer just anything. However, this can be controlled via the check numbers in the computer log, whereby such results can be lifted out of the study. The interviews also showed that a slightly darker material could seem much darker, depending on the computer screen. Thus darker rooms seemed too dark. It is also impossible to tell exactly what affect the look and shape of the room has on the respondent when testing different flooring and also how the floor is affected by the surroundings. But since the study was conducted in three versions, it is easy to see that the context changes the experience.

When it comes to experiencing wood, the greatest bias in paper II is perhaps that it is very hard for viewers to separate between what they understand and what they like. It might be easier to understand what kind of wood the picture is supposed to communicate and how it looks in one picture, but because of other factors, such as the colors, light and picture composition, it might be easier to like another picture.

The researcher also chooses which pictures are to be discussed. Thus, he or she has decisive control over the answers. That is, if the researcher chooses a picture he or she thinks has a lighting error, the respondents often naturally give the answer *light*. Awareness of this bias problem is important. Since the researcher is also interpreting the answers, there is a double responsibility. This is, however, also an advantage, as the researcher is in control of his material.

In paper IV, the image on screen and the image on a photo lab printout will not match exactly, but they will still provide us with a clue about what is important. Second, it is likely that the memory of the first picture is affected by all the other pictures.

There are three major bias risks in paper IV, the first one being the inevitable difference between the original digital photographic image and the photo lab printout. The lighting and viewing angle during the interview are also important. This was managed by allowing the respondents to try different views. The third and most critical bias risk is the obvious risk that the *mental picture* was affected by all the versions, and that it may have varied during the interview. Even though most respondents claimed that they were able to stay with their first *mental picture* throughout the interview, it is reasonable to believe that this mental picture was affected by at least the first pictures in the interview and then melted together into a new picture that then was held on to during the remaining interview. If this is correct, it means that

the results of the first step of the interview (in which six versions of the pictures were chosen for further competition) are correct, but that the validity of the second step has decreased. But this is only a hypothesis. Perhaps the great number of versions made the comparisons easier and the respondents had to choose some properties in order to be able to remember the picture. But this is only an assumption. The order of the images was randomized to avoid systematic errors.

Common for all the first studies (papers I–III) is that the language is important. The results are only valid (at least until further studies are done) in the language in which they are conducted, i.e., Swedish, but the methods should be relevant for all languages. Naturally, the interpretation of the words used by the respondents in papers I–III is crucial to the validity of the results. Therefore, the results must always be discussed with others. In paper IV, no words were used by the respondents, and the only language-related issue was the phrasing of the instructions given before the interview.



## 4 Results

The results from the first study indicate that the most important categories for wood visualization are *Appraisal*, *Reality*, *Entirety* and *Spirit*. These names are simply a way for the researcher to sort the data and could of course be named something else. The results also indicate that good visualization of wood should avoid erroneous details, repetitive patterns and lighting or shadowing errors. It was hard for respondents to separate what they liked/disliked from what they understood (what the respondent sees in the picture, the perspective, the furniture and the material, etc.). Most respondents also reacted more to how the wood in the pictures reacted to shades and colors than they did to its textures. This may mean that photorealism is no guarantee of acceptance for a picture, or at least that photorealism is more than the surface, the texture. In addition, more important than high resolution is for wood to be part of the whole picture and not stand out or appear more processed than the surroundings. The study also indicates that single (not group) interviews were not the best method for collecting this data.

The results from the second study indicate that *Light*, *Color*, *Entirety* and *Comprehension* are of the greatest importance when visualizing wood. Compared with the first study, the results here are more tangible, easier to connect to physical aspects in the pictures. The result is an ordered map of aspects that indicate that a successful visualization should avoid disturbing the whole with erroneous details, repetitive patterns and lighting errors. The natural wood pattern reveals any attempt to fake it. The right composition of light and color combined with an adequate level of detail gives the viewer the entirety, and thus the possibility to discuss the viewer's comprehension, i.e., what the viewer sees or thinks he or she sees in the picture. Many respondents preferred wood in hyperrealistic colors (example: image 7a in Figure 1). Perhaps some kind of smart modification, rather than photorealism, is sometimes the more appropriate goal. The category *Light*, however, is more than weight or lamps or the opposite of darkness—it is also how the light is reflected and on which surfaces. This needs to be investigated further.

The results from the third study indicate that there is no such thing as a *neutral room*. The importance of the context is inevitable. Changes in one part of the picture affect items that are not changed at all. Changed context changes the wood, and changed wood changes the context. See images 8a and 8b in Figure 1 for the evolution of the images used. This phenomenon requires further study.

The study also shows that it is not possible for the respondents to deal with more than twenty choices without losing focus. A method for reduction is the balanced binary tree used by Silverstein and Farrell (2001), and it proved to be a good way to reduce the number of comparisons without reducing validity. Darker colors seemed to become even darker on the computer screen, and were therefore not chosen as favorites. This has perhaps to be adjusted in order to seem *normal*. Overall, the two-by-two comparison used in this study proved to be a good way to provoke answers.

The results from the fourth study indicate that most people would prefer a computer picture that is something more than physically correct. Somehow, wood makes a strong impression that makes a picture on a computer seem pale, even when the representation is physically accurate. Many respondents chose a picture with deeper colors, stronger contrast, smaller knots and darker material as the picture they thought was most like the photo lab printout. With only two top votes for the *Original* picture (when compared to the photo lab printout) the study supports the opening hypothesis regarding the need for some kind of smart

exaggeration. People need more than just accurately recaptured wood to experience wood on a computer screen as real wood. The results indicate that *Contrast* is the most important property when visualizing wood, both for good and bad visualization (i.e., incorrect contrast makes the visualization *not* work). *Shadows* seem to be the least critical property. These results also provide us with a ranking of the properties.

## 5. Discussions and conclusions

### 5.1 Discussions

Wood is more multimedia than a computer can handle. Visualizing wood in a computer is therefore a bad idea. But we have no choice. The wood material must compete with other materials on the computer screen; therefore we must do the visualization the best way we can.

In papers I and II we found and verified the properties that are of importance when visualizing wood. The results from those papers match each other relatively well. In paper III we found that the context is critical, and we also found a way to reduce the number of comparisons. In paper IV we tested the hypothesis of smart exaggeration and ranked selected properties from papers I and II.

The investigations in this thesis show that there is a difference between what we look at and what we see and experience. This is nothing new. When it comes to colors, Fridell Anter (2000) writes about factors that affect the perceived color: the observer, the surroundings, observation angle, viewing distance, light, gloss and surface structure, size and shape of object and finally, the physical color. Most of these findings also apply in this study, although size and viewing distance are not considered here.

The studies also point up the problems inherent in research that compromises between the qualitative and quantitative paradigms; there are many risks here in the twilight zone—it is important to be precise and to openly present one's methods. Even so, the risk of doing halfway *soft* research is inevitable. Papers I–III fall within the borders of the paradigms, but paper IV is an attempt to measure picture judgments (not preferences), and is therefore naturally at risk for biases.

Biases were discussed previously in chapter 3.5, but will also be taken up briefly here. There are three major bias risks in paper IV: differences between the original digital photographic image and the photo lab printout; lighting and observation angle; and most critical of all, the risk that the *mental picture* will be affected by all the variations and that the memory of it may have varied during the interview. Even though most respondents claimed that they were able to stay with their first *mental picture* throughout the interview, it is reasonable to believe that this mental picture was affected by at least the first pictures in the interview and then melted together into a new picture which, in the best case, was held on to during the remaining interview.

Performing 17 different comparisons is not the optimal interview situation for such a study. The complexity of experiencing wood was in this study increased by dividing it into properties (light, contrast, etc.) which were investigated separately and then combined and analyzed. It cannot be guaranteed that it is the same entirety we are discussing after such a process.

It might have been better to let the respondents walk into a physical room and then walk out again and choose an image on a computer screen. Even better might be enabling respondents to adjust one image instead of choosing amongst many items. Perhaps is this something to consider for further research.

These results support the hypothesis of smart exaggeration of chosen wood properties and indicated the necessity of controlling the context relation. Exaggeration is probably important when it comes to the texture surface (color, contrast and detail), and light is important for the interplay between properties and revelation of the structure of the visualized object. Even

though *contrast* was the most important property, with *color* in second place, *light* is the key to both revealing the rugged wooden structure and managing the interplay between the different properties, the wood object and the surrounding context.

Given the results from these four studies, it is easier to see the entirety of the complex topic of visualization of wooden interiors. The results can be summarized in the sentence, “It’s not what you show, it’s what they see”, but there is, of course, much more to it than that. The results can be divided into issues relating to the whole and issues relating to the parts, or details, which taken together are of course not equal to the whole. The most important issues to think about when visualizing wooden interiors as a whole are the following:

- Try to reach some level of smart modification with exaggeration of such important properties as contrast and colors. The art of computer visualization is ready to go beyond realism, not merely achieving photorealism. Do not say too much too soon.
- Make efforts to make the wood part of the whole and do not let it appear more processed than its surroundings. Most respondents reacted negatively when the elements in the picture were not consistent with each other. Choose your context, but be careful. The context in which the wood is situated is crucial. The wood affects the context and the context affects the wood.

The most important detail issues to think about when visualizing wooden interiors are the following:

- If the right light and color saturation are combined with an adequate level of detail, and if disturbing detail errors are removed, an entirety is produced that, in the best-case scenario, gives the viewer a feeling of understanding. *Right* and *adequate level* do not necessarily mean physically accurate, however. Naturally, disturbing detail errors must be completely eliminated if the picture is to be accepted as a whole. This aspect of visualization is not discussed further in this work.
- Contrast is, as is color, more important than texture (the look of a surface), but the pattern on the surface of the wood can play visual tricks when you zoom in and out of a picture. This is also a question of the level of detail—when you are close to the material in the picture you want to see it, but when you zoom out you want the pattern details to zoom out naturally, too.
- The category *Light* is more than weight, or lamps, or the opposite of darkness; it is also how the light is reflected and on which surfaces. But dark pictures still have problems receiving a fair judgment, since darker colors seem even darker on a computer screen.

Please note that the results from paper IV, which indicated a need for exaggeration, are based only on measuring which pictures were judged to be alike, not which pictures were liked and preferred. In a commercial selling situation, it is naturally also important for the content in the picture to be liked, which would probably entail even more exaggeration. The memory game situation used in paper IV is not as useful for objective studies in which respondents have to remember their choices all the way through as it is for more subjective studies in which the goal is to compare only two images and choose the one that is most appealing.

The studies reported in this thesis were conducted mostly with modified photographs of wooden textures, but the methods used should be valid for modeled and parameterized wood as well. This assumption is based on the fact that modeled textures today look much like photographs.

This study indicates that computer visualization cannot encompass the whole of the experience of wood. There are nonvisual wood values that people miss when looking at a computer screen, important values of warmth, feel and smell that are hard to visualize. For instance, how do we communicate the slightly softer echo from walking on a wooden floor?

## 5.2 Conclusions

Given the results in papers I–IV, some conclusions can be reached.

- Smart exaggeration is desirable, rather than merely correct photorealism.
- Contrast, color and light are as important as the wooden texture itself..
- Being part of the whole is most important.
- The context in which the wood is situated is crucial.
- Understanding is not the same as liking.
- *Light* is more than weight, lamps or the opposite of darkness.

## 5.3 Practical implications of the results

Before an optimal wood visualization can be made for commercial use, more research and development must be conducted. Since smart exaggeration and being part of the whole are more important than merely having a correct texture, it is time to start work with factors that make the wood interact with its context. Light is a good example of this. The light gleam reflecting from the wooden surface tells us that this is not just a flat texture, but a topological and varying structure.

The two ways of making wood into three-dimensional pictures today are with either two-dimensional texture maps or with parameterized wood. Both of these methods concentrate on making the surface look correct. Given the results in this thesis, it is fairly safe to assume the best way to achieve a well-visualized picture of interior wood (one that most respondents would accept) is to exaggerate the colors and the contrast of the texture maps (or parameterized model) and then to make the elements in the picture interact and come to life using the light and its possibilities to reveal the structure and connect the context.

And finally, we must not forget that we never *really* can visualize wood in computers; visualization is something that takes place within each viewer's head and not in computers. The complex phenomenon of experiencing wood that feels authentic, i.e., what we like to call the *rock'n'roll* of wood, requires physical stimulation: “You better knock, knock, knock on wood, baby.”

## 5.4 Future work

In order to verify the results and methods that have been used in this work, more investigations will need to be carried out. The most important issues are:

- The results from paper IV. A new study should be conducted and the results should be compared with the results in paper IV. In such a study, other methods should be used, both for collecting data (just one comparison) and for interpreting it (all aspects must be compared with each other).
- To follow up real product cases that were commercially successful (or not) with a preference study where the visualization results found here are implemented.

Given the results presented in this thesis, it would also be interesting to do more studies into some of the following tracks:

- Further investigate the differences between the wood we see and the wood we think of.
- What is an issue for visualization in general, and what is wood specific?
- Work more with the interplay between properties than ranking of them.
- Treat the property *Light* more carefully as a something more than the opposite of darkness, i.e., how the daylight reflects off the wood surface, etc.
- Do a large, perhaps international, study from which statistically reliable conclusions can be drawn.

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# *Paper I*



## **Visualizing Wooden Interiors** **- What people react to and how they describe it.**

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## **Abstract**

Wood is more than a material with technical characteristics. It is a material with aesthetic qualities and is the object of subjective appraisal. Today it is common to use computers to show how a room or product will look when it is produced. In communicating the aesthetic properties of wood in such cases, the ways people experience wood are of interest, as are what is important to focus on and what is best avoided.

The objective of this study was to explore and gather descriptions of computer-visualized wooden interiors through qualitative interviews. The Grounded Theory method was used to get a map of what people react to in such images. The principle is to sort data into groups consisting of aspects of a certain quality. Eighteen pictures were used in a two-by-two comparison study. 21 persons were interviewed for about 20 minutes each.

The results indicate that good visualization of wood should avoid erroneous details, repetitive patterns and lighting or shadowing errors. Another result is recognition of the difference between seeing and describing. It was hard for respondents to separate what they liked/disliked from what they understood. Most respondents also reacted more to how the wood in the pictures handled shades and colors than to its textures. This could mean that photorealism is no guarantee for getting acceptance for the picture. In addition, more important than high resolution is for wood to be part of the whole picture and not stand out or appear more processed than the surroundings.

## **Note Abstract**

Wood is more than a material with technical characteristics. Objective of this study was to gather descriptions of computer-visualized wooden interiors through qualitative interviews (grounded theory). Pictures were shown in a two-by-two comparison. The results indicate that visualization of wood should avoid erroneous details, repetitive patterns and lighting errors. More important than high resolution is being part of the entirety. Respondents reacted more to how the wood handled shades and colors than to its textures.

# 1. Introduction

## 1.1 Background

Wood is more than a material of technical characteristics to be weighed, measured and calculated. Wood is a material with aesthetic qualities, biological variations and different appearances dependent on wood species and treatment.

It is when wood is used in products where the wood texture is visible that the highest price per cubic meter can be obtained (Wiklund 1992). But in a wood-product chain it is common that knowledge of the preferences of the end customers is poor, especially concerning the aesthetic features of wood (Swearingen et al. 1998, Hansen and Weinfurter 1999, Hansen and Bush 1996, Marchal and Mothe 1994). The industry must become better at communicating wood and its advantages and disadvantages throughout the wood-processing chain (from forestry to housing and recycling). This communication is what we here call "wood communication".

The overall goal for the wood industry is to reach new customers and to keep existing ones. Here, wood, like most other materials, must become a *smart material* easier to use for professionals as well as nonexperts. A computer might be a useful tool to achieve this goal, and one aspect of wood communication is computer visualization. The efficacy and validity of using the computer for visualization is well known and has been documented by Sheppard (2000), among others. It has become more common to use computer-generated images to show how a room or a product will look when produced. To communicate the essence of wood—the *soft* or *qualitative* features (such as visual, tactile and “mental” qualities of wood)—expressed and visualized by a computer is both an interesting opportunity and a challenge because of the medium’s limited means of communication. Vital knowledge is missing about what factors are important when visualizing wooden interiors.

The overall aim of this study is to study human reactions to and perceptions of computer visualizations of wood. If it is possible to discover what people react to and how they describe it, it should be possible to know (or study) which factors are to be given extra consideration in computer visualizations of wood.

## 1.2 Objective

The objective of this study was to explore and gather descriptions of the respondents’ reactions when looking at computer-visualized wooden interiors. The purpose was also to screen for factors that are of importance when visualizing wood. Henceforth, “the respondents” are here understood as the particular sample of people that were chosen for these interviews.

### **1.3 Previous work**

Work concerning wood and visual impressions is presented in articles by Broman (1995a, 1995b), which contain qualitative interviews, but focus on methods of interrogation. Broman (1995b) also investigates people's attitudes towards wood and shows that it is possible to draw adequate conclusions about real, live wood experience from computer experiments. By comparison to Broman (1995a), the study described in this article is more oriented towards conceptions about computer-visualized wood interiors. Architectural scientific discussions regarding "experiencing beauty" are nothing new. During the course of years considerable work has been done (Hesselgren 1971, Hesselgren 1987, Rasmussen 1962) and still is being done. A study about the perceived color of paint (Fridell Anter 2000) is an interesting example, but it is directed more towards color and painted façades.

The entire field of digital picturing and scientific visualization (Cox 1990) is maturing. Substantial advances in computer capabilities and improvements in graphics software have made visualization easier and more accurate, but the research is still somewhat limited (Daniel and Meitner 2001), though some results can be found in the literature. Results indicate that aspects of computer visualization, e.g., resolution and color fidelity, may significantly affect observers' perceptions, understanding and judgments. For example, some features of visualization are known to affect attention and interpretation and to arouse positive and/or negative emotions (Mitchell 1983, Broudy 1987, Cox 1990). Daniel and Meitner (2001) discuss the validity of visualization, but as applied to forest landscapes, not to wooden interiors. However, the studies above deal with visualization in general or of trees, not of wood and/or wooden interiors. Attempts to compare most of today's architectural ways of visualizing wood (model, sketch, computer image, watercolor painting, etc.) were also made by Persson (2001).

### **1.4 Scope and limitations**

This is not a study of wood as a material nor of computer visualization in general. This study concerns wood qualities involved when wooden interiors are computer-visualized. This means wood not isolated, but in a context, and does not include nonvisual qualities such as tactile and sound qualities. Obviously, many of wood's competitive advantages will be missing in such visualization. This study deals with the general problems of computer visualization to the extent that they apply to the experience of interior wood. Other aspects of computer visualization have not been studied.

## **2. Materials and Methods**

### **2.1 Theory**

To learn more about a phenomenon than quantitative data can provide (what we can measure, weigh and scan), it is necessary to use qualitative methods, such as the Grounded Theory (Glaser and Strauss 1968, Eneroth 1984). The idea behind the Grounded Theory paradigm and most other qualitative research theories is not to generate generalizable statistics, but to investigate and understand a phenomenon and to generate theory from data. Here, the Grounded Theory is used for making a map of an unexplored new landscape by dividing a phenomenon into categories, properties and aspects.

### **2.2 The pictures**

Eighteen pictures of interior surroundings (examples in Fig. 1-3) with visible wood elements were produced in the computer. To avoid biased results and to avoid a situation where the researcher is measuring responses to his own pictures, six originals were collected from outside sources such as CAD companies and architects. Each original was varied so as to obtain three versions of each picture with wide variations in light, shadows, color, contrast, etc. A system was prepared on a laptop computer for viewing the pictures two at a time for comparison in pairs. The two-by-two comparison strategy was used because it is considered a good way to provoke opinions where respondents have to choose and then motivate their choice (Silverstein and Farrell 2001).



*Figure 1. Examples of interview pictures. Many respondents preferred colors more intense than normal wood.*



*Figure 2. Examples of interview pictures. Light and a sense of welcome were important for the respondents.*



*Figure 3. Examples of interview pictures. Colors and knots were important for the respondents.*



## 2.3 The interviews

The interviews took place at the Central Station and the City Terminal in Stockholm, Sweden, during a week in June 2002. These locations were chosen so as to get as broad a random selection of respondents (age 20–70, both sexes, varied education, style, origin and interests) as possible, all in accordance with theory (Glaser and Strauss 1968, Miles and Huberman 1994). Except from sex and age, no background data was however noted, since this sample was not intended for quantifying the importance of the aspects. The study aimed at exploring and gathering possible aspects that may be of importance when visualizing wooden interiors. The places were also chosen to find enough people willing to take the time necessary for the interview, about 20 minutes.

Twenty-one persons were interviewed, all in Swedish. Eighteen of the respondents, nine of each sex, completed the interview and these were used in this study. In order to influence the respondents as little as possible, the wording of the questions was deliberately kept vague, although the purpose of the questions was quite precise. After a short introduction to the study, only one main question was used to start up the response from the respondents. This question was: *Which picture do you think is "better"?* No difference was explained or made between *better* and *more realistic/more beautiful/I like it*. No mention of the wood itself was made in the main question (although the pictures were dominated by wooden objects). This was done to avoid directing the respondent to wood as a subject. The comments about wood textures came naturally as part of the description of the pictures. Supporting questions, used when needed, consisted of expressions like these: “And why do you think this picture is better?” “Is *better* the same as *more natural*?” “Is the difference obvious?”

According to the Grounded Theory paradigm, the collection of data is ended when the answers stop presenting much new data. After 18 persons not very many new words and descriptions were used (expressions like “lonely” and “true” started to recur) and the amount of data was sufficiently stable to make a map of expressions. To be sure, three more interviews were conducted. The interviews were recorded on a minidisc recorder; supporting notes were also taken on paper. About six hours of interviews were recorded, which resulted in about 15,000 characters on the paper transcription.

## 2.4 Data processing

In order to take in all aspects of the data and to lift them to a generally applicable level, they have to be summarized. The principle (Miles and Huberman 1994) is to group data under different qualities, i.e., to sort the explained data into different groups, each consisting of a cluster of aspects of a certain quality. The goal is to find a small number of qualities which allow each datum to be transferred to one of the qualities, i.e., constitute an aspect of one of the qualities. In this closing phase, the important thing is to concentrate the data into qualities that together explain something about the examined phenomenon. The parts of the six-hour recorded interview data that contained useful words and phrases connected (even slightly) to wood were transcribed exactly (about 300 different sentences) and then thoroughly and systematically grouped and regrouped into different categories according to theory. Since the pictures were dominated by wood, most responses also had a connection, even if vague, to wood. This grouping and regrouping continues until the researcher thinks the map of expressions

gives a fair picture of the interviews. Naturally, this puts the researcher in crucial control of the data and the result. The subject of the study was "Experiencing Computer-Visualized Wooden Interiors", and this *phenomenon* was divided into *categories* and *properties*. Each property had several different *aspects*. (Fig. 4)

### 3. Results

The result of a qualitative study is a somewhat ordered map of aspects (Miles and Huberman 1994).

After grouping and regrouping (to give as complete a survey map as possible), four main categories were found (Fig. 4). How people describe what they see and react to can be described by the four categories here named *Appraisal*, *Reality*, *Entirety* and *Spirit*. These categories are simply a way for the researcher to sort the data and could of course be named something else.

The data within the category *Appraisal* deals not so much with the details and the wood itself as with the respondent's personal taste and opinions. This category is sorted into the properties *Opinion* and *Taste*. *Opinion* contains judgments such as "optical illusion", "looks like a hospital" and "everything on a computer is unrealistic". *Taste* is more concerned with judgments like "delightful", "awesome" and "kitchens should be bright". This category, *Appraisal*, is too personal to be a real part of this study and is noted as information only.

The category *Reality* contains opinions about how real and naturalistic the pictures seemed. Since this is more connected to the personal judgments of the respondents than to physical objects in the pictures, the data in the category *Reality* is highly subjective, whereas the categories *Entirety* and *Spirit* are less subjective (more oriented towards objects in the picture), although not fully objective. Even so, *Reality* contains features in wood, such as knots. The properties here are *Material*, *Realism* and *Clarity*. Opinions like "imitation of wood", "untreated wood" or "feels like concrete" would come under the category *Material*, whereas "like a drawing", "strange" or "like expected" fit under *Realism*, and "knots and stuff are visible", "legible details" and "more of the structure" come under *Clarity*. Altogether, the properties in the category *Reality* have significance when the viewer is interested in details and in the material itself.

*Entirety* and *Spirit* are of great interest in this study, since they are more easily connected to details in the pictures and with opinions such as "dimmed" or "disturbing detail". In these categories are the factors that affect the whole, the comprehensive picture (Fig. 4).

The category *Entirety* contains two properties, *Harmony* ("light balance", "washed out" and "calmer") and *Detail error* (a repetitive pattern or a "flying" lamp without cord). *Entirety* shows that a single erroneous detail can ruin the whole picture. The tolerance for this was very low among all respondents.

The interviews show that the features within the category *Spirit* are decisive for the understanding of wood. *Spirit* contains properties such as *Light*, *Contrast*, *Color*, *Life*

and *Warmth*. In the *Light* category, people noted characteristics such as “dimmed”, “dazzling” or “the shadows are gone”, but also commented on the actual lightness/darkness in the material, and in *Contrast* they—naturally—talked about “contrasts”. *Color* contains such aspects as “clear colors”, “pale” or “matching colors” and *Warmth* such aspects as “cooled”, “too cold”, “warm”, etc. *Life* is the property dealing with presence; it holds diffuse feelings such as “alive”, “stiff”, etc. This is just one way to look at the category *Spirit*; the data are of course interlinked and interactive (Fig. 5).

Another result was the difference between what people see and how they describe it. Usually the respondents saw one erroneous thing and described the whole picture in terms of that, even though the opposite also occurred. It was hard for the respondents to separate sensory impression from comprehension, i.e., what they liked/disliked and what they understood. The term “understand” here stands for understanding what the respondent sees in the picture, the perspective, the furniture and the material, etc. Some respondents—regardless of age and sex—tended to like wood that was more wood than wood is, i.e., hyperrealistic, in brighter colors and higher contrasts than real wood. Others, on the other hand, did not. Such variations in opinion are a natural element when researching subjective descriptions.

Photorealism (to look like a photograph) seems to be no guarantee for getting acceptance for the picture. Sometimes the respondents claimed that they liked one picture better, but understood the other one better.

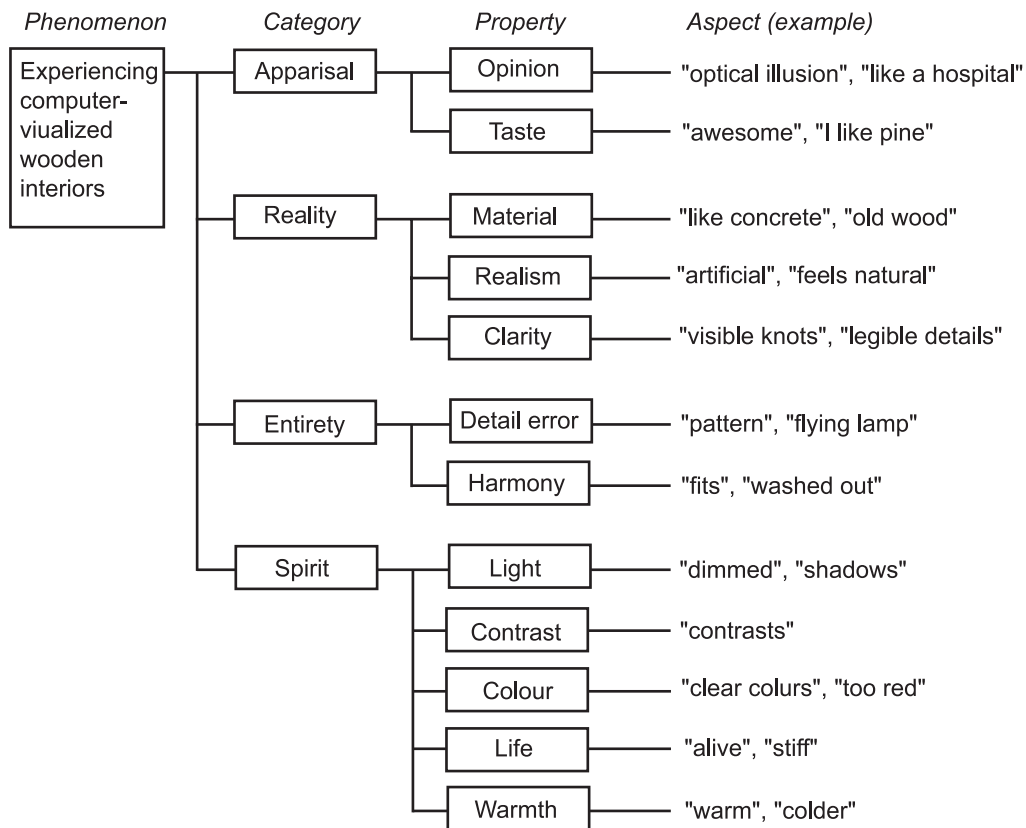


Figure 4. Experiencing Computer-Visualized Wooden Interiors. Sorted descriptions.

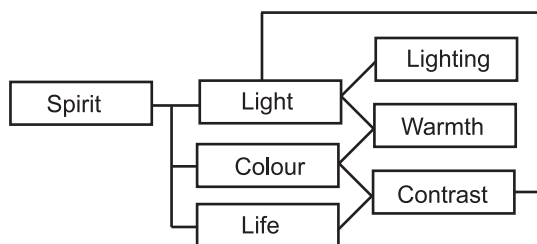


Figure 5. Interacting properties within the category Spirit.

## 4. Discussions and conclusions

### 4.1 Limitations

To study a phenomenon as complex as this could be considered too much at once, but on the other hand, the only way to study wood in its context is to do it in its context. However, previous attempts (Persson 2001) show that not limiting it to only computer-generated pictures would have made the study task immense. For example, although the judgments in the category *Appraisal* that concern associations (“looks like a hospital”) are interesting, they have not been further investigated in this study, since they are difficult to use for the purposes of the study.

### 4.2 Interpretations/implications

The researcher has crucial control over the answers by choosing which pictures are to be discussed. That is, if he or she chooses a picture with a lighting error, he often gets the answer "light". Therefore awareness of this problem is important. This risk was found during pretesting of the pictures and could therefore be managed. The pretesting also showed that the free form of the interviews gave the desired result. Since the researcher also interprets the answers, he or she has a double responsibility. This is, however, also an advantage, as the researcher is in control of the material.

Within the category *Spirit* is also the “diffuse light” that could be considered as “how the light is reflected by the surface structure”. This aspect may require further investigation.

### 4.3 Importance

The results conform to common sense and were not unexpected, even if they sometimes point in different directions. This is normal, of course, when researching subjective phenomena. Factors outside the nature of wood itself greatly affect our experience of wood. It is hard to draw a distinct line between the appearance of the wood interiors and attitudes relating to other phenomena that influence the pictures. Light, shadows and colors all interact to provide us with a complete picture; therefore, they also influence how we understand wood. However, wood normally exists in a context, which is why an isolated wood study probably would not have given better map of descriptions.

This result is a roadmap for further research, but it also gives an idea of what should be avoided when using computers for visualizing wooden interiors, as mentioned below.

### 4.4 Conclusion

Experiencing wood is a quite complex affair. A number of factors (look, feel, smell) cooperate in giving us the impressions we get (“I miss feeling the structure and warmth, wood doesn’t work on a computer screen”). Wood is a great deal more multimedia than a computer can handle. Although no single factor that divided the answers into two logical groups was found, still many of the findings are of interest, both for further research on the experience of wood and for visualization in general.

The results of this study indicate that to produce a picture that most people would accept, the person visualizing wood will have to carefully avoid disturbing the whole with single erroneous details, repetitive patterns and lighting or shadowing errors. The natural wood pattern reveals any attempt to fake it. In addition, more important than high resolution is for wood to be part of the whole picture and not stand out or appear more processed than the surroundings. When it comes to experiencing wood, the biggest bias is perhaps that it is very hard for viewers to differentiate between what they understand from the picture and what they like in it. This means that it might be easier to understand what kind of wood the picture is supposed to communicate and how it looks in one picture, but because of other factors, such as the aspects in the category *Spirit* and the picture composition, it might be easier to like another picture. This is, of course, something to consider when visualizing wood: “is this a *selling* picture or an *informative* picture?”

Furthermore, the researcher has a great responsibility to interpret the words the viewers try to describe their experiences with. Knowing this, it is important to discuss the validity of the results with other researchers.

This study indicates that computer visualization can’t encompass the whole of the experience of wood. For instance, how do we communicate the slightly softer echo from walking on a wooden floor? And finally, we must not forget that we can’t *really* visualize wood in computers; visualization is something that takes place within each viewer’s head.

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# *Paper II*



# Visualizing the Qualities of Wood

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## Abstract

Wood is more than tensile strength, moisture content and biological degradation. The hard, quantitative characteristics have been investigated for decades, but wood has also soft, or qualitative, features.

Communicating the advantages of the whole material, even the softer qualities, such as visual and aesthetic impressions, has become increasingly important when trying to reach new customers and keep existing ones.

The computer has become a useful tool in this effort.

The overall aim of this study is to study people's descriptions of computer-visualized wood. Three different groups were interviewed regarding eighteen pictures with visible wood interiors and various executions in a two-by-two comparison. Grounded Theory has been used to explore, gather and sort the descriptions into a map of a unexplored phenomenon.

The result is a ordered map of aspects. They indicate that a successful visualization should avoid disturbing the whole with erroneous details, repetitive patterns and lighting errors. The natural wood pattern reveals any attempt to fake it. The right composition of light and color combined with the adequate level of detailing gives the viewer the entirety, which gives her the possibility to discuss her comprehension i.e. what the viewer sees or think she sees in the picture. Many respondents preferred wood in hyper-realistic colors. Perhaps is some kind of smart modification instead of photo-realism sometimes the goal.

Further research it could try to verify and rank the importance of the found aspects by conducting a study where the respondents could compare modified computer images with an original.

# 1 Introduction

## Background

Wood is a material like most other materials. It has technical, or quantitative, characteristics and also soft or qualitative features. The technical characteristics are and have been thoroughly investigated through years of research, but the attitudes and feelings towards wood are sadly not as well-documented. In the wood product chain, the knowledge of the final customers' preferences is poor, especially regarding the aesthetic features of wood (Swearingen et al 1998, Hansen and Weinfurter 1999, Marchal and Mothe 1994). Also, the research regarding aesthetic features of wood and people's preferences for different looks of wood has so far been rather limited. Although some studies have been carried out both in Europe and Japan (Marchal and Mothe 1994, Mazet and Janin 1990, Nakamura et al 1993) the lack of knowledge in this field is very evident.

Broman (1995a, 1995b) has been working with visual impressions of wood and people's attitudes towards wood and even with qualitative interviews, but was focused on methods of interrogation. Broman (1995b) also shows that it is possible to draw adequate conclusions about wood experience from computer images of wood. When compared to Broman (1995a), this study is more oriented towards conceptions about computer-visualized wood interiors.

Considerable work has, during many years, been conducted in the field of architectural discussions about experiencing beauty (Hesselgren 1987 and Rasmussen 1962). But even though the field of digital picturing is some decades old, social scientific studies of people's reactions to computer-visualization are still hard to find.

Communicating the whole material, even the softer qualities, such as visual impressions, has become increasingly important when trying to reach new customers and keeping existing ones in times of harder competition. This communication is what here is called "wood communication". Pakarinen (1999) states that it is important not only to put emphasis on design, the manufacturers also have to sell wood by its aesthetic features. The computer could be a useful tool in this communication, but how well does wood adapt to being trapped on a computer screen?

## **Objective**

The overall aim of this study was to gather, explore and sort the respondents' descriptions of computer-visualized wood and to describe these descriptions. A bonus effect of this objective is the screening for factors that are of importance when visualizing wood. What factors per se or in cooperation can give a true feeling about the wood visualized? If it is possible to find and describe what people react to, it should be possible to know which factors that are of most importance when computer-visualizing wood and also which of these factors are easily transferred into technical parameters that is possible to control. Henceforth, "the respondents" are here understood as the particular sample of people that were chosen for the interviews in this study.

Yesterday, technology was not ready for this. Today technology is ready, but are we? Or are we still computer teenagers impressed by any dazzling attempt to make an object alive on the screen?

An earlier study (Nordvik 2003) was using the same image material, but executed with interviews one-by-one. In this study the interviews are conducted in small groups instead, to get more input data.

## **Scope and limitations**

This study concerns wood qualities involved when wooden interiors are computer visualized. This means wood as a part of the whole, in a context, and does not include nonvisual qualities (such as tactile or sound features). Obviously, many of woods competitive advantages will be missing in such a visualization. This study deals with the general problems of computer-visualization as long as it is adequate for the experience of interior wood. Else, computer-visualization in general has not been studied.

## **2. Materials and Methods**

### **Theory**

To learn more about a phenomenon than quantitative data can provide (what we can measure, weigh and scan), it is adequate to use qualitative methods, such as the Grounded Theory (Glaser and Strauss 1968). The idea behind most qualitative research, including Grounded Theory, is not to generate generalizable statistics, but to investigate and understand a phenomenon and thereby generate theory from data. The Grounded Theory is in this effort used for sorting a phenomenon into categories, and thereby make a map of an unexplored new landscape.

### **The pictures**

Eighteen pictures with visible wood interiors (examples given in fig. 1-3) were produced. To avoid a situation where the researcher measured his own pictures and thereby gets biased results, the six original images were collected from outside sources such as construction and architectural companies. Each original was varied so as to get three versions of each picture with clear variations regarding lighting, shadows, detailing, color contrast etc. A laptop computer was prepared for viewing the pictures two-by-two for comparison in pairs. The reason for the two-by-two comparison was that the goal was to gather reactions and it is common knowledge that the easiest way to provoke opinions regarding something is to compare it with something else (Silverstein and Farrell 2001). The respondents then have to choose and justify their choice.



Figure 1. Example of interview pictures; Space and Warmth. Many respondents preferred hyper-realistic colors to understand the picture as “warm”. *“It doesn’t bring out the wood. The color contrast is too small between the wood and the rest.”*



Figure 2. Example of interview pictures; gleam and reflections. Gleam and reflections were important to understand the picture as realistic. *“There are no daylight reflections on the floor, its unreal”.*



Figure 3. Example of interview pictures; Composition and Shadows. Many respondents spoke of the picture composition and how it affected them. *“That foreground wall should be cropped away”.*

## The interviews

Inspired by the ideas behind focus groups (Krueger 1994, Morgan 1998) for gaining the data input three groups were put together. The members of the groups were chosen to get three distinct groups: one younger group (20-30 years), one older group (40-60) and finally one expert group (architecture, construction and wood people etc). All groups were Swedish and between 4-5 persons of both sexes and already acquainted and comfortable with each other, all in accordance with theory (Morgan 1998).

The interviews, or discussions, took place in Skellefteå. They lasted approximately one hour and were recorded on a minidisc recorder; supporting notes were also taken on paper. The researcher led the discussion and passed the word. The main question was “*Which picture do you think is better?*”

No difference were explained or made between *better* and *more realistic/more beautiful/I like it* etc. Supporting questions, which were used when needed, would consist of expressions like “And why do you think this picture is better?”, “Is *better* the same as *more natural?*”, “Is the difference obvious?” “What do you mean by *warm?*” etc. After these three groups, many of the comments were similar, i.e. no new data occurred and the input data was assessed as of sufficient amount.

The researcher has to interpret the words the respondents try to describe their impressions with. Therefore, this study’s exact terms only are adequate in Sweden, even if the results and the methods could be of interest worldwide and the methods are possible to repeat and therefore adequate .

The researcher also chooses what pictures are to be discussed. Thereby, he or she has decisive control over the answers. That is, if the researcher chooses a picture he or she thinks has a lighting error, the respondents often naturally give the answer ”light”. Awareness about this bias problem is important. Since the researcher is also interpreting the answers there is a double responsibility. This is, however, also an advantage, as the researcher is in control of his material.

## Data processing

In order to take in all aspects of the data and to lift them to a generally applicable level, they have to be summarised. The principle (Miles and Huberman 1994) is to group data under different *categories*, i.e. to sort the explained data into different groups, each consisting of a bundle of *aspects* of a certain *property*. The goal is to find a small number of properties, which allows each datum to be transferred to one of the properties. i.e. constitute an aspect of one of the properties. In this closing phase, the important thing is to concentrate the data into categories that together explain something about the examined phenomenon.

The useful words and phrases of the recorded interview data were transcribed exactly and then thoroughly and systematically grouped and regrouped into different categories according to theory. The subject of the study was ”Describing Computer-Visualized Wooden Interiors” and this *phenomenon* was divided into *categories* and *properties*. Each property had several different *aspects*. (Tab. 1)



### 3. Results

A total of 12 persons divided in three groups were shown 18 pictures, in a to-by-to comparison. The result of a qualitative study is a somewhat ordered map of aspects (Miles and Huberman 1993). For each group, the sessions lasted for about an hour.

After grouping and regrouping (to give as complete a survey map as possible) more than 500 descriptions, the data were divided into a map (Tab. 1). Mind that this map is strictly a map of how the comments are sorted, not a map of which factors that are of importance when visualizing wood. What the respondents talked about when they tried to describe wooden interiors was worked into four categories; *Light*, *Color*, *Entirety* and *Comprehension*. Personal views and pure appraisals are not taken into this map, and are therefore sorted under the side-category *Appraisal*. Also, statements regarding the *Purpose* of the image are side-sorted. Nevertheless, both of the left-out categories are taken into consideration in this study.

Each category in the description map (Tab. 1) has its own properties. *Light* and *Color* are more concerned with specific factors, whereas the two other categories deal with descriptions of the whole picture; the *Entirety* or what the respondents can understand or guess from the given pictures (*Comprehension*).

| CATEGORY             | PROPERTIES  | ASPECT  |
|----------------------|---|---|
| <b>THE LIGHT</b>     | <ul style="list-style-type: none"> <li>- LIGHTING</li> <li>- GLEAM</li> <li>- SHADOWS</li> <li>- COLOR CONTRAST/PALE</li> <li>- WARMTH/WELCOMING</li> <li>- LIGHT ERRORS</li> </ul>   | <p>"gives that fluorescent lamp feeling"<br/> "no daylight reflections on the floor, its unreal"(Fig 2)<br/> "very strange shadows"<br/> "color contrast too small between the wood and the rest."(Fig 1)<br/> "this is a cold environment"<br/> "that mirrored light doesn't make sense"</p>   |
| <b>THE COLORS</b>    | <ul style="list-style-type: none"> <li>- COLOR CONTRAST/PALE</li> <li>- WARMTH/WELCOMING</li> <li>- TREATMENT</li> </ul>  | <p>"it doesn't look like wood with these colors"<br/> "the upper shelves are a bit wishy-washy"(Fig. 3)<br/> "warmth feels more welcoming"<br/> "soap-scrubbed and gleamy floor"</p>  |
| <b>ENTIRETY</b>      | <ul style="list-style-type: none"> <li>- LIFE</li> <li>- DEPTH/ SPACE</li> <li>- WEIGHT</li> <li>- REALISM <ul style="list-style-type: none"> <li>- PHOTO</li> <li>- COMPUTER-MADE</li> </ul> </li> <li>- COMPOSITION <ul style="list-style-type: none"> <li>- COMPUTER TECHNIQUE</li> </ul> </li> <li>- STYLE</li> <li>- DISTURBING DETAIL ERROR <ul style="list-style-type: none"> <li>- PERSPECTIVE</li> <li>- SHADOWS</li> <li>- SCALE</li> <li>- REPETITION</li> <li>- LIGHT ERRORS</li> </ul> </li> </ul> | <p>"irritated if I don't understand how it's connected"<br/> "like it was alive", "sterile"<br/> "a ceiling painted white gives a feeling of space" (Fig. 1)<br/> "too heavy, takes too much room"<br/> "I believe this is a photograph"<br/> "this feels computer-made"<br/> "that foreground should be cropped away" (Fig 3)<br/> "too low pixel resolution"<br/> "wood doesn't really fit into that furnishing"<br/> " the floor boards have wrong direction" (Fig. 2)<br/> "no shadows – it's flying"<br/> "the knots are way too big"<br/> "you've taken a small wood surface and just repeated it"<br/> "where does the light come from?"</p> |
| <b>COMPREHENSION</b> | <ul style="list-style-type: none"> <li>- RESEMBLANCE</li> <li>- CONSTRUCTION</li> <li>- TREATMENT</li> <li>- MATERIAL <ul style="list-style-type: none"> <li>- WOOD SPECIFIC</li> <li>- OTHER MATERIALS</li> </ul> </li> <li>- LEGIBLE DETAILS</li> </ul>   | <p>"feels like an industrial area."<br/> "solid wood construction"<br/> "newly varnished" (Fig. 2)<br/> "mixed heart wood"<br/> "linoleum mat"<br/> "you can see the knots"</p>   |
| .....                |   |   |
| <b>APPRAISALS</b>    | <ul style="list-style-type: none"> <li>- OPINION</li> <li>- TASTE</li> <li>- STYLE</li> </ul>   | <p>"equal amount of information in these two images"<br/> "I would not buy these kitchen cabinet doors"<br/> "feels too much like my childhood in the seventies"</p>  |
| <b>PURPOSE</b>       |   | <p>"it depends on where you should use it"</p>  |

Figure 4. Experiencing Computer-Visualized Qualities of Wood. A map of descriptions. Some properties are shared by two categories.

**The Light** is the first category. It is divided in *Lighting, Gleam, Shadows, Color contrast (or Paleness), Warmth* and *Light error* where *Lighting* are lamps, spotlights and other created light. Light is the most common category in all the answers and all the groups. Many respondents tend to describe light as the single most important factor, especially errors in light matters are of decisive importance. For a good example of gleam and shadows, see Fig. 2. Examples of the comments could be “*where does the light come from?*”, “*a cold light that doesn’t communicate the colors of the room*”.

**The Color** shares some properties with the previous category, like *Color contrast* and *Warmth*, but also *Treatment* and - of most importance here - the *Color* itself; Color seems to be very important for the overall “wood feeling”, for instance when distinguishing wood from painted non-wood materials. Color was also often the first thing the respondents reacted at, at the same time as they decided whether the picture was realistic or not. For a good example of the color importance, see Fig. 1. Examples: “*The colors are too pale, it feels not like wood*”, “*strange colors*”, “*not wood, looks painted*”

**Entirety** deals with the respondents comments about the whole picture, both general expressions like *Life, Depth/Space* or *Weight* but also whether the picture feels *Realistic* (“*computer-made*”, “*like a photograph*”) or not. Comments about space only occurred in one single picture, a very bright one (Fig. 1).

Also, the actual *Composition* of the picture is discussed as well as the overall *Style* (whether it feels like the environment fits in one furnishing style). *Detail errors (Scale, Perspective, Shadow, Repetition* etc) are very critical and could disturb the whole experience of the picture. The tolerance for this is very low among all respondents.

For a poor example of this, see Fig. 2, and it’s direction of the floor boards. Examples: “*if it has no knots or yearning pattern it is not wood*”, “*I don’t understand how it’s connected*”

**Comprehension** is the category where people talk about what they see or think they see or understand in the pictures. Here are the opinions about what the interior surrounding looks like, *Resemblance* (“*a hospital*”, “*a school at night*”) and, more interesting for this study, comments about *Construction, Treatment* and most important; comments regarding the *Material*. Such comments are often very precise; “*This is heartwood*”, “*imitation of wood*”, “*feels like concrete*” would come under the property *Material*. Details are also discussed, i.e. how *Legible details* are shown. This experienced legibility has a direct connection to the resolution of the computer wood surface. Details could be small natural features in wood, such as knots. For a poor example of material feeling, see fig. 3. Examples: “*You don’t have to wonder whether it’s computer-made or not, makes you feels safe*”, “*Its wood alright, I can see the knots*”.

The data within the side-category **Appraisals** deals not so much with the details and the wood itself, but more with the respondent's personal taste and opinion. This category is sorted into the properties *Opinion, Taste* and *Style*. *Style* is also a property of the category **Entirety**. *Opinion* contains general judgements such as “*small differences between the pictures*”. *Taste* is more concerned with judgements like “*delightful*”, “*awesome*” and “*kitchens should be bright*”. *Style* talks about matching; “*That modern chair doesn’t fit in such a picture*”.

Another result of this study is that many respondents were asking for the **Purpose** of the picture and said that they needed to know what the picture was meant for before they could comment it. This could be seen as no picture stands for itself and is neutral, but more of a victim of its context.

Yet another result was the difference between what people see and how they describe it. It was hard for the respondents to separate sensory impression from comprehension, i.e. what they liked/disliked and what they understood. *“More realistic to the right, but more appealing surroundings to the left”*.

Some respondents - regardless of age and sex - tended to like wood that was more wood than wood is, i.e. hyperrealistic in brighter colors and higher contrasts than real wood. More of the respondents reacted to shades and colors, than to textured details.

Thus, photo realism (to look like a photograph) seems to be no guarantee for getting acceptance for the picture. Sometimes the respondents claimed that they liked one picture better, but understood the other one better.

## 4. Discussions and conclusions

Visualizing wood in a computer is a rather bad idea. A lot of wood natural advantages disappear on the screen, while a lot of other materials *disadvantages* also disappear. The coldness of a stone material is for instance not communicated. But, computer-visualization provides us with ways to communicate things not yet built or things too ungainly for a seller to bring. Therefore, computer visualization is a tool for the future and we must learn to communicate what we can and cannot communicate through the computer.

The results of this study indicate that to receive a picture that most people would accept, the person visualizing wood will have to carefully avoid disturbing the whole with single erroneous details, repetitive patterns and lighting or shadowing errors. The natural wood pattern reveals any attempt to fake it. In addition, more important than high resolution is for wood to be part of the whole picture and not stand out or appear more worked on than the surroundings. When it comes to experiencing wood, the biggest bias is perhaps that it is very hard for viewers to separate between what they understand and what they like. It might be easier to understand what kind of wood the picture is supposed to communicate and how it looks in one picture, but because of other factors, such as the colors, light and the picture composition, it might be easier to like another picture. This is of course something to consider when visualizing wood; *“is this a selling or an informative picture?”*

The main categories were *Light, Color, Entirety* and *Comprehension*. *Details* were a part of the *Entirety*. These four categories are parts of a map of the sorted comments, not a map of what factors that are of most importance when visualizing wood. They impact in different ways. Color is, for instance, a factor that is easy to vary, while comprehension is experienced and completely beyond the researchers control. One conclusion that is possible to draw is that the right light and color combined with the adequate level of *Details* gives the viewer the *Entirety*, which in turn gives her the possibility to discuss the comprehension i.e. what the viewer sees or think she sees in the picture.

Many respondents asked for the purpose of the picture, and what kind of room it was. Others did not like the room, and had therefore hard times to describe the wood at all. This shows that it is impossible for wood to become free from the surroundings when you visualize wood.

Some of these findings are general for all kinds of computer visualization (like shadows and crucial detail errors), but some seems to be special for wood visualization. Examples of this is that color and light seems to be more important than detailing. This could mean that photo realism is not the goal. This also matches the global trend amongst architects and visualizers to go beyond realism, to say more than just imitating a photograph. Or, a more earthbound example; Worldwide furniture company IKEA:s web-based “room visualizer” never promises more than they can keep (“dark wood” or “light wood”).

Some respondents demanded wood that was more woody than wood is, i.e. in brighter and shinier colors than natural wood is when you see it live. Here is it also possible to draw the conclusion that photo realism does not do all the work. Thus, some kind of smart modifications, where the colors and light is enforced, could be is the goal.

One important thing in the Grounded Theory paradigm is to compare the first maps with later ones. Compared with the earlier study (Nordvik 2003) with the same materials, these results

do consist of mostly the same properties and aspects as the first one. Some new elements were found, like *Composition* and *Style*, but most important was that the effort to bring judgments like *Warm* and *Life* into more precise meanings succeeded.

Features beside the features in wood itself greatly affect our experience of wood. It is hard to draw a distinct line between the appearance of the wood and the attitudes concerning other phenomena that influence the pictures. Light, shadows and colors all interact to provide us with the whole picture; therefore, they also influence how we understand wood. However, wood normally exists in a context, wherefore an isolated wood study probably would not have given a true picture.

These findings confirm both the initial findings (Nordvik 2003) for instance regarding the importance of light and colors and it is also a roadmap for further research at the same time as it gives an idea about what should be avoided when using computers for visualizing wooden interiors.

One question still remains; If we know what people talk about when looking at wood, do we necessarily know what we need to take into extra consideration when visualizing wood? Does it work both ways?

The overall aim of this study was to study human descriptions of computer-visualization and describe these descriptions. And also to answer some questions:

\* What factors per se or in cooperation give a true feeling about the wood studied?  
The right color, light (shadows, daylight, lightness) and adequate level of details could give an entirety that can bring understanding of the wood material.

\* Which of these factors are easily transferred into technical parameters that are possible to control?  
Color, Light and Details – in this order, but since entirety is so important, why bother finding out which factor is of the most importance?

\* Yesterday, technology was not ready for this. Today technology is ready, but are we? Technology is ready. We could be ready. If we are awake and critical.

In further research it would be interesting to try to verify and rank the importance of the found aspects by conducting a study where the respondents could compare modified computer images with an original.

Finally, we must not forget that we can't really visualize wood in computers; a visualization is something that takes place within each viewer's head. And wood is still much more multimedia than a computer can handle.

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# *Paper III*



# Metod för mätning av människors preferenser för synligt trä med hjälp av Internet

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## SAMMANFATTNING

Detta utvecklingsarbete är finansierat av Svenskt Trä och arbetet faller inom två prioriterade FoU områden, synligt trä och marknad.

Det är av intresse att studera och analysera marknaden för synligt trä för att på så sätt producera rätt träutseende till rätt produkt och till rätt kund. Val av träkvalitet till en produkt bestäms alltför ofta i produktionsledet utan god information om känslighet för olika blandningar av träegenskaper (smakprofiler) bland sina tänkta slutkunder. Det finns idag ingen etablerad teknik för och kunskap om hur man kan mäta folks preferenser för olika träutseenden.

Målet har varit att utveckla en metod för preferensstudier där synligt trä står i fokus och som ska kunna användas av företag och branschorganisationer. Målet är också att presentera de skillnader i tycke och smak som råder bland de intervjuade personerna, dels för att verifiera tidigare resultat och föreslagna metoder och dels för att visa på metodens möjligheter så att den kan utvecklas vidare till att bli ett användbart verktyg för marknadsstudier.

I denna undersökning har enbart utseenden på trägolv av parkettyyp studerats och endast ett visningsrum har använts dock med förändring av dess utseende och möblering under studiens gång. Ett 50-tal personer har deltagit och svarat tre gånger var under utvecklingsprocessen. Frågorna har förbättrats och rummets utseende har varierats. Förbättringsarbetet fortgår och det är snart dags att offentliggöra länken så att fler har möjlighet att delta. Fler exempelprodukter kommer att studeras.

Ett konkret resultat av FoU arbetet hittills är den mötesplats på nätet <http://trasmak.tt.luth.se>, som utvecklats för att mäta preferenser för olika utseenden på trä. Intervjukonceptet är självinstruerande och interaktivt där de intervjuade svarar på frågor som rör deras visuella intryck och trätexturernas utseende. Det kanske viktigaste resultatet av FoU arbetet är att det går att mäta vad folk föredrar och till viss del varför.

Metoden bygger på att man rangordnar bilder av ett och samma rum men med olika trägolv med hjälp av parvis jämförelse. När rangordningen är gjord ställs frågor med både öppna och fasta svarsalternativ för att få en beskrivning av orsaken till personens val.

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Principal Component Analysis, PCA tillsammans med enkla tabellsammanställningar har använts med framgång för att beskriva resultaten av intervjustesterna. Grupper av olika smakriktningar kan ses även om testpersonerna var få. De olika träslagens utseende har beskrivits i ord av de intervjuade vilket kan vara värdefullt för en fullgången marknadskommunikation i träförädlingskedjan.

Miljöns (rummets) betydelse för hur människor väljer har en större roll än vad vi initialt trodde. Det mesta pekar på att vi ej kan använda oss av ett ”neutralt rum” och sedan mäta människors allmänna inställning (smakprofil) till olika träutseenden. Man bör använda sig av vad producenten tror är den rätta miljön för sin produkt med ett specifikt träutseende (riktad till en speciell målgrupp). I en sådan situation är det av största intresse för företaget att undersöka om deras antagande var rätt genom att använda metoden (när den är färdig) och testa av flera träutseenden och inte bara den nyligen framtagna ”träkvaliteten”. Svaret de får är om tänkt köpargrupp är stor nog för att våga satsa på den nya produkten eller kanske att något annat träutseende var bättre än de annat.

Resultat av använd metodik ger bl.a. en trendbild av de olika smakriktningar som finns bland de som ingått i studien. Människors preferenser ändras med tiden. Dock är sådana resultat viktiga att lyfta fram för att väcka intresse för marknadsstudier och träindustrin kan på så sätt utvärdera om liknande studier eller metoder kan användas för deras egna produkter.

I det fortsatta FoU arbetet skulle det vara önskvärt att aktuell metod testas på en större grupp människor. Både öppet deltagande och styrd sampling av de intervjuade kommer att tillämpas. T ex vore det intressant att studera om det finns skillnad i preferenser mellan vanliga konsumenter och föreskrivare/specialister.

Kopplingen mellan använd råvara och människors preferenser ger en anvisning om vilka träegenskaper som bör undvikas och vilka som skulle kunna nyttjas i större utsträckning än idag.

# INLEDNING

## Bakgrund

Drivkraften för den träindustriella processen är konsumenternas vilja att köpa dess produkter. Trä är ett material med estetiska egenskaper som rätt utnyttjat kan ge fördelar framför andra material. När vi köper en produkt så köper vi funktion, form och ett utseende. Det är när trä används synligt som det högsta priset per kubikmeter trä erhålls<sup>16</sup>. Människors preferenser för vad som är vackert är olika, det vet vi. Därför är det av intresse att studera och analysera marknaden för synligt trä för att på så sätt producera rätt träutseende till rätt produkt och till rätt kund.

Varje plank och bräda har sina individuella egenskaper vilket skapar både möjligheter och problem för den trämekaniska industrin. Idag ser man inte den biologiska variationen som något positivt utan mer som något som försvårar klassificering av råvaran till olika råvarukvaliteter. För produkter med synligt trä skulle det vara en fördel om det fanns sätt att kommunicera de från marknaden önskade estetiska egenskaper och därmed bättre kunna ta tillvara den naturliga variationen av egenskaper som finns i råvaran och möjliggöra förädling av denna.

Kunskapen om människors tycke och smak är bristfällig vad gäller olika blandningar av träegenskaper för produkter innehållande synligt trä. Den tillverkande träindustrin har ofta dålig information om sina slutkunders preferenser för olika träinnehåll<sup>8,9,14</sup>. Det finns led mellan producent och konsument som kan utgöra hinder för en fullgången marknads-kommunikation<sup>2</sup>. De marknadsnära kontakterna, säljare, återförsäljare eller grossister är främst av ekonomisk art och den information som återförs till produktionssidan är om en produkt säljer eller inte. Mer sällan rapporterar man orsakerna till varför en produkt säljer eller ej. Val av träkvalitet till en produkt bestäms alltför ofta i produktionsledet utan bra information om känslighet för olika blandningar av träegenskaper (smakprofiler) bland sina tänkta slutkunder. I Sverige finns en lång tradition av träbearbetning och en kultur vad som är god eller dålig träkvalitet och det gör att många träegenskaper klassas som värdelösa redan vid sågverken. Idag finns inga kända studier som visar t.ex. att folk ogillar svarta, torra eller kluvna kvistar. Anledningen till att dessa sorteras ut som dålig kvalitet torde vara av mer produktionsrelaterad karaktär.

Från intervjuer med svenska träsäljare, som gjorts inom ramen för en pågående förstudie inom området Träkommunikation, pekar intervjuerna på att vi måste komma närmare slutkunden med våra träprodukter. Att analysera slutkundens preferenser och beslutsprocess samt hur attityder och preferenser kan påverkas upplevs som mycket angeläget.

Alltså, en bättre verktyglåda behövs för att kunna mäta och kartlägga subjektiva attityder och omföra dessa till objektivt mätbara parametrar som förstås av den producerande industrin.

Det finns idag ingen etablerad teknik för att mäta folks preferenser för olika träutseenden. Forskning på området är eftersatt både i Sverige och övriga världen. Därför har detta intresserat LTU, avdelningen för Träteknik i Skellefteå, under ett antal år. I en doktorsavhandling med titeln "Means to Measure the Aesthetic Properties of Wood"<sup>5</sup> har Broman arbetat både med kvalitativa och kvantitativa studier i syfte att utveckla metoder för att omföra subjektiva preferenser till kvantifierbara resultat. Arbetet är tvärvetenskapligt och föreslagna metoder liknar de som används inom forskning och produktutveckling för mat<sup>10,11</sup>. Avhandlingen visar på lämpliga frågor att ställa, hur intervjuresultaten ska analyseras samt hur sambanden mellan blandningen av objektivt mätbara träegenskaper och intervjuresultat

kan analyseras. Avhandlingen skall ses som ett första steg och som en kunskapsbas till att utveckla metoder att mäta estetiska egenskaper hos trä.

## Projektet

Detta utvecklingsarbete är finansierat av Svenskt Trä och arbetet faller inom två prioriterade FoU områden, synligt trä och marknad.

Projektets idé är att använda Internet som hjälpmedel för att utveckla en metod för att kartlägga slutkonsumenters känslighet (tycke och smak) för olika blandningar av träegenskaper dvs. träutseenden. Att använda sig av färdiga produkter med olika träinnehåll vore självklart bäst men synnerligen kostsamt och ej praktiskt. Alternativet är att visa datorbilder av olika trästrukturer applicerat på en given produkt. (Resultat visar att likvärdiga resultat nås vid användande av datorbilder jämfört med att använda enkla trätytor<sup>4</sup>).

Internet erbjuder här en möjlighet. Man kan nå fler människor än vid platsberoende undersökningar. När intervjupaketet väl är utvecklat, sjösatt och testat en gång kan man förbättra intervjumetoderna och genomföra fler studier till en låg kostnad. Detta skulle underlätta utvecklingsprocessen dels ur kunskapsperspektiv och dels ur ett metodutvecklingsperspektiv. Erfarenheter från preferensstudier av människors visuella intryck av olika landskapsbilder med hjälp av internet har använts<sup>3,6,15</sup>.

Nuvarande produkt som studeras är utseendet på trägolvet och ambitionen är att metoden skall testas för andra produkter. Bilder av trätexturer med olika träinnehåll appliceras på en och samma exempelprodukt. Intresset från industrin är stort men metoden (rangordning, sätt att visa bilder, frågor och analys av svar) behöver förbättras ytterligare innan den är direkt tillämpbar för industrin. Andra exempelprodukter skall även studeras. Val av produkter, träslag och vilka marknader som skall studeras har gjorts i samråd med en referensgrupp.

*Denna rapport är en delredovisning av det pågående FoU arbetet. Exempel på framtagen metod för att mäta människors smakprofiler för olika träutseenden med hjälp av internet kan ses på länken <http://trasmak.tt.luth.se>. För att förstå diskussionen om metodutvecklingen och resonemang kring resultaten är det bra om läsaren har provkört testet.*

Nuvarande intervjukoncept är självinstruerande och interaktivt där de intervjuade svarar på frågor som rör trätexturernas utseende. Ett 50-tal personer har deltagit och svarat tre gånger var under utvecklingsprocessen. Frågorna har förbättrats och rummets utseende har varierats. Förbättringsarbetet fortgår och det är snart dags att lägga ut länken så fler har möjlighet att delta. Både öppet deltagande och styrd sampling av de intervjuade kommer att tillämpas i det fortsatta utvecklingsarbetet. Det sätt på vilket man visar trästrukturerna för de intervjuade är en viktig faktor att studera.

## Mål

Huvudmålet är att utveckla en metod för preferensstudier där synligt trä står i fokus och som ska kunna användas av företag och branschorganisationer. Målet är också att presentera de skillnader i tycke och smak som råder bland de intervjuade personerna, dels för att verifiera tidigare resultat och föreslagna metoder och dels för att metoden kan utvecklas vidare till att bli ett användbart verktyg för marknadsstudier.

## Avgränsningar

I denna undersökning har enbart utseenden på trägolv av parkett-typ studerats och golven var gjorda av kända lövträslag. Endast ett visningsrum (modell av ett rum) har använts dock med förändring av dess utseende och möblering under undersökningens gång.

Den viktigaste avgränsningen är tiden, den tid en intervju (test) får ta eftersom ambitionen har varit att intervjukonceptet skall vara självinstruerande och attraktivt så att de som hittat dit också genomför testet med bibehållet intresse. Detta har ställt höga krav på begränsningar i form av antal bilder (varianter) att visa och antal frågor att ställa.

## MATERIAL OCH METODER

Flera utvecklingssteg av den i rapporten redovisade hemsidan för preferensundersökning har skett mer eller mindre samtidigt och kontinuerligt.

### Val av produkt och trätexturer

Golv som exempelprodukt valdes därför att den är en viktig del av ett rum och troligtvis har betydelse för (påverkar) de flesta människor. Antal olika trægolv reducerades till 7 st för att hålla ned intervjutiden. Enbart parkettgolv studerades då det är en vanlig produkt (utseende) i landet. Trätexturerna som använts är digitala bilder av golv som säljs på marknaden. Golven valdes så att en stor spridning i utseenden erhöles (ljus-mörkt och lugnt-livligt).

### Intervjupersoner

Personer som intervjuades var främst anställda vid Luleå tekniska universitet, inst. i Skellefteå, men även personer som på andra sätt kommit i kontakt med utvecklingen av metoden. Anledningen till denna begränsning var osäkerhet om hur självinstruerande och förståelig undersökningen skulle te sig för vilt främmande deltagare. En stor fördel med denna nära grupp människor var möjligheten till återkoppling och dialog. Ett antagande var att tycke och smak mest är personberoende och i mindre grad kopplat med var man arbetar. De intervjusvar som samlats in från denna grupp av intervjuade människor kan bara anses gälla för denna grupp och är i stort sett inte generaliserbara.

### Intervjuer i fyra omgångar

Ett första pilottest genomfördes där forskaren deltog passivt som observatör och den intervjuade fick kommentera (tänka högt) vad som fungerade bra och dåligt. Förslag till förändringar och förbättringar framkom på ett naturligt sätt.

Därefter följde tre intervjuomgångar utan forskarens närvaro:

- Test 1: Första version av visningsrum (Bild 1) och frågor.
- Test 2: Repetition av Test 1 två veckor senare för att mäta förändring av svar (osäkerhet i bedömning).
- Test 3: En månad efter Test 2. En förbättrad version både vad gäller rummets utseende, frågor samt svarsalternativ (se Bild 2).

Alla de sju olika golven kan ses i bilaga 2 med rummets utseende enligt Test 3.

### Rummets utseende

Ett val gjordes mellan att använda ett riktigt foto av ett rum och byta ut golvet mot en rad träutseenden eller att skapa en modell av ett rum. Den senare lösningen valdes då skuggor och ljus lättare kan skapas på ett likartat sätt för alla varianter av golv.

Rummets komposition skapades så att golvet fick en central betydelse för det allmänna intrycket. Ett fönster lades in så att ljus och skugga skulle falla in och skapa naturtrogenhet. Grundtanken var också att försöka skapa ett så neutralt rum som möjligt för att alla utvalda varianter av golv skulle kunna passa (vara tänkbara). Rummet gjordes därför om från att innehålla en boisering (Bild 1) till ett än mer neutralt rum (Bild 2).





**Bild 1** – Rummets utseende i testomgång 1 och 2. Björkgolv.



**Bild 2** – Rummets utseende i testomgång 3. Björkgolv.

## Layout på undersökningens hemsida (ses i bilaga 1, bild A1-A12).

Layout och utformning gjordes så att följande egenskaper uppfylldes:

- Attraktivt, intresseväckande förstahandsintryck så att personer som hittar dit vill fortsätta. För att stärka viljan att delta kan utlottning av någon populär produkt bland dem som deltar vara ett bra sätt (här exemplet två sittmöbler).
- Ren och enkel layout där det tydligt framgår att det är en seriös organisation som ligger bakom studien.
- Skall fungera även på mindre bildskärmar t.ex. bärbara datorer.
- Maximal storlek på rumsbilderna så att så mycket av egenskaperna hos trätexturerna framgår.
- Möjlighet till mer information om forskningen på området.
- Möjlighet till återkoppling via en mailadress.
- Möjlighet till att vara helt anonym (dock utan att delta i utlottning av vinsterna).

## Intervjukonceptets delar

Direkt efter förstasidan fås en introduktion av hur testet kommer att gå till och en uppmaning till inte tänka för länge då första intrycket säger mest. Om en presumtiv testperson vill vara med trycker denne på start och genomför undersökningen som består i följande tre faser:

- Rangordning av rumsbilderna (där bara golvet ändras) med hjälp av parvis jämförelse.
- Frågor kring det bästa och sämsta golvet för att detektera hur bra det golv är som valdes främst och hur dåligt det golv är som hamnat sist i rangordningen (A6, A9).
- Frågor där den intervjuade får både fritt och enligt svarsalternativ beskriva det bästa och sämsta golvet i dess miljö (A7, A8, A10, A11).
- Personbeskrivande frågor med koppling till heminredningsintresse (A12)

## Frågor

Frågorna i undersökningen syftar till att inte bara mäta vad de intervjuade föredrar utan även varför. Tre varianter av svarsalternativ användes, skalor, öppna och fasta svarsalternativ.

## Parvis jämförelse

Parvis jämförelse valdes för att det är en bra metod för att rangordna saker i situationer där antalet objekt som skall rangordnas är många och framförallt i situationer med objekt som nästan är lika. I denna studie valdes parvis jämförelse också för att det är praktiskt omöjligt att på en datorskärm visa sju rumsbilder samtidigt.

Den parvisa jämförelsen gjordes ej som en komplett jämförelse (enl. principen alla mot alla) utan som en reducerad variant som bygger på en sorteringsmetod med balanserat-binärt-träd, beskriven av Silverstein och Farrell<sup>12, 13</sup>. Denna metod resulterar i att sannolikheten att ”bästa” jämförs med ”sämsta” minskar (valet självklart) och sannolikheten ökar att två bilder som ligger nära varandra jämförs (enligt den intervjuades smakprofil). I stället för 21 jämförelsepar (7 bilder) vilket en komplett jämförelse skulle ha krävt erhöles ca 14 stycken jämförelser. Metoden minskar också risken för att de intervjuade tröttnas ut.

## Resultatfil

De intervjuades svar lagras automatiskt i en resultatfil på den server som används för ändamålet. De personer som vill vara anonyma uppger helt enkelt inte sin mailadress (men kan då inte vara med i utlottningen av vinsterna). Lösenord krävs för att komma åt genererad resultatfil. Genererad resultatfil kan med lätthet överföras till t ex programmet EXCEL.

## Analysen

Principal Component Analysis, PCA<sup>1,7</sup>, användes för att beskriva variationen bland de intervjuades tycke och smak. Vanliga tabellsammanställningar gjordes också som komplement till detta.

Rangordningen av rumsbilderna resulterade i att varje golv tilldelades poäng från 7 till 1 där 7 var bästa golvet. Denna hypotetiska skala korrigerades utifrån vad de intervjuade svarade på frågorna om hur mycket de tyckte om det bästa golvet och ogillade det sämsta (frågor ses i bild A6 och A9). För att begränsa intervjutiden efterfrågades endast preferensdata för det bästa och sämsta golvet och övriga golv fördelades likformigt däremellan. Tabellen nedan illustrerar ändrad skalning för en person som inte varit säker på att vilja ha det bästa alternativet och inte direkt ogillat det sämsta golvet.

**Tabell 1** – Exempel på ändrad skala av rangordningens resultat för en enskild individ

|                 | Bäst  | ----- | ----- | ----- | ----- | ----- | Sämst |
|-----------------|-------|-------|-------|-------|-------|-------|-------|
| Rangordning     | golv4 | golv3 | golv2 | golv1 | golv5 | golv7 | golv6 |
| Ursprungspoäng: | 7     | 6     | 5     | 4     | 3     | 2     | 1     |
| Omskalad poäng  | 4     | 3.71  | 3.42  | 3.12  | 2.83  | 2.54  | 2.25  |

## RESULTAT

Ett konkret resultat av FoU arbetet hittills är den mötesplats på nätet <http://trasmak.tt.luth.se>, som utvecklats för att mäta preferenser för olika utseenden på trä. Det kanske viktigaste resultatet av FoU arbetet är att det går att mäta vad folk föredrar och till viss del varför. För att förstå diskussionen om metodutvecklingen och resonemang kring resultaten är det bra om läsaren har provkört testet.

De människor som utfört testen är en begränsad skara och de faktiska resultaten kan därför bara anses gälla för denna grupp. Testet har körts i tre omgångar där 29 personer har gjort alla tre testerna:

- Test 1: Rummets utseende enligt Bild 1.
- Test 2: Lika som Test 1, men två veckor senare, för att se hur svaren varierar per individ.
- Test 3: Rummets utseende ändrat, se Bild 2. Testet gjordes 1 månad efter Test 2.

Ett 50-tal personer har genomfört två av dessa tre tester och ytterligare 17 personer har genomfört testen bara en gång.

Resultatet av den i studien genomförda rangordningen genom parvis jämförelse kan ses i Tabell 2. Tittar man på medelrangpoängen för respektive golv ser vi att inga stora förändringar sker mellan de tre testkörningarna. Sett över alla testpersonerna rankades *körsbär* främst och därefter *al*, *björk*, *lönn* eller *ek*, *ekplank* och sist *valnöt*. Studerar vi den tredje testomgången i relation till de två först omgångarna ser vi att *körsbär* och till viss del *al* har ökat och att *björk*, *ek* och *lönn* har tappat i attraktionskraft. Inför testomgång 3 ändrades miljön i visningsrummet, däribland väggbeklädnad och betraktarens närhet till golvet, vilket kan vara en förklaring.

Granskar vi hur många 7:or, 6:or osv. respektive träslag fått ser vi *körsbär* och *al* som vinnare och *valnöt* som förlorare. Vi ser också för golven *ekplank*, *lönn*, *ek* och *björk* finns tendens till två grupper av smakinriktningar, de som gillar och de som ogillar respektive utseende.

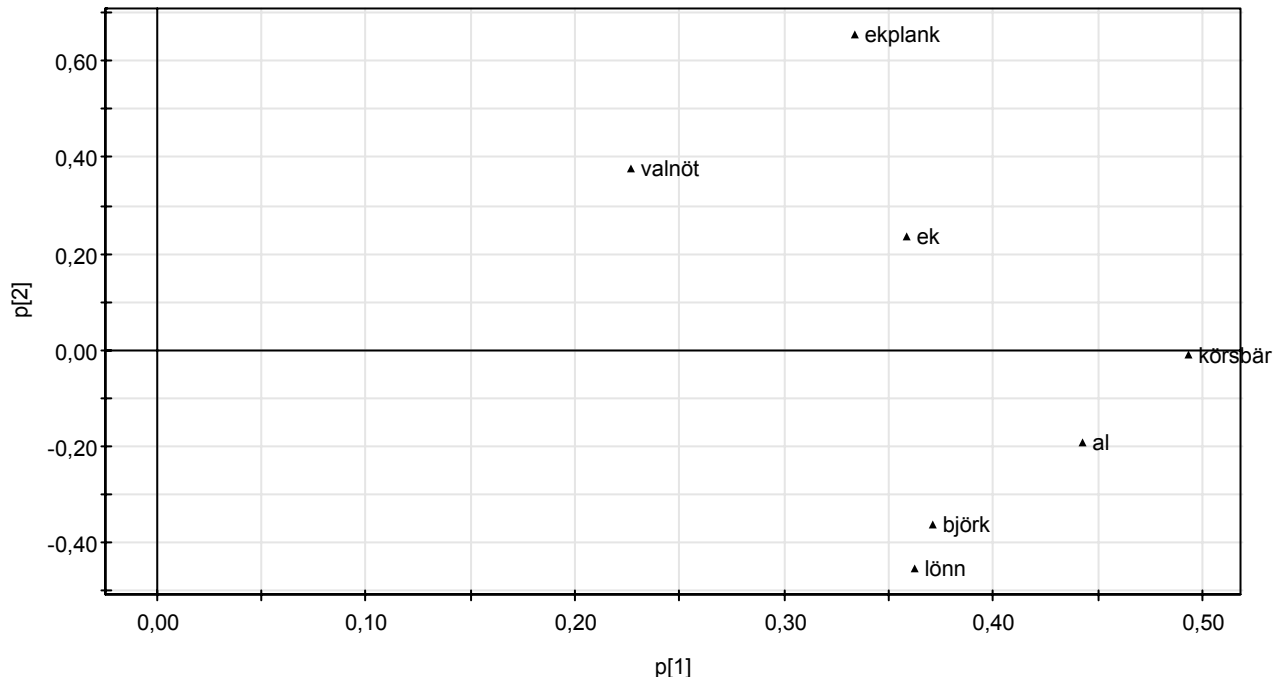
**Tabell 2** – Procentuell fördelning av hur de intervjuade rangordnade de olika trägolven i de tre testerna. Skalan är likformig mellan ytterlägena 7 för det bästa och 1 för sämsta golvet.

|               |                   | <i>al</i>  | <i>björk</i> | <i>ek</i>  | <i>körbär</i> | <i>lönn</i> | <i>ekplank</i> | <i>Valnöt</i> |
|---------------|-------------------|------------|--------------|------------|---------------|-------------|----------------|---------------|
| <b>Test 1</b> | <b>Medelpoäng</b> | <b>5,0</b> | <b>4,4</b>   | <b>4,1</b> | <b>5,8</b>    | <b>4,0</b>  | <b>3,2</b>     | <b>1,6</b>    |
| 42 pers       | Antal 7:or        | 12         | 14           | 7          | 43            | 10          | 14             | 0             |
|               | Antal 6:or        | 26         | 7            | 19         | 24            | 17          | 7              | 0             |
| (%)           | Antal 5:or        | 38         | 21           | 10         | 17            | 5           | 5              | 5             |
|               | Antal 4:or        | 10         | 29           | 19         | 7             | 21          | 12             | 2             |
|               | Antal 3:or        | 10         | 17           | 29         | 5             | 29          | 7              | 5             |
|               | Antal 2:or        | 2          | 10           | 17         | 5             | 14          | 31             | 21            |
|               | Antal 1:or        | 2          | 2            | 0          | 0             | 5           | 24             | 67            |
| <b>Test 2</b> | <b>Medelpoäng</b> | <b>5,2</b> | <b>4,8</b>   | <b>3,9</b> | <b>5,5</b>    | <b>4,4</b>  | <b>3,3</b>     | <b>2,1</b>    |
| 40 pers.      | Antal 7:or        | 23         | 13           | 8          | 30            | 18          | 10             | 0             |
|               | Antal 6:or        | 23         | 20           | 8          | 30            | 15          | 5              | 0             |
| (%)           | Antal 5:or        | 33         | 18           | 20         | 10            | 13          | 5              | 3             |
|               | Antal 4:or        | 5          | 35           | 13         | 18            | 13          | 15             | 3             |
|               | Antal 3:or        | 13         | 8            | 33         | 13            | 33          | 3              | 0             |
|               | Antal 2:or        | 5          | 8            | 20         | 0             | 3           | 45             | 20            |
|               | Antal 1:or        | 0          | 0            | 0          | 0             | 8           | 18             | 75            |
| <b>Test 3</b> | <b>Medelpoäng</b> | <b>5,3</b> | <b>4,0</b>   | <b>3,8</b> | <b>6,2</b>    | <b>3,8</b>  | <b>3,3</b>     | <b>1,6</b>    |
| 51 pers       | Antal 7:or        | 12         | 6            | 2          | 53            | 12          | 14             | 2             |
|               | Antal 6:or        | 35         | 10           | 14         | 29            | 6           | 6              | 0             |
| (%)           | Antal 5:or        | 31         | 22           | 16         | 6             | 14          | 10             | 2             |
|               | Antal 4:or        | 12         | 27           | 18         | 6             | 25          | 6              | 6             |
|               | Antal 3:or        | 10         | 22           | 33         | 4             | 12          | 14             | 6             |
|               | Antal 2:or        | 0          | 8            | 16         | 2             | 27          | 35             | 12            |
|               | Antal 1:or        | 0          | 6            | 2          | 0             | 4           | 16             | 73            |

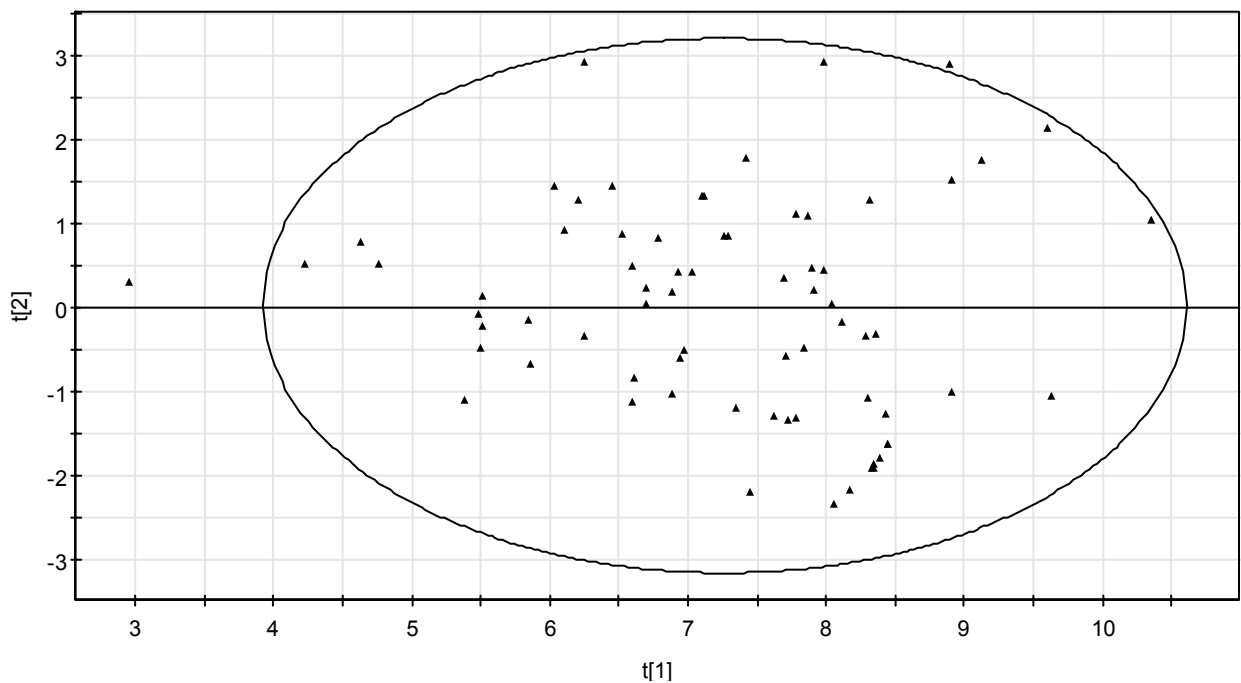
## Principal Component Analysis

För att grafiskt och visuellt beskriva hur testpersonerna har rangordnat de olika golven gjordes en analys av intervjudatats principalkomponenter. Fördelen med denna teknik är att man får en överblick över variationen i datasetet. I Figur 1 ses hur variablerna ”laddar” principalkomponenterna (kan förklaras som de bakomliggande huvuddragen i intervjudatat).

Golv som är långt från varandra har bedömts som olika och golv som ligger nära varandra som lika. Horisontell riktning visar den allmänna preferensriktningen och den lodräta riktningen skiljer mellan mörka (övre delen) från ljusa träslag (nedre delen). *Om vi grovt betraktar alla intervjuade samtidigt så är golv av körbär och al bäst åtföljt av björk, lönn, ek, ekplank och lägst poäng för valnöt.*



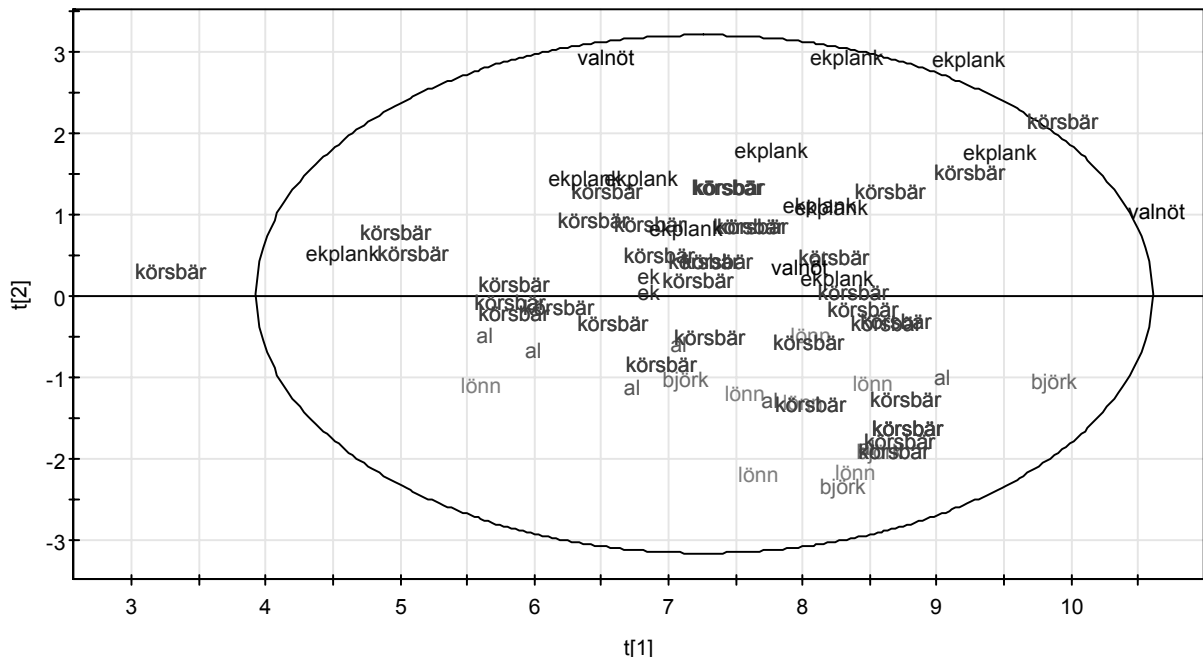
**Figur 1** – Loading plot som visar hur de olika variablerna (golven) laddar principal-komponenterna (grundstrukturen inom variationen i intervju svaren). Variablernas (golvens) vikt representeras av avståndet från origo. Första principalkomponenten p[1] särskiljer de golv som fått högst ranking av flest personer (körsbär) från de som erhållit i lägst ranking (valnöt) Komponent p[2] särskiljer mellan mörka (uppe) och ljusa träslag (nere)



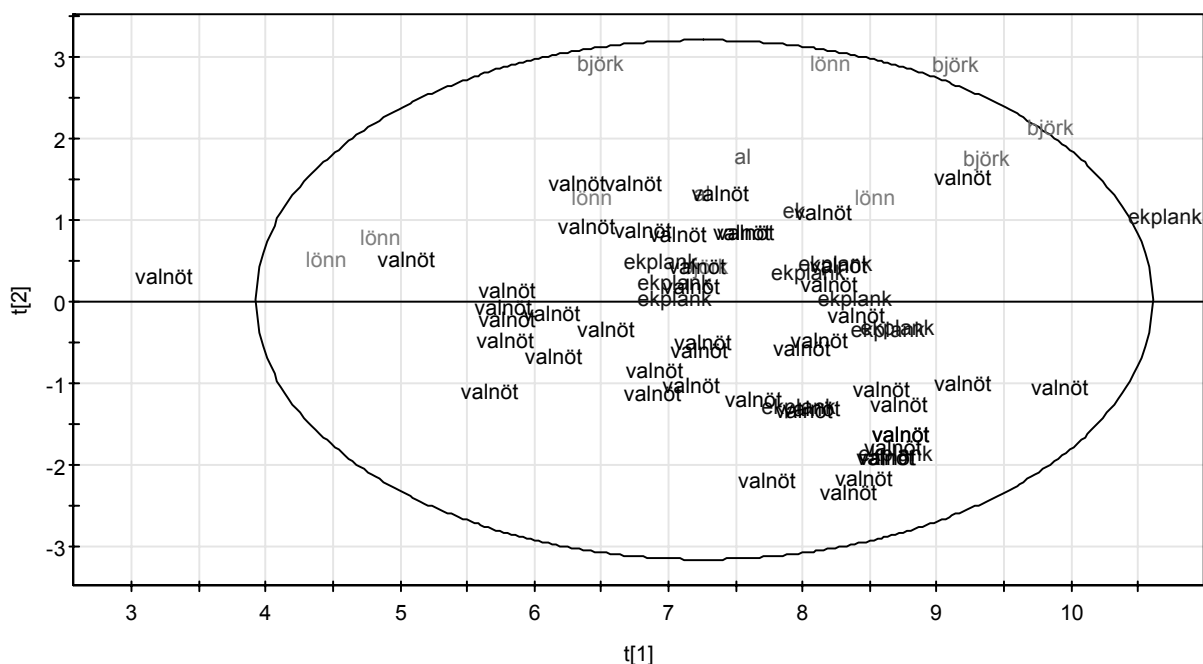
**Figur 2** – Score plot som visar variationen i hur de intervjuade har rangordnat de 7 olika golven. Varje prick är en person och varje individs position bestäms av hur de rangordnat golven. Individer som ligger långt nere till föredrar de ljusare träslagen och de som ligger långt upp de mörka träslagen.

## Analys av Bästa och Sämsta golv

Mer intressant blir det om vi i Figur 2 granskar hur de svarande fördelar sig i motsvarande scoreplot eller preferensrymd och där varje prick är en individ. Figur 1 och 2 är direkt jämförbara (superimposible) vilket innebär att en position i den ena figuren motsvarar samma position i den andra figuren. Alltså, de personer som ligger långt nere till höger i Figur 2 har gett högre rangpoäng för träslagen lönn, björk, al och körsbär och låga poäng för valnöt, ekplank och ek. Tvärtom gäller för de personer som ligger högt upp i Figur 2, de föredrar de mörkare träslagen före de ljusare.



**Figur 3** – Samma score plot som figur 2 men med respektive individs ”bästa golv” visat. Ljusa träslag har givits ljusgrå markering och vise versa.



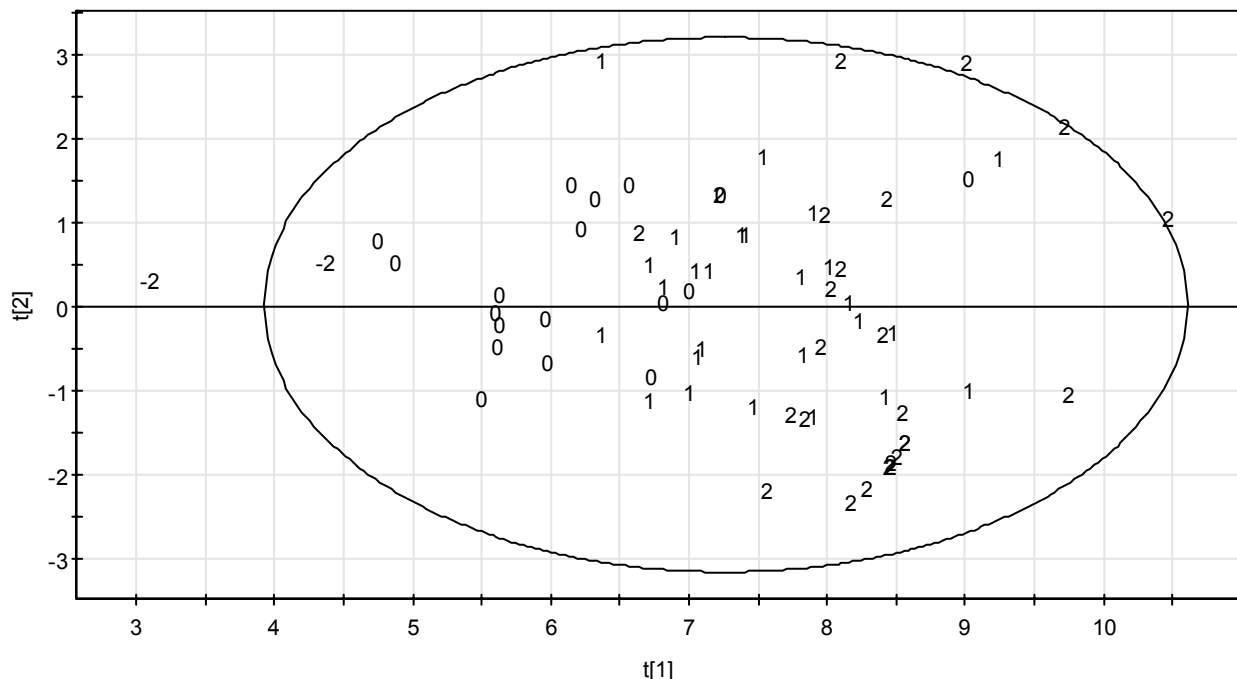
**Figur 4** – Samma score plot som figur 2 men med respektive individs ”sämsta golv” visat. Ljusa träslag har givits ljusgrå markering och vise versa.

I Figur 3, som är samma som Figur 2, har de golv som valts som favorit visats på dess rätta position. Figur 4 visar vilka golv de intervjuade rangordnat som sämst och detta stöder resultatet angivet i fet stil ovan. Om gruppen av intervjuade människor hade varit stor skulle det vara motiverat och fullt möjligt att försöka dela upp de svarande i fler mindre grupper eller kluster baserat på mer precisa smakprofiler. Detta görs ej i denna rapport.

Än mer intressant blir det när vi betraktar Figur 5 som visar hur starkt de intervjuade vill ha golvet som de röstat fram som det bästa. Skalan i bilden är:

Vill ha (2) (1) (0) (-1) (-2) Vill ej ha [\*]

Vi ser alltså att de intervjuade personer i högra halvan av Figur 5 är säkra eller ganska säkra på att vill ha det golv de röstat fram som bäst och tvärtom för den vänstra halvan i figuren.



**Figur 5** – Identisk med figur 2 men med illustration av hur mycket respektive individ vill ha det golv de rangordnat främst enl. skala i fem steg:  
Vill ha (2) (1) (0) (-1) (-2) Vill ej ha.

Bland de intervjuade har i princip alla gett svaret att de inte vill ha (-2) det golv de röstat fram som sämst. Detta resultat bekräftas av Tabell 3, som visar fördelningen av svaret på frågan om hur mycket de vill ha det bästa och hur mycket de ogillar det sämsta golvet. Tabellen visar att endast 43 procent av de intervjuade verkligen ville ha det bästa golvet och att 83 procent inte ville ha det golv de sorterat ut som det sämsta.



**Tabell 3** – Fördelning i procent av svaret på frågan ”Vad tycker du om golvet egentligen?”

och svarsalternativet enligt [\*] ovan. Alla 155 intervju svar.

| Svarsalt. | Bästa (%) | Sämsta (%) |
|-----------|-----------|------------|
| 2         | 43        | 1          |
| 1         | 31        | 1          |
| 0         | 20        | 1          |
| -1        | 3         | 15         |
| -2        | 4         | 83         |

#### Förändring av val (rangordning) mellan de tre försöken

För att på något sätt fånga hur de intervjuades val av rangordning varierar beroende av tid, allmän osäkerhet i bedömningen och/eller rummets utseende presenteras i Tabell 4 hur många i procent som ändrat sitt val vad gäller bästa och sämsta golv.

**Tabell 4** – Procentuell fördelning av hur många som ändrat sitt val av Bästa och Sämsta golv mellan testomgångarna. Inom parentes anges i procent hur många som gjort en radikal ändring i sitt val.

| Mellan test-<br>omgång nr: | Ändrat val i procent |          |
|----------------------------|----------------------|----------|
|                            | Bästa                | Sämsta   |
| T1 <-> T2                  | 42 (6.5)             | 6.5 (0)  |
| T1 <-> T3                  | 54 (43)              | 26 (8.6) |
| T2 <-> T3                  | 52 (30)              | 24 (8.7) |

Granskar vi talen i tabellen så ser vi att ändringen i val av bästa och sämsta golv är minst mellan testomgång 1 och 2 (ingenting ändrat förutom att det gått två veckor mellan testerna). Granskar vi hur många som radikalt ändrat sitt val (siffror i parentes) ser vi samma trend men helt andra och lägre nivåer. Förklaring: Ett radikalt val har skett om den intervjuade personen ändrat sig mer än ett steg längs skalan ljust till mörkt golv (*lönna – björk – al – körsbär – ek – ekplank – valnöt*). Tabellen stöder slutsatsen att rummets utseende har större betydelse än tidsfaktorn och eller den allmänna osäkerheten i valet.

Analyserar vi inte bara förändringen i valet av rangordning vad gäller det bästa och det sämsta golvet utan bland alla de olika golvutseendena samtidigt, utgår vi från hur de enskilda personerna förflyttat sig i en scoreplot (typ Figur 2). Plotten visas ej här men i Tabell 5 redovisas medelvärde och standardavvikelse för denna förflyttning. Absolutvärdena är ej viktiga utan det är jämförelse av storleksordningen för de tre fallen.

**Tabell 5** – Den totala förflyttningen (baserad på hela rangordningen per individ) mätt som distansen mellan varje individs positioner i en scoreplot för de tre intervjustesterna. Talen är enhetslösa, det är den relativa jämförelsen som är viktig.

|                   | Mellan testomgång nr: |           |           |
|-------------------|-----------------------|-----------|-----------|
|                   | T1 <-> T2             | T1 <-> T3 | T2 <-> T3 |
| Antal personer    | 30                    | 40        | 39        |
| Medelförflyttning | 1,06                  | 1,46      | 1,37      |
| standardavvikelse | 0,56                  | 0,71      | 0,90      |

I tabellen ser vi att både medelvärde och standardavvikelse för denna förflyttning (ändrad smakprofil per individ) är minst i jämförelsen mellan testomgång 1 och 2 och är större när vi ställer de två första med testomgång 3. Enda skillnaden mellan första och andra testomgången var en tidsfaktor på två veckor medan i Testomgång 3 hade visningsrummet ändrats en del. Detta pekar på att hur rummet ser ut och är möblerat har betydelse för hur vi väljer golv. Jämförelsen mellan testomgång 1 och 2 kan möjligen ses som uttryck för de intervjuades ambivalens (eller osäkerhet) i valet av golv.

## De intervjuades beskrivning av det Bästa och Sämsta golvet

De intervjuade ombads beskriva det golv som de rangordnat främst och det som hamnat sist genom att bocka för de beskrivande ord som angivits i förväg, se bild A8 och A11 i bilagan. Denna möjlighet fanns bara i försöksomgång 3 och resultatet ses i Tabell 6 och 7, som beskriver vilka ord de använt för respektive träslag (golv). I Tabell 6 ser vi att av 40 personer har 21 st valt *körbär* som favorit, 6 personer *lönn* osv.

Det var så få som valt *björk*, *ek* eller *valnöt* som bästa golv att slutsatser angående dessa ej kan dras (ljusgrått).

Vi ser att de som valt de två mest ljusa golven *lönn* och *björk* ej använt samma beskrivande ord som övriga. Golv av *lönn* beskrivs som ljust, trivsamt, fräscht, harmoni och i viss mån stilrent, luftigt, lätt och modernt.

*Algolvet* beskrevs som ljust, varmt, trivsamt, livfullt och i viss mån luftigt, rofyllt, fräscht, lätt och balans medan storfavoriten *körbär* som harmoniskt och i viss mån balanserat, fräscht, varmt och trivsamt.

De som valt *ekplank* som favorit (från gruppen mörka träslag såsom *ek*, *ekplank* och *valnöt*) har också valt en något annorlunda beskrivning. Ord som användes var stilrent, trivsamt och i viss mån lugnt, fräscht eller prydligt.

**Tabell 6** – Fördelning per träslag hur de använt svarsalternativen (Bild A8) för att beskriva det BÄSTA golvet. Testomgång 3 (procent).

|              | <b>Lönn(6)</b> | <b>Björk(2)</b> | <b>Al(5)</b> | <b>Körbär(21)</b> | <b>Ek (0)</b> | <b>Ekplank(5)</b> | <b>Valnöt(1)</b> |
|--------------|----------------|-----------------|--------------|-------------------|---------------|-------------------|------------------|
| Ljust        | <b>66</b>      | 50              | <b>60</b>    | 4                 |               |                   |                  |
| Stilrent     | 33             |                 | 20           | 9                 |               | <b>80</b>         |                  |
| Luftigt      | 33             | 50              | 40           | 14                |               |                   |                  |
| Lugnt        | 16             | 50              | 20           | 4                 |               | 40                |                  |
| Varmt        |                |                 | <b>60</b>    | 33                |               | 20                |                  |
| Mysigt       |                |                 | 20           | 4                 |               |                   | 100              |
| Rofyllt      |                |                 | 40           | 19                |               | 20                |                  |
| Trivsamt     | <b>50</b>      | 50              | <b>60</b>    | 33                |               | <b>60</b>         | 100              |
| Neutralt     | 16             |                 |              | 23                |               | 20                |                  |
| Hemtrevligt  |                |                 | 20           | 23                |               |                   |                  |
| Färgglatt    |                |                 | 20           |                   |               |                   | 100              |
| Fräscht      | <b>50</b>      | 100             | 40           | 38                |               | 40                | 100              |
| Prydligt     | 16             |                 |              | 19                |               | 40                |                  |
| Livfullt     |                |                 | <b>60</b>    |                   |               |                   | 100              |
| Lätt         | 33             | 50              | 40           | 23                |               | 20                |                  |
| Konstnärligt |                |                 |              |                   |               |                   | 100              |
| Balans       |                |                 | 40           | 42                |               | 20                | 100              |
| Modemedvetet |                |                 |              |                   |               | 20                | 100              |
| Bebott       |                |                 | 20           | 4                 |               | 20                |                  |
| Glad         | 16             | 50              | 20           |                   |               |                   |                  |
| Modernt      | 33             |                 |              | 4                 |               | 20                | 100              |
| Harmoni      | <b>50</b>      | 50              | 20           | <b>57</b>         |               | 20                | 100              |

I Tabell 7 ser vi att av 40 personer har så många som 30 st rangordnat *valnöt* sist, 5 personer *ekplank* osv. Det var så få som valt *lönn*, *al*, *körbär* och *ek* som sämsta golv att slutsatser angående dessa ej kan dras (ljusgrått).

**Tabell 7** – Fördelning per träslag hur de använt svarsalternativen (Bild A11) för att beskriva det SÄMSTA golvet. Testomgång 3, (procent).

## *Sämsta golvet*

|               | <i>Lönn</i> (1) | <i>Björk</i> (3) | <i>Al</i> (0) | <i>Körbär</i> (0) | <i>Ek</i> (1) | <i>Ekplank</i> (5) | <i>Valnöt</i> (30) |
|---------------|-----------------|------------------|---------------|-------------------|---------------|--------------------|--------------------|
| Mörkt         |                 |                  |               |                   |               |                    | <b>73</b>          |
| Instängt      |                 |                  |               |                   |               |                    | 10                 |
| Blaskigt      | 100             | <b>66</b>        |               |                   | 100           |                    | 6                  |
| Felnyanserat  |                 |                  |               |                   |               |                    | 23                 |
| Uttryckslöst  |                 |                  |               |                   |               |                    | 6                  |
| Blekt         | 100             | <b>66</b>        |               |                   |               |                    |                    |
| Stilbrytning  |                 |                  |               |                   |               | 20                 | <b>26</b>          |
| Kalt          |                 | 33               |               |                   |               |                    | 13                 |
| Tungt         |                 |                  |               |                   |               | 40                 | <b>70</b>          |
| Dött          |                 |                  |               |                   |               |                    | 13                 |
| Dystert       |                 |                  |               |                   |               |                    | <b>56</b>          |
| Oroligt       |                 | 33               |               |                   |               |                    | 13                 |
| Disharmoniskt |                 | <b>66</b>        |               |                   | 100           | 20                 | <b>63</b>          |
| Tråkigt       |                 |                  |               |                   |               |                    | 13                 |
| Motbjudande   |                 | 33               |               |                   |               |                    | 20                 |
| Otrivsamt     |                 | 33               |               |                   |               | 20                 | 3                  |
| Smutsigt      |                 |                  |               |                   |               |                    | <b>30</b>          |
| Intetsägande  | 100             |                  |               |                   |               |                    | 3                  |
| Rörigt        |                 | 33               |               |                   | 100           |                    | <b>30</b>          |
| Strikt        |                 |                  |               |                   |               | <b>60</b>          |                    |
| Stelt         |                 |                  |               |                   |               | 20                 | 10                 |
| Omodernt      |                 |                  |               |                   |               |                    | 10                 |

Olika beskrivande ord har använts för de som valt de ljusa golven som sämst jämfört med de som rangordnat de mörka träslagen som sämst.

*Björk* beskrivs som blaskigt, blekt, disharmoniskt och till viss del kalt, oroligt, motbjudande, otrivsamt och rörigt. *Ekplank* beskrivs som stelt och i viss mån tungt. *Valnöt* beskrivs som mörkt, tungt, disharmoniskt, dystert och i viss mån smutsigt, rörigt, stilbrytning och felnyanserat.

Alla svarsalternativ i båda tabellerna bockades för minst en gång men några var mycket lite använda. Hade gruppen av intervjuade människor varit större och mindre homogen kunde detta indikera att vissa beskrivande ord kunde tas bort eller ersättas.

De intervjuade gavs också möjligheten att fritt i ord beskriva sitt bästa och sämsta golv. Dessa redovisas nedan och några kan möjligen ersätta de minst använda i Tabellerna 6 och 7.

*För BÄSTA golvet:* Prestigefyllt, ombonat, kul, matchande, kontrastrikt, praktiskt, karaktärsfullt, stilfullt, uttrycksfullt, lugn och ro, coolt, vilsamt, naturligt, rent, soligt, mjukt, lagom, rogivande, traditionellt, lugnande och inbjudande.

*För SÄMSTA golvet:* Tröttsamt, grovhugget, fel färgkombination, glåmigt, trist, flammigt, matchar ej, murrig höst, grillrigt, för ljust, sterilt, konstgjort, torrt, brutalt, golv och rum i olika stil, kantigt, fläckigt, grovt, för stor kontrast, färglöst, plottrigt och hårt.

## DISKUSSION OCH SLUTSATSER

Metodutvecklingen och resultaten i denna studie grundar sig på preferensdata från en liten grupp människor som var lokalt rekryterade. Resultaten har använts bara för att visa på vad som går att mäta samt för att demonstrera hur man kan analysera och presentera människors olika smakprofiler rörande utseende på trägolv.

Utseendet och upplägget av hemsidans innehåll är styrt mot projektets mål, vilket är att utveckla ett verktyg för preferensstudier där synligt trä står i fokus. Om man vill studera andra produkter med synligt trä måste givetvis bildmaterial och en del annat ändras. Men, centrala delar av den nuvarande intervjuplattformen kan säkert återanvändas.

Rangordningsförfarandet med hjälp av parvis jämförelse fungerar bra enligt muntlig uppföljning med de intervjuade personerna. Resultaten visar att det går att särskilja olika grupperingar av smakprofiler, dvs hur många som föredrar mörka/ljusa trägolv, hur många som föredrar resp träslag i en given miljö etc.

PCA, principal komponent analys har använts för att dels åskådliggöra olika kluster av personer baserat på deras smakprofiler (hur de svarat). Denna metod visade sig bra för att grafiskt beskriva variationen i intervju svaren. Som ett komplement till denna analys har resultaten även sammanställts i enkla tabeller som då mer betraktar en aspekt i taget jämfört med PCA.

Det kanske viktigaste resultatet är att man även får en beskrivning av varför de föredrar respektive ogillar ett visst utseende. De beskrivande ord som de intervjuade angivit för respektive träslag ger en anvisning om argument som kan anföras i marknadsföringssyfte. Motsatsen gäller för beskrivningarna rörande det de intervjuade inte velat ha. Man får en indikation på varför produkten ej skulle sälja i den miljö den visats i. Frågorna och dess svarsalternativ kan alltid förbättras så att de fångar upp värdefull information för företaget.

Eftersom gruppen av människor som testkört är liten och ej är representativ för annat än dem själva, har vi valt att inte gå vidare med analysen av sambandet mellan val av golv och de personbeskrivande frågorna (bilaga, Bild A12).

Miljöns (rummets) betydelse för hur människor väljer har en större roll än vad vi initialt trodde. Det mesta pekar på att vi ej kan använda oss av ett "neutralt rum" och sedan mäta människors allmänna inställning (smakprofil) till olika träutseenden. I förarbetena till denna studie gjordes också "slaskförsök" med dels ett rum med starka färger och dels ett rum med i princip inga störande färger eller detaljer. Intrycken från dessa enkla tester visade att ett superneutralt rum ej fungerar då vi gärna vill se produkten i dess riktiga miljö och att vi har svårt att tänka bort rummet och koncentrera oss på bedömningen av golvet.

Alltså tror vi att man måste använda sig av vad producenten tror är den rätta miljön för sin produkt med ett specifikt träutseende (riktad till en speciell målgrupp). Denne kan med fördel ta experter såsom inredningsarkitekter, fotografer, visualiserare m.fl. till hjälp för detta. I en sådan situation är det av största intresse för företaget att undersöka om deras antagande var rätt genom att använda metoden (när den är färdig) och testa av flera träutseenden och inte bara den nyligen framtagna "träkvaliteten". Svaret de får är om tänkt köpargrupp är stor nog för att våga satsa på den nya produkten eller kanske att något annat träutseende var bättre än de annat. Vi märker att marknadsföring, marknadsundersökning och möjligheten att påverka marknaden är intimt sammankopplade.

När metoden är färdigutvecklad ser vi goda möjligheter att varianter av denna kan användas på företagens hemsidor, i samband med mässor, av branschorganisationer och i vissa fall i samband med försäljning. Principen eller rättare sagt metoden kommer att kunna användas för fler produkter än golv.

## Framtida arbeten

Resultat av studier som denna ger bl.a. en trendbild av de olika smakriktningar som finns bland dem som ingått i studien. Människors preferenser ändras med tiden. Dock är sådana resultat viktiga att lyfta fram för att väcka intresse för marknadsstudier och träindustrin kan på så sätt utvärdera om liknande studier eller metoder kan användas för deras egna produkter.

I det fortsatta FoU arbetet skulle det vara önskvärt att aktuell metod testas på en större grupp människor. Både öppet deltagande och styrd sampling av de intervjuade kommer att tillämpas. T ex vore det intressant att studera om det finns skillnad i preferenser mellan vanliga konsumenter och föreskrivare/specialister.

Kopplingen mellan använd råvara och människors preferenser ger en anvisning om vilka träreenskaper som bör undvikas och vilka som skulle kunna nyttjas i större utsträckning än idag.

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Träsmak. - Microsoft Internet Explorer

Arkiv Redigera Visa Favoriter Verktyg Hjälp

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**Tyck till om trägolv - vinn en stol!**

Hur ser snyggt trä ut?  
Du kan hjälpa mig!

Jag vill se om det går att mäta människors tycke och smak för olika utseenden på trä. Hur vi visar bilder och ställer frågor kommer att förbättras med tiden. Två [sittmöbler lottas ut](#) bland er som deltar. Testen tar ca 10 min.

Jag vill delta

T.v: Olof Broman forskar på metoder för att mäta preferenser för olika utseenden på trä.

Klar Internet

Bild A1 – Introduktionssida med möjligheter till utlottade vinster.

Träsmak. - Microsoft Internet Explorer

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Röd stol

Jag vill delta

Tillbaka

**Delta och vinn en stol!**

t.v: Flax. Fåtölj i tyg i blått, gult, rött, svart eller tegel. Mio möbler.  
ovan: Tove. Fåtölj i formpressad bok och fårskinn. Mio möbler.  
Info: Dessa två möbler lottas ut när 500 personer svarat.

Klar Internet

Bild A2 – Vinster som lottas ut bland de som deltar.



Bild A3 – Kort introduktion hur det går till.

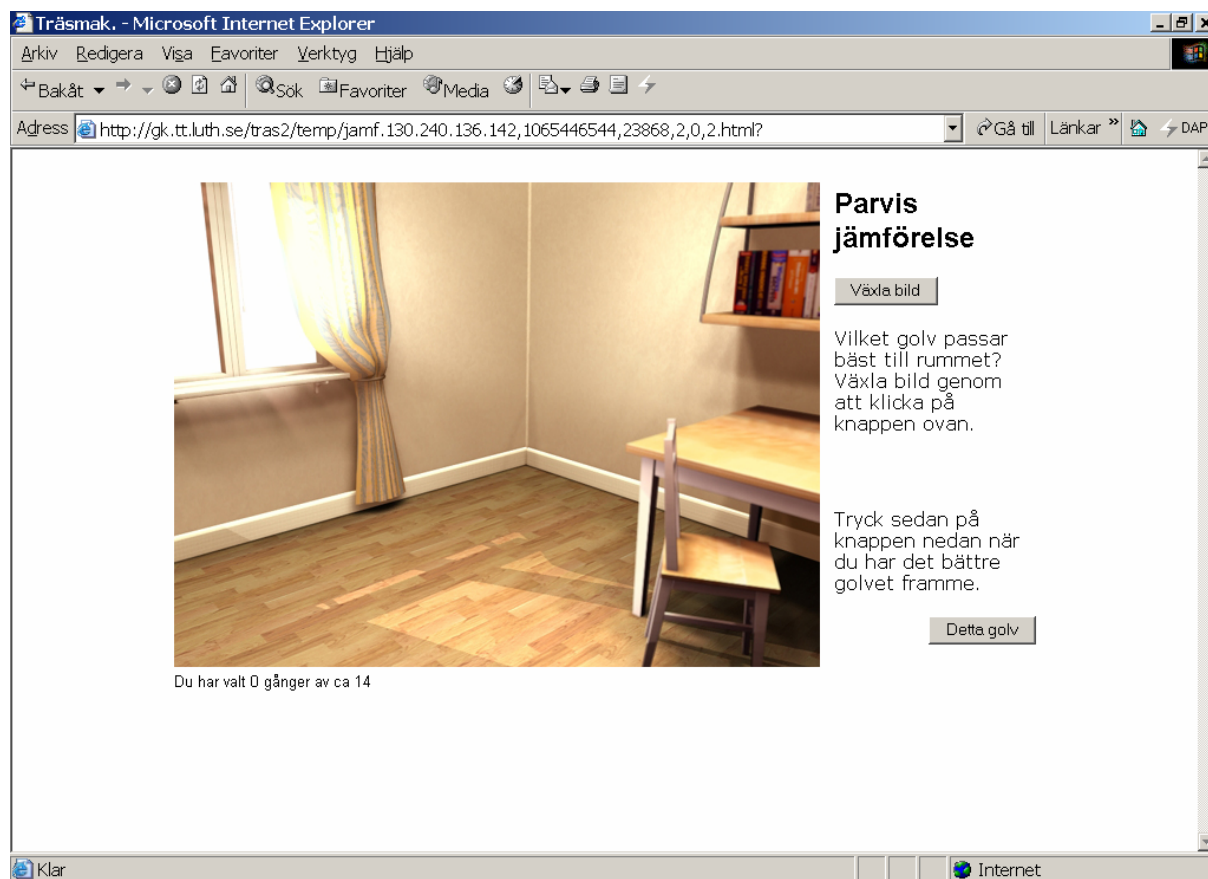
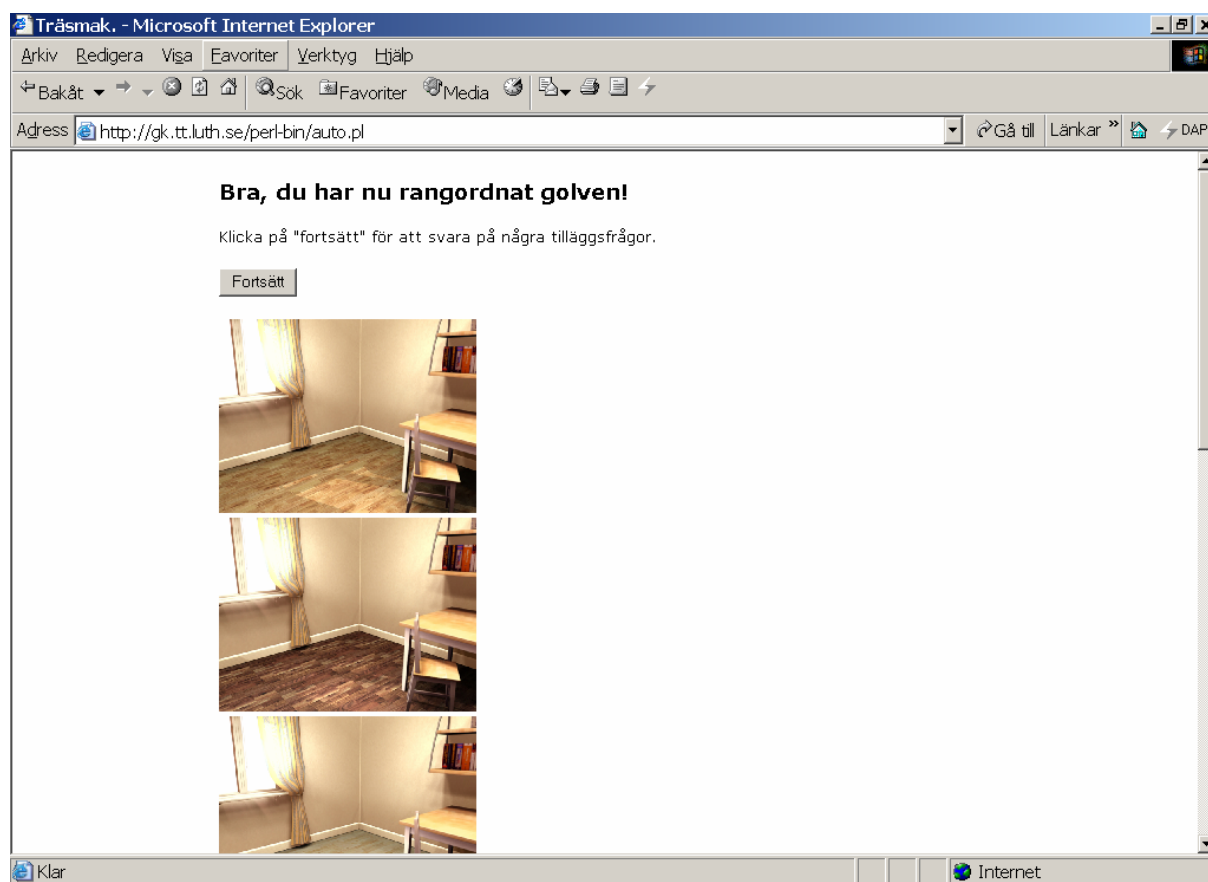
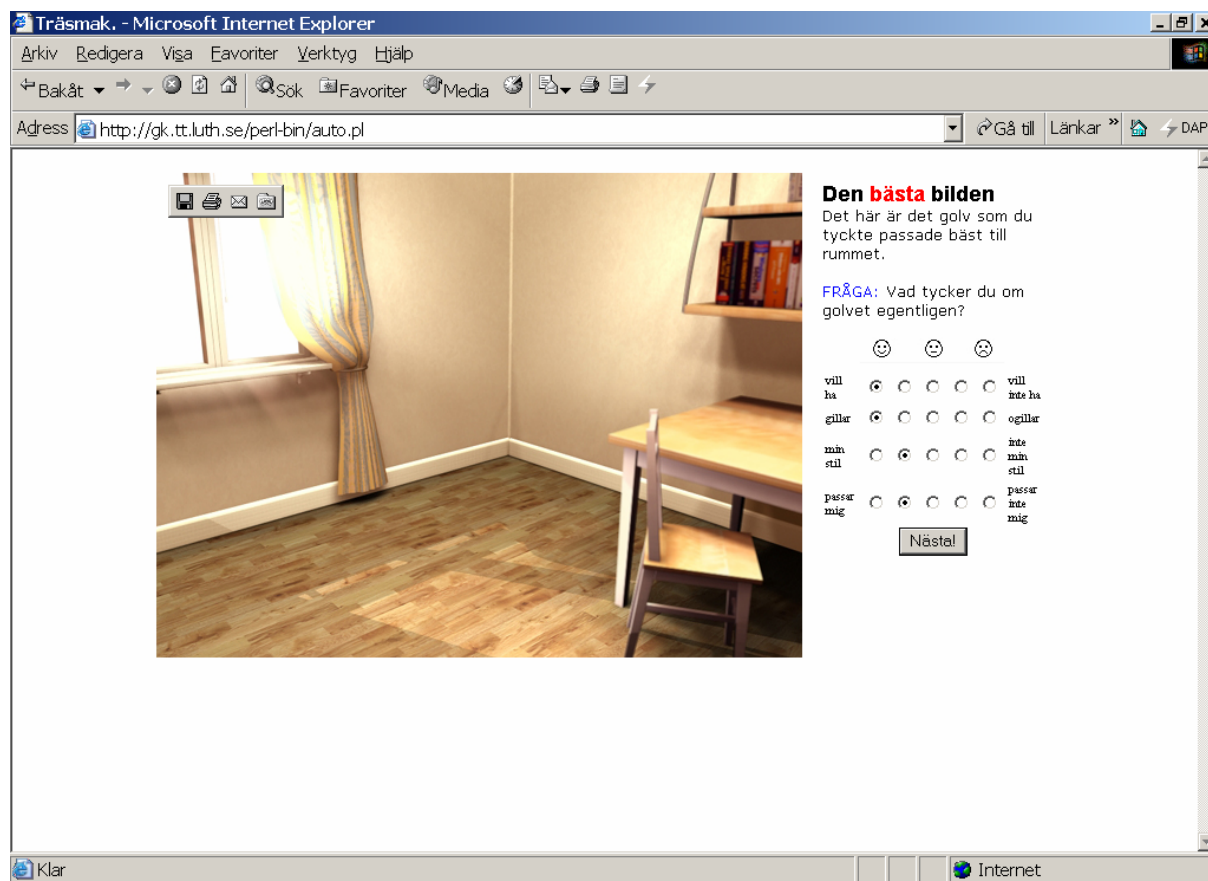


Bild A4 – Första golv i den parvisa jämförelsen. Nästa fås genom att klicka på "Växla bild".



**Bild A5** – Efter ca 14 jämförelser är rangordningen färdig och presenteras kort.



**Bild A6** – Frågor om hur mycket de egentligen tycker om det golv de rangordnat främst.





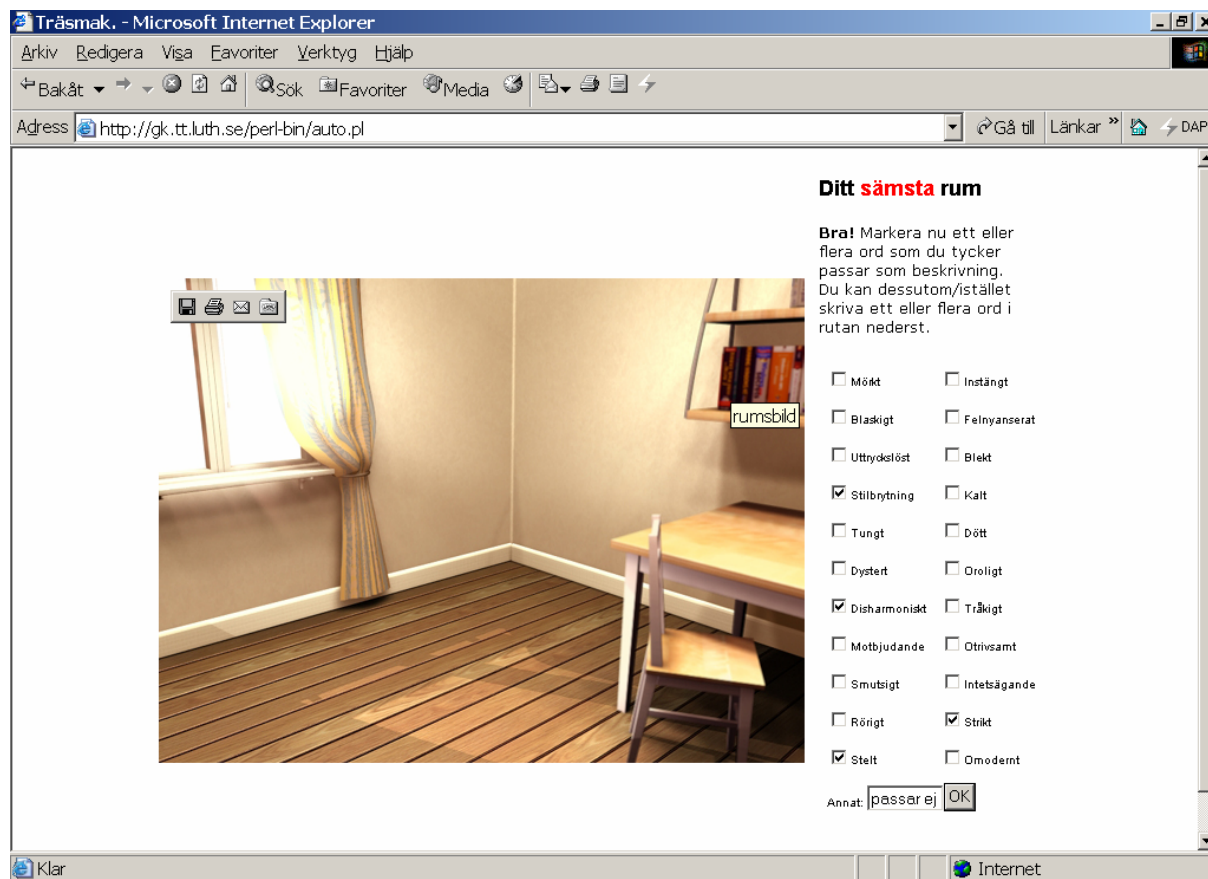


Bild A11 – Styrk beskrivning av det SÄMSTA golvet i dess miljö .

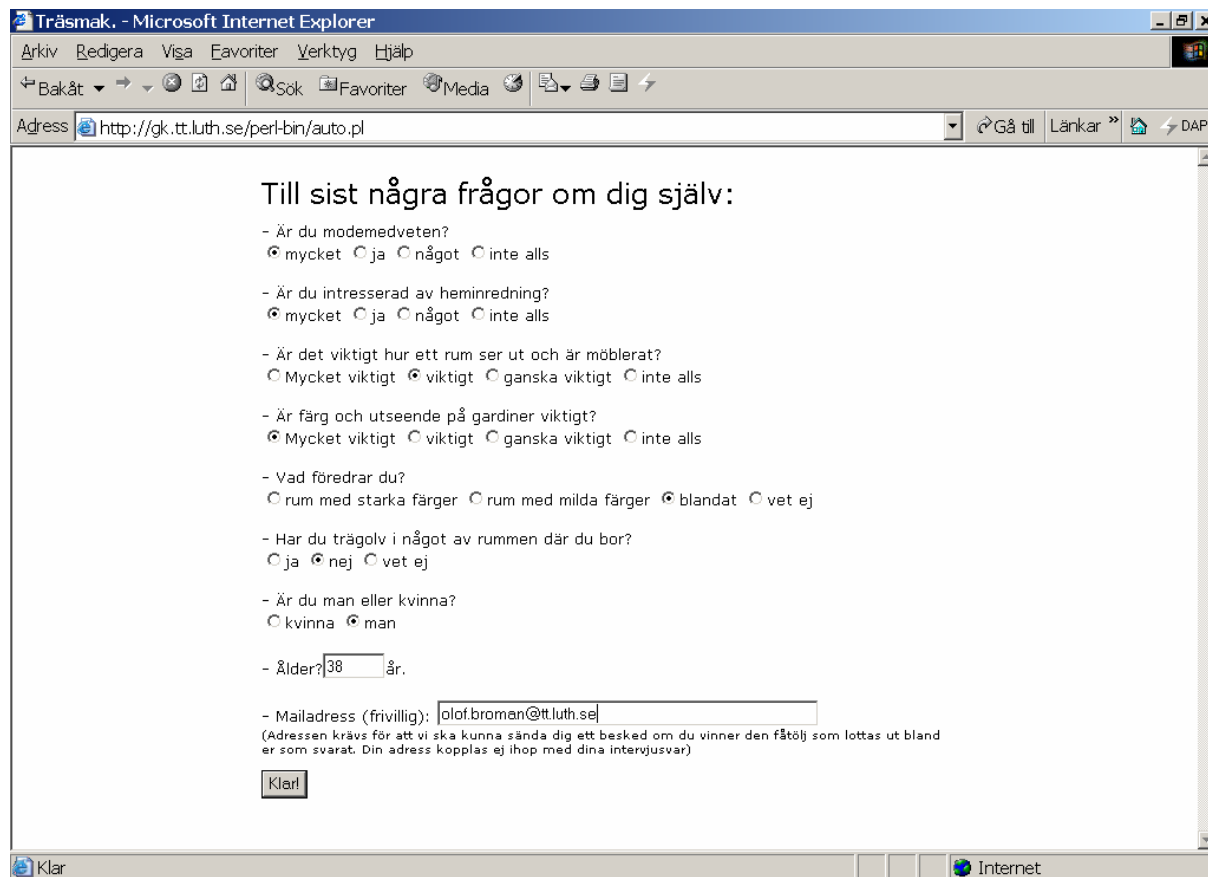


Bild A12 – Mer personbeskrivande frågor möjliga att koppla mot smakprofiler.



**Bild B2** – Björk



**Bild B4** – Körsbär



**Bild B1** – Lönn



**Bild B3** – Al

# Utseenden på de trägolv som användes i studien

Bilaga 2 1(2)



**Bild B6** – *Ekplank*



**Bild B5** – *Ek*



**Bild B7** – *Valnöt*



# *Paper IV*



## **Paired Comparison of Properties of Digital Images of Wood**

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## Abstract

Communicating the advantages of the whole wood material, even the softer qualities such as visual and aesthetic impressions, has become increasingly important when trying to reach new customers and to keep existing ones. The computer can be a useful tool in this effort.

The overall aim of this study was to find out whether there was an experienced difference between wood seen physically and the picture of it on a computer screen. This was done by creating a situation like a memory game wherein the respondents first studied a physical picture (photograph) and then tried to choose among similar pictures (12 variations and one original) on a computer screen.

The twelve variations were composed from six properties found in earlier qualitative studies. The properties were Shadow, Light, Scale, Contrast, Saturation and Gleam, and they were varied in a plus and a minus level (more shadow/less shadow). After a contest, six properties were compared with the original in a two-by-two comparison.

The results indicate that *Contrast* is the most important property when visualizing wood, both for good and bad visualization. *Shadows* seem to be the least critical property. The study also supports the hypothesis of smart exaggeration, with only 2 top votes for the *Original* picture. People seem to need more than just physically correctly recaptured wood to experience wood on a computer screen as true wood.

# 1. Introduction

## 1.1 Background

Wood—like most other materials—has both technical/quantitative characteristics and “soft”/qualitative features. The technical characteristics have been thoroughly investigated through years of research, but attitudes and feelings towards wood are sadly not as well documented. This is, however, starting to change.

Research regarding aesthetic features of wood and people's preferences for different looks of wood has to date been rather limited. Although some studies have been carried out both in Europe and Japan (Mazet and Janin 1990, Nakamura et al. 1993, Marchal and Mothe 1994), the lack of knowledge in this field is still very evident.

Also, knowledge of the final customers' preferences is still poor in the wood product chain, especially when it comes to the aesthetic features of wood (Marchal and Mothe 1994, Swearingen et al. 1998, Hansen and Weinfurter 1999), although later studies are oriented towards this subject (Jahn et al. 2001, Bumgardner et al. 2001, Donovan and Nichols 2003).

Broman (1995a, 1995b) has studied visual impressions of wood and people's attitudes towards wood, but focused on methods of interrogation. Broman (1995b) also indicates that it might be possible to draw adequate conclusions about the experience of real wood from computer images of wood, and Bishop and Leahy (1989) show that the perceptual judgments based on computer images closely correspond to those made from actual photographs. When compared to Broman (1995a), this current study is more oriented towards the experienced difference between computer image and physical image.

Over a period of many years, considerable work has been conducted in the field of architecture in discussions about the experience of beauty (Rasmussen 1962, Hesselgren 1987) and also in a new study about perceived color of paint (Fridell Anter 2000), but this work has been more directed towards color and painted façades. The entire field of digital imaging and scientific visualization (Cox 1990) is becoming more reliable, and advances in computer capabilities and graphic software have made visualization easier and more accurate, but the research is still somewhat limited (Daniel and Meitner 2001), even though some results are being produced. Results indicate that properties of computer visualizations (e.g., resolution and color fidelity) may significantly affect observers' perceptions, understandings and judgments. For example, some features of visualizations are known to affect attention and interpretations and to arouse positive and/or negative emotions (Mitchell 1983, Broudy 1987, Cox 1990). Daniel and Meitner (2001) are engaged in discussions about the validity of visualization, as applied to forest landscapes, however, not to wooden interiors. Many of the studies mentioned above deal with visualization in general or visualization of trees, not of wood and/or wood interiors.

Communicating the whole material, even the softer qualities, such as visual impressions, has become increasingly important when trying to reach new customers and to keep existing ones in times of harder competition. This communication is what is here called *wood communication*. Pakarinen (1999) states that it is important not only to place emphasis on design; manufacturers also have to sell wood by its aesthetic features. The computer could be a useful tool in this communication, but do we have knowledge about which properties of wood we want to communicate and how best to do it?

## 1.2 Objective

The main objective of this study was to search for an experienced difference between an image on paper and the same image on a computer screen. In this case, the image on paper represents physical reality, and the image the respondent chooses represents experienced reality. The idea of an actual world and an experienced world is one of our oldest (Plato 400 BC), but still science seems to be stuck in measuring the physical world, not the one we experience. This latter objective is grounded in a hypothesis derived from earlier qualitative studies (Nordvik 2003a, Nordvik 2003b). The hypothesis is that most people would prefer a computer image that was slightly exaggerated (compared to the physical reality), i.e., *hyperrealistic*, in order to find the image realistic. This study also intends to rank six chosen properties in order of importance to the visualization of wood in a computer.

## 1.3 Scope and limitations

This study concerns wood qualities involved when wooden interiors are computer visualized. This means wood as a part of the whole image, in a context, and does not include nonvisual qualities (such as tactile or sound features). Obviously, many of wood's competitive advantages will be missing in such visualization. Also, this study deals with the general problems of computer visualization to the extent that it is adequate for the experience of interior wood. In other regards, computer visualization in general has not been studied.

Only six properties were chosen for this study, properties that were easily managed technically in an image editing software program. The amount was chosen mainly to reduce the comparisons the respondents had to make (here, a maximum of seventeen comparisons). The properties were darkness/lightness, color saturation, contrast, shadows, gleams and texture scaling.

## 2 Materials and Methods

### 2.1 Theory

In earlier studies (Nordvik 2003a, Nordvik 2003b), properties of importance to computer visualization of wood were studied. These studies were conducted as qualitative interviews based on the grounded theory paradigm with the aim of finding which image of two the interviewed persons liked better and the reasons why.

Among six main categories found in the earlier studies, the four most important for peoples' impressions were *Light*, *Color*, *Entirety* and *Comprehension*. Out of these findings six technical properties were chosen for further investigation in this current study: *Lightness* (in material), *Color Saturation*, *Shadow intensity*, *Contrast*, *Texture Scaling* and *Gloss*. The term *technical properties* here denotes properties that can be technically created and controlled (in contrast to properties such as *Style*, *Composition*, *Resemblance*, etc).

The approach was to compare properties of importance when visualizing wood for ranking purposes and to verify or invalidate the results found in earlier studies, i.e., whether the properties found are important or not. This would also result in verification or invalidation of another idea from earlier studies (Nordvik 2003a, Nordvik 2003b)—that most people would prefer a picture that is slightly exaggerated (more contrast, stronger colors, etc.) in order to feel that the picture is one of actual wood. This study was conducted as a paired comparison, which has proven to be a good way to obtain results (Silverstein and Farrell 2001).

## 2.2 The images

A table made out of pine wood (*Pinus sylvestris* L.) was chosen for this study because of its large and distinct surface. It was placed in fitting, somewhat discreet surroundings. A simple photo studio was set up with halogen lamps and with daylight from the windows blocked out. All preparations were done in cooperation with a photographer in order to establish a controlled environment. A system camera was placed on a stand, and the photographer took the pictures. The floor was found to be too shiny, so a carpet was added to the environment. The goal was to get one good default (or original) picture and then vary it high/low in the six properties (more light/less light, stronger colors/paler colors, etc.) to finally end up with thirteen images, including the original. Only the wooden surfaces in the pictures, i.e., the table, were edited. Although most of the variations were done in the computer image-editing program, some extra shots were taken to make it easier to vary shadows, lighting, scale, etc. The image editing was done using image editing software (Adobe Photoshop 7.0), and the differences were made to be clear, but not obvious. The images were varied as many steps up for the plus level (*Shadows+*) and as they were varied down (*Shadow-*). See Figures 1 and 2 for example pictures. It should be noted that differences between pictures are appear more clearly on a computer screen.



Fig. 1 The original picture.



Fig. 2. Example of the image variations (*Gleam+*).

## 2.3 The viewing system

A system was prepared by a computer programmer allowing the interviews to be done in four steps with image presentation and data collecting handled by a laptop computer. The system also handled the random order of the images. The laptop computer screen was turned 90 degrees to enable the showing of two images in normal proportions (1000 x 700 pixels) one above the other. The monitor was calibrated with a standard color profile from Kodak to ensure validity between the photo lab printout and the original digital picture.



## 2.4 The interviews

### Step 1 – The photo lab printout

In the first of four steps, each respondent was shown a physical image, i.e., on paper, not on screen. This image was a 20- x 30-cm photo lab printout of the default image mentioned earlier. The respondent was instructed to study the image carefully and try to memorize it and then later to choose the one image of two on the screen that was most like the printout, not the image he/she liked better. The reason for using an image outside of the computer was the need to *break out of the box* and to be a step closer to a real experience.

### Step 2 – Favorite variation

In step 2 the respondent had to put down the photo lab printout and choose between images in a two-by-two comparison on a laptop (see images in Figures 1 and 2). The reason for the two-by-two comparison was that the goal was to gather reactions, and it is common knowledge that the easiest way to provoke opinions regarding something is to compare it with something else (Silverstein and Farrell 2001). In the second step, only the chosen property variations were compared with each other, that is “more shadow” versus “less shadow”, “lighter” versus “darker” and so on. The six winning variations went on to step three. The *original* picture was *not* incorporated in step 2. The term *original* in this article denotes the original digital photograph that the printout and the digital variations were made from and that the pictures in step 3 were compared with.

### Step 3 – Winner competition

In step 3, the computer fetched all six winners from step 2, added the original default image, and let the respondents compare them all with each other with instructions to choose the picture that was most like the printout they no longer were allowed to see. None of the respondents knew that the original picture was incorporated into this ranking competition. Again, a two-by-two comparison was executed, and a method called balanced binary tree (Silverstein and Farrell, 2001) was used to reduce the amount of the respondents' comparisons. The border between steps two and three was seamless for the respondents, who just kept on choosing the images they thought looked more like the paper printout. Even with the reduction of comparisons, the respondent had to choose at maximum 17 times, including step 2. The result from this part was a ranking of the seven pictures from 1 pt for the least preferred to 7 pts for the most preferred.

#### **Step 4 – Statistics**

Step four consisted of questions for gathering statistical, personal data to see if some kind of grouping could be found (which is not very likely with a base as small as 50 persons) and to obtain a wide representation of background, sex and age. The questions covered interest in home furnishing, wood experience, need for vision correction, sex, age, profession and where the respondents lived. The respondents were chosen in order to get as wide a variation of respondents as possible (in terms of age, sex, background, etc). All respondents were Swedish speaking.

Naturally, this interviewing method has many risks. Correct viewing angle is critical on a laptop screen. Room lighting is important. The quality of the printout affects the results. And most importantly, there is an obvious risk of forgetting, or distorting the memory of, the first, physical image. The method chosen here should be regarded as second best to comparing with a real, live environment, but this latter would be impracticable to implement. Creating a *memory game-like* situation was important to ensure that it was the image inside the head of the respondent that was compared to the computer images shown.

The data from the interviews, including some check numbers and the order of the pictures, was automatically saved into a log file on the computer. This log file was easily read and converted into a spreadsheet and analyzed.

### 3. Results

Each respondent (a total of 50 persons) was shown one physical photo lab printout and 12 digital variations (with varied wooden texture), in a two-by-two computer comparison. The results were logged on a computer. Each interview lasted for about 10 minutes. The respondents were between 16 and 64 years old, 25 of each sex and with varying interest in wood and furnishings. Most of them (88%) used a computer daily.

In step 1 of the interviews, the photo lab printout was shown for about 30 seconds and then put away. In step 2, one of each property variation (*Shadows+* or *Shadows-* etc) was shown and chosen on a computer screen.

In step 3, all the winning pictures from step 2 were compared with each other on a computer screen (in a two-by-two comparison) together with the *Original* picture. Since Step 1 was a reference look at the printout, it returned no results.

#### 3.1 Step 2

As seen in Table 1, the result of the comparisons between the variations of the properties (“more or less shadow”, “higher or lower color saturation”) is shown.

Table 1. Results after Step 2. The preferred variation of the original picture (percentage).

| Light |    | Color |    | Contrast |    | Gleam |    | Shadows |    | Scale |    |
|-------|----|-------|----|----------|----|-------|----|---------|----|-------|----|
| -     | +  | -     | +  | -        | +  | -     | +  | -       | +  | -     | +  |
| 62    | 38 | 32    | 68 | 26       | 74 | 26    | 74 | 38      | 62 | 68    | 32 |

As seen in Table 1, the picture with the darker wood texture (*Light-*) was preferred 62% of the time (compared to *Light+* with 38%). Also, the picture with higher color saturation (*Color+*) in the wood texture was preferred 68% of the time. The picture with higher contrast (*Contrast+*) won clearly with 74% over the one with lower contrast (*Contrast-*), which got only 26% of the votes. The same results held for the pictures with more gleam (*Gleam+*) when compared to the ones with less (*Gleam-*). The pictures with stronger shadows (*Shadow+*) or smaller wood texture scale (*Scale-*) also won (68% for *Scale-* and 62% for *Shadows+*). The percentage here is a simple doubling of the actual number of answers, since the study included 50 persons. 50% is therefore the same as 25 persons.

Given this result, it is clear that a good computer picture of interior wood should be darker, have higher color saturation, more gleam, stronger shadows and definitely have higher contrast than the object it tries to communicate. The scale of the texture (size of knots, etc.) also seems important to manage correctly. A slightly decreased texture scale is preferable to increased scale. This result can be seen a confirmation of the hypothesis regarding preferred exaggeration, especially since this was the first six comparisons and therefore not as disturbed by memory issues (the respondents may have forgotten the printout when exposed to so many variations) as the comparisons during step 3 may have been.

### 3.2 Step 3

The competition between the winning variations (for each respondent) from step 2 returned the results shown in table 2. For all pictures except the original, these results are naturally grounded in the results from step 2, i.e., the more victories in step 2, the more chances in step 3. The result from this part was a ranking of the seven pictures, from 1 point for the least preferred to 7 points for the most preferred.

Table 2. Results after Step 3. The number of votes for each property variation (percentage). Higher points are better.

| Points       | Orig | Light |    | Color |    | Contrast |    | Gleam |    | Shadows |    | Scale |    |
|--------------|------|-------|----|-------|----|----------|----|-------|----|---------|----|-------|----|
|              |      | -     | +  | -     | +  | -        | +  | -     | +  | -       | +  | -     | +  |
| <b>7 pts</b> | 4    | 8     | 4  | 2     | 12 | 4        | 28 | 8     | 4  | 4       | 2  | 14    | 6  |
| <b>6 pts</b> | 20   | 8     | 4  | 2     | 12 | 2        | 14 | 6     | 12 | 2       | 6  | 8     | 4  |
| <b>5 pts</b> | 8    | 6     | 6  | 2     | 18 | 4        | 14 | 2     | 12 | 4       | 14 | 4     | 6  |
| <b>4 pts</b> | 12   | 16    | 2  | 10    | 6  | 4        | 4  | 2     | 24 | 4       | 10 | 6     | 0  |
| <b>3 pts</b> | 18   | 6     | 6  | 6     | 10 | 2        | 2  | 0     | 16 | 12      | 14 | 8     | 0  |
| <b>2 pts</b> | 28   | 10    | 6  | 6     | 8  | 6        | 2  | 6     | 2  | 4       | 10 | 10    | 2  |
| <b>1 pt</b>  | 10   | 8     | 10 | 4     | 2  | 4        | 10 | 2     | 4  | 8       | 6  | 18    | 14 |
| Sum          | 100  | 62    | 38 | 32    | 68 | 26       | 74 | 26    | 74 | 38      | 62 | 68    | 32 |

As seen in Table 2, the property with the most wins (most 7-point votes) was *Contrast+*, i.e., the image where the contrast in the wood texture was slightly modified for higher contrast. It got 28% of all 7-point votes, while number two (*Scale-*) got 14%. As mentioned earlier, all properties had variations with a more (+) and a less (-) level.

The *Original* picture got only 4% (two persons) of the 7-point votes and 10% of the 1-point votes. Even though it got 20% of the 6-point votes, it also got 28% (14 persons) of the 2-point votes.

*Light-* got 8% of the 7-point votes and 8% of the 1-point, votes indicating that *Light-* is of average importance, but still more important than *Light+* with only 4% of the 7-point votes. This should mean that some darkness is preferred. It should be noted that this is a rather unsophisticated interpretation of light; it only dealt with the darkness of the material.

The property *Color* had its most popular variation in *Color+*, the one with higher color saturation. It got 12% of the 7-point votes, 12% of the 6-point votes and 18% of the 5-point votes. *Color-* was not as popular, with only one vote (2%) for 7 points. It also had very few votes overall, since it was seldom chosen in step 2.

The property *Contrast* had variations with more (+) and less (-) contrast. With 28% (14 persons) 7-point votes and 14% (or seven persons) 6-point votes, the variation *Contrast+* is clearly very important. *Contrast-* is also important because of its very few wins (2 persons). Overall, *Contrast* seems to be the most important property to pay attention to when visualizing wood textures.

The property *Gleam* had rather average results, with *Gleam-* getting 8% of the 7-point votes. *Gleam+* was also somewhat modest with only 4% of the 7-point votes, but with 12% of the 6-point and 5-point votes, it still indicates some importance.

The property *Shadows* is the really average performer here. With no high and no low results for either *Shadows+* or *Shadows-*, it yields no distinct result. The result could be interpreted as an indication that shadows are not the most crucial of the chosen properties when visualizing wood.

The property *Scale* had a rather large span between *Scale-* and *Scale+*. *Scale* here denotes the scale of the wood texture on the table, the size of knots, annual-ring pattern and other features. When *Scale-* had both distinct high (14% of the 7-point votes) and low (18% of the 1-point votes) scores, *Scale+* was more moderate (6% 7-point votes). *Scale* is, however, the only property that is connected to details (for instance smaller or larger knots), while other properties are more involved with the overall impression of the picture (for instance darker material). This may mean that for some individuals it was easier to see this property.

### 3.3 Combined results of step 2 and step 3

One way of grading the importance of the properties after step 3 would be to present the average score, the term *average* here meaning the sum of all points for one property (for instance *Colors+*) divided by the number of respondents (50). The *Original* picture (the one the printout was made from) has no average value. The reason for this is that it couldn't be rejected, since it entered the viewing system when all rejections were made. It would then get a misleadingly high average (3.56 to be precise). Since the result in step 3 is naturally grounded in the result from step 2 (the more victories in step 2, the more chances in step 3), the winning aspect variation (*Contrast+*) is no surprise.

Table 3 clarifies the results presented in Table 2. As seen in Table 3, *Contrast+*, *Colors+* and *Gleam+* are judged as the picture most like the memory of the photo lab printout. The variations in the middle of the ranking scale appear to be the least important, whereas most important are the variations where there is a large span between both versions (+ and -), for example *Contrast* and *Color*.

Table 3. Average score after step 3 for all 50 interviews. Sorted with the winners first.

|                      |      |
|----------------------|------|
| 1. <b>Contrast+</b>  | 3.86 |
| 2. <i>Colors+</i>    | 3.18 |
| 3. <i>Gleam+</i>     | 3.12 |
| 4. <i>Scale-</i>     | 2.52 |
| 5. <i>Light-</i>     | 2.44 |
| 6. <i>Shadow+</i>    | 2.28 |
| 7. <i>Light+</i>     | 1.3  |
| 8. <i>Shadow-</i>    | 1.28 |
| 9. <i>Gleam-</i>     | 1.24 |
| 10. <i>Scale+</i>    | 1.14 |
| 11. <i>Colors-</i>   | 1.1  |
| 12. <b>Contrast-</b> | 0.98 |

In the results from Step 2, the respondents seem to have chosen pictures that are darker, more colorful, have stronger shadows and greater contrast, etc. All those properties give better contrast when looking at the pictures. After step 3 it's possible to claim that *Contrast* is most important overall, since it was both the most preferred (*Contrast+*) and the least preferred (*Contrast-*) by the respondents. This can be seen as an indication that people experience wood accurately depicted on a computer screen as *wishy-washy* or watered down.

## 4. Discussion and conclusion

### 4.1 Discussion

The results presented in this study support the hypothesis of the need for smart exaggeration when visualizing wood interiors and they also provide us with a ranking of the properties. *Contrast* seems to be outstandingly important, since *Contrast+* is ranked highest and *Contrast-* is ranked lowest. The *Original* picture gained only 2 top votes as opposed to the 14 top votes for *Contrast+*. *Color* is also important, given the span between + and – variations.

The reason that both *Light+* and *Light-* ended up in the middle of Table 3 may be found in the fact that *Light* is here defined as the actual lightness (as opposite to darkness) of the surface material. The truth is probably much more complex and connected with reflections and shadows. It is reasonable to assume that when the respondents in earlier studies (Nordvik 2003a, Nordvik 2003b) talked about *Light*, they meant something more than this difference.

After conducting and analyzing this study, it might appear that this is not the best way to examine the phenomenon of wood visualization. Compared with earlier studies (Nordvik 2003a, Nordvik 2003b) with a qualitative approach, this study had a quantitative approach, with 50 persons trying to choose the correct picture and the computer registering how many did it. The ranking of the chosen pictures was also handled by the computer, which rendered a material that was far easier to control and compare than the descriptive words from earlier studies. But having better control over the output data (getting numbers to put into graphs instead of merely words) does not necessarily mean that one is in control over the input data (issues that affect the choices—memory issues, observation angle, etc.). It would be dangerous to assume that is the case. However, this study was no doubt a necessary step on the quest for a good way to examine the phenomenon of wood visualization.

There are three major bias risks in this study, the first one being the inevitable difference between the original digital photographic image and the photo lab printout. Lighting and viewing angle during the interview are also important. However, these two risks were managed by allowing the respondent to try different views before the interviews started.

The third, and most critical, bias risk is the obvious risk that the *mental picture* was affected by all the versions viewed, and that it may have varied during the interview. Even though most respondents claimed that they were able to keep in mind the *mental picture* of the photo lab printout throughout the interviews, it is reasonable to believe that this mental picture was affected by—at least—the first pictures in the interview, that these then melted together into a new picture that then was held on to during the remaining interview. If this is correct, it means that the result of the first step of the interview (where six versions of the pictures were chosen for further competition) was more correct, but that the validity of the second step has decreased. But this is only a hypothesis; it may be that the large number of versions made the comparisons easier. The respondents had to choose some details in the picture in order to be able to remember the picture. The order of the images was randomized, which limited the risk for systematical errors, but also meant that no interview was exactly the same as another (when it came to the order of the images).

The optimal interview situation for a study dealing with differences between physical and experienced wood reality is probably to let the respondent walk into a physical room and then walk out again and choose an image on a computer screen.

Wood visualization is a complex phenomenon in which all aspects affect and interplay with each other. In this study, all aspects were treated separately and then combined in the results. The question remains whether this method gives a good representation of the situation as a whole, but that is a matter further investigation.

This study had two goals, as mentioned earlier: to test the exaggeration hypothesis and to rank the impact of the properties. The properties were light, color saturation, shadow, gleam, texture scale and contrast, and the images were modified to provide two versions of each property. In the first part of the study, half of the property versions were winnowed out by the respondents. Only one version (i.e., the image with more contrast survived and not the one with less contrast) of each property went on to the next step. But one must bear in mind that in this part of the study it was impossible to choose the *correct* picture, since the original picture was not there in the batch.

The comparison with the original picture included came in the next part of the study, where the winning pictures all were compared to each other in a contest. The property variations that were chosen were thoroughly compared with each other and the original image, and they all ended up ranked in order of preference into the result file. From this the assumption is made that the winning property version is typical for its property, and all results assume this. It is important to make the distinction between *winning* in this study and being *important for visualization*.

This result indicates which properties make an image work, not which properties make it *not* work. Both issues are important for visualization. In fact, the *bad* properties are sometimes more important than the *good* ones. *Contrast* and *Colors* are examples of properties well represented both high and low. Given that the winners on average were *Contrast+* and *Colors+*, it can reasonably be claimed that the properties *contrast* and *colors* are important overall. This means that both the winners and the losers of this ranking are important for success in wood visualization. The middle results (not first, not last) are the ones that are less critical. Naturally, this result would have been more reliable if all the pictures were tested against each other, instead of a first round where half of the pictures were culled before the competition started. But that would have made the study immense, and the reliability of the judgments of the respondents after the 78 comparisons that would be required would also be rather limited.

For future work, it is important to further investigate the differences between the wood we see and the wood we think of. It would also be good to treat the property *Light* more carefully as something more than the opposite of darkness, i.e., to investigate how daylight reflects off the wooden surface, etc. A large study with some hundreds of respondents is also needed if we want to be able to draw more statistically reliable conclusions. Naturally, it would also be interesting to do a study similar to the one described in this article, but without the large amount of comparisons, as described earlier. Perhaps it is possible to adjust one image (using some kind of handle or control on the computer screen) instead of choosing amongst many. But most important is to find a way to focus more on the interplay between the properties, on how they affect each other.



## 4.2 Conclusion

Given these results, some conclusions regarding the visualization of wood can be drawn.

- \* Smart exaggeration instead of correct photorealism is preferred.
- \* Contrast, color and light are as important as detail and texture pattern.
- \* *Light* is more than weight, lamps or the opposite of darkness.

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