People's Perceptions of the Visual Appearance of Wood Flooring: A Kansei Engineering Approach

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Abstract

Evaluations of products based on visual stimuli are at the same time both subjective and important. The aim of this study was to examine the relationship between the visual properties of wood flooring and people's reactions to computer visualization of interior wood products. The research strategy involved showing digital pictures of the same room, but with different wood floorings. The impressions of potential consumers were measured by means of rating scales for each descriptive word. This was done using the method of Kansei engineering, in which statistical connections between properties and semantics (descriptions) were analyzed. The research presented here contributes to theory and practice in two important ways. First and most important, the study shows that the chosen method is suitable for measuring people's preferences on visualizations of interior wood. Second, the results indicate that certain properties are important for a floor to be judged as ''good-looking'' and others for a floor to be deemed ''modern'' or ''vivid.''

Evaluations of wood flooring by individuals are highly subjective. Nevertheless, they are important. When wood is used in products having a visible wood surface, such as flooring, the highest unit prices are obtained (Wiklund 1992). As is the case with most materials, wood has features that together could be either advantageous or disadvantageous depending on how the wood is used. To meet competition from other countries and to survive, the Swedish wood industry must find ways to sell more wood or get higher value for it. To do so, it is important to reach new customers and show new possibilities for wood.

Computer visualization is becoming increasingly important for communicating messages about new products (Sheppard 2000), and corporate marketing managers need better knowledge about what and how to communicate about their products. A study concerning color copy machines (Fukushima et al. 1995) even tried to implement ''an intelligent interface to copy more beautifully than the original colour.'' At the same time, strong trends such as individuality, hedonism, spirituality, and downsizing (Jordan 2001) are shifting the traditional focus on functionality to more affective issues—issues that influence emotional responses. Helander et al. (2001) identifies the most urgent research needs in this area. First, theory formation and measurement issues associated with people's affective response to various stimuli must be addressed. Second, methods to predict user and customer wants and needs for affect in products must be developed. This is also the case when it comes to people's reactions to wood interiors.

Earlier studies on the topic by Nordvik and Broman (2005, 2009) outlined the expressions used when people experience computer visualizations of interior wood. In a comparative study of visual properties in digital wood pictures, Broman et al. (2006) studied people's preferences for different wood floorings. Ranking results and the questionnaire data were analyzed with the aid of multivariate statistics. Different taste profiles were found and described, and the study highlighted the impact of the context of the product (showroom). Nordvik and Broman (2007) attempted to manage qualitative data in a quantitative way and provided a ranking of the important expressions. The results indicated a need for some kind of ''smart adaptation'' of the wood aspects, such as stronger colors and brighter light. The physical characteristics of

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wood products are well known, but not the affective values of interior wood, which was the focus of these earlier studies.

The science of visualization requires capturing the interplay between product properties and impressions. Kansei engineering (KE) is a method for translating feelings and impressions into product parameters. It is a cross-disciplinary product design methodology that spans the humanities and social and natural sciences. It was developed in the 1970s (Nagamachi 1997) and defined as a ‘‘technique for translating the human kansei into product design elements.’’ The term *kansei* is defined as ‘‘a Japanese word which implies a customer's psychological feeling and image regarding a new product’’ (Nagamachi 1997). KE can ‘‘measure’’ feelings and shows correlation to certain product properties. As a consequence, products can be designed in a way that responds to the intended feeling. KE is, foremost, a product development methodology (Harada 1998), but Schütte et al. (2004) also shows how it is possible to use it as an improvement tool for existing products or concepts.

The current study was an attempt to use KE to connect the product parameters of wood floors to the affective values. If we know what combination of wood picture properties results in a high score among the descriptive words, we should be able to reverse the process and make floors (and pictures thereof) that support the most important descriptive word.

Objective

The objective of this study was to examine the relationship between the visualization of visible properties of wood floorings and people's affective impressions of it. This study was also an evaluation of KE as a tool for studying visualization of wood.

Materials and Methods

The overall approach used in this study was to show digital pictures (same room with various wood floorings) and then measure the impressions of the study participants by means of rating scales for certain descriptive words. See Figure 1 for an illustration of the process.

The general KE procedure (Schütte 2002) starts with a definition of research area (Choice of Domain) before the affective values (the Semantic Space) and product properties (Space of Properties) are investigated and connected (Synthesis) to end up with a model being built and validated.

Choosing the domain

In general, the Kansei domain can be described as the ideal concept behind a certain product. A domain can include existing products, concepts, and still unknown design solutions (Schütte and Eklund 2005). Here, the study was directed to the reaction to pictures of wood floorings. Thus, only commercial products—floors available on the European market through the Internet and retailers—were chosen for inclusion in this study. Flooring products in this study were manufactured from eight species: spruce (*Picea abies* L.), birch (*Betula pendula* Roth), merbau [*Intsia bijuga* (Colebr.) O. Kuntze], jarrah (*Eucalyptus marginata* Donn ex Sm.), beech (*Fagus sylvatica* L.), maple (*Acer saccharum* L.), oak [*Quercus rubra* L. and *Q. petraea* (Mattuschka) Liebl.], and cherry (*Prunus serotina* Ehrh.).

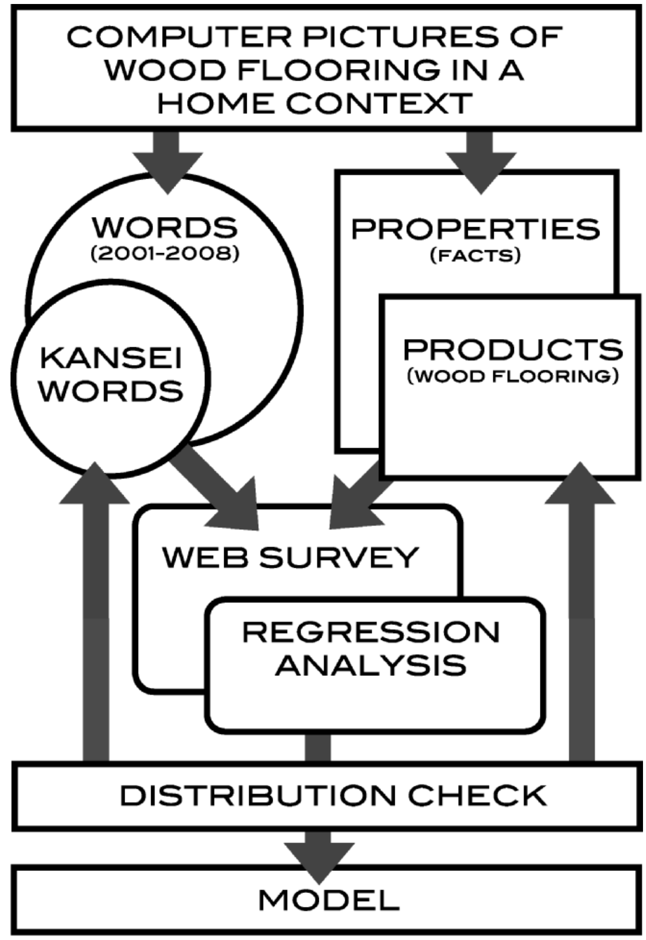


Figure 1.—Graphical depiction of the Kansei engineering process in the current study.

- Domain chosen: Computer pictures of wood flooring in a home context.
- Target group chosen: Swedish end-consumers, between 25 and 55 years of age, considering purchasing new flooring for their home.
- Market niche: Home improvement.
- The representative products (pictures of floorings) were made up of several species from several sources available on the European market.

Spanning the Semantic Space

A Kansei product domain is described both from a value-based semantic and a physical property perspective, both presented as vector spaces. The methods behind semantic descriptions are based on the Semantic Differential Technique by Osgood (Osgood and Snider 1969).

Collection of low-level Kansei words describing the domain.—Kansei words (KEW) are typically collected from diverse sources (magazines, manuals, ads, Internet forums, user interviews), but since a vast number of words on this topic were already found and structured in earlier qualitative interview studies (Nordvik and Broman 2005, 2009; Broman et al. 2006) it was decided to work with this word set. This word set consisted of about 1,500 words describing the domain ''Computer pictures of wood flooring in a context.'' Examples of the words were ''feels unreal,'' ''cozy and familiar,'' ''awkward,'' ''modern,'' ''welcoming,'' and ''colorful.''

Kansei structure identification.—The number of words was reduced to make the data manageable. For this study, the goal was to end up with no more than six to eight KEW, which was necessary to limit survey administration time to a desired maximum of 15 minutes. The Kansei is hierarchic, i.e., one high-level Kansei can join together several low-level Kansei, and in this way can facilitate the representation of the customers' affective values. In KE, only higher level Kanseis are connected to product properties in the synthesis phase in order to achieve a better generalization of the results. This is equivalent to the work done by Nordvik and Broman (2005, 2009), in which Grounded Theory (Glaser and Strauss 1967) was applied to sort the words into dimensions and categories that could be seen as low- and high-level Kansei. These categories (Table 1) were used as input for the continued reduction process. Using brainstorming techniques (Osborn 1957) and affinity diagrams (Bergman and Klefsjö 1994), the 1,500 words were evaluated, clustered, and grouped hierarchically in a dynamic and iterative process ending up with 24 groups of words. These words were further reduced in a second step into 10 groups. One word was chosen to represent each group (Schütte 2002).

Final selection of KEW.—The six most relevant words representing the Semantic Space were chosen. One example of words removed was ''homely/cozy,'' which was seen as aspects of ''harmonious'' and ''good-looking.'' Further, the words ''realistic'' and ''understandable'' were merged into the word ''realistic,'' and the phrases ''connects to the surroundings/blends in/fits'' were all merged into ''harmonious.'' Eventually, the final KEW selected so as to span the Semantic Space of the Domain ''Computer pictures of wood flooring in a home context'' were as follows:

- Vivid
- Realistic
- Colorful
- Good-looking
- Harmonious
- Modern

Spanning the Space of Properties

The Space of Properties consists of those product properties that affect the user experience the most. There is, unlike the Semantic Space, no consistent way of developing the Space of Properties (Schütte 2002). However, following the model proposed by Schütte provides us with a parallel method to that used in defining the Semantic Space that comprises three steps: collection of traits, selection of traits, and selection of products.

Collection of product traits.—It is generally recommended that inspirational material regarding a product domain be collected from a variety of sources to identify potential product traits. Sources used here were

- Retailer's Internet sites
- Manufacturer's catalogues and technical data sheets
- Wood dry sorting rules
- Computer software manuals and menu systems

Table 1.—Structure found on experiencing computer-visualized wood (Nordvik and Broman 2009).[a]

Category			
LIGHT	COLOR	UNITY	AUTHENTICITY
Brightness	**Contrast**	**Composition**	**Computer-made**
- Brightness	- Contrast	- Harmony	- Scale
Lighting	**Colorfulness**	- Activity	- Authenticity
- Light errors	- Warmth	- Life	- Detailing
- Gleam	- Color	**Context**	- Clarity
- Shadows		- Purpose	**Material**
Contrast		- Style	- Treatment
- Pale		- Taste	- Construction
		- Surroundings	- Wood specific
		Spatial	
		- Depth/Space	
		- Weight	
		- Perspective	

[a] Words selected for dimension groups are in boldface.

Some 100 different product words and traits were found. The product, in this case a digital picture, was found to have the following trait categories:

- Visual wood traits
- Visual floor traits
- Visual picture traits, i.e., image editing software traits
- Other visual traits (orientation, composition, etc.)

Examples of visual wood traits are knots, graining, species, material color, and darkness. Floor traits could include patterns, strips, and surface treatment. Examples of picture traits (image editing software traits) are scale, orientation, saturation, contrast, size, resolution, and lighting.

Selection of product traits.—According to theory, the number of traits and their variations should be reduced by selecting the most important ones for further evaluation (Schütte et al. 2004). In most cases, high frequency traits are also of high importance. This was, however, not the case here, since the rather small number of visual wood traits are far more decisive than the high number of image editing software traits. Pareto diagrams (Juran 1954) were therefore not used in this process; the reduction of traits was conducted manually. However, the rule of 80/20 (Foster 2001) is still applicable; roughly 80 percent of the appearance was due to 20 percent of the traits.

The product (i.e., the picture) concerns more than wood issues, but wood has some very distinct material properties that influence the appearance of a picture with wood content. For instance, Broman (1995) points out coloration (brightness), contrast (graining), knots (distribution), and texture (pattern), whereas Svedmyr (2002) mentions species, surface treatment, and wood-working effects. Nakamura et al. (1994) show that pattern anisotropy and color variations influence the psychological image of ''wood looking.'' Thus, with help from collected data, literature, and expert groups, the traits regarded to have the most influence on the visual characteristics of wood flooring are as follows (before reduction):

- Material brightness
- Color of the material
- Level of visual activity
- Laying pattern
- Technical contrast of the picture

Table 2.—Selected Kansei product items and variations.

Item (trait)	Variations (levels)
Visual activity	High/low
Color nuance	Yellowish/reddish
Lightness	Light/dark
Pattern	1-Strip/3-strip

Table 3.—Kansei products and products traits.

Product	Visual activity	Color nuance	Lightness	Pattern
Spruce Haro	Active	Yellow	Light	1-Strip
Birch Jaso	Calm	Yellow	Light	1-Strip
Merbau Haro	Calm	Red	Dark	1-Strip
Jarrah Haro	Active	Red	Dark	3-Strip
Beech Haro	Calm	Red	Light	3-Strip
Maple Haro	Active	Yellow	Light	3-Strip
Oak Haro	Calm	Yellow	Dark	1-Strip
Cherry Witex	Calm	Red	Dark	3-Strip

- Surface treatment of the material
- Wood species

Material brightness and *color* were seen as natural traits to incorporate in the study. *Visual activity* meant natural variations caused by distribution of knots, streakedness, grain, etc. The most decisive *pattern* of wood flooring is the way it is laid in strips: one, two, or three strips. The intended trait *technical contrast* of the picture was removed since it had a direct correlation with visual activity of the material. The intended property *surface treatment* (oil, lacquer, etc.) was removed, since the software was not able to handle the difference between subdued and glossy surfaces. *Species* was also noted, but not as a property, since it was considered to be covered by lightness, color nuance, and visual activity.

To facilitate statistical interpretations, the number of variations of the traits should not be more than three (Ishihara 2001). The chosen traits and the two variations eventually used are shown in Table 2. Following convention (Nagamachi 1997), traits are called *items*.

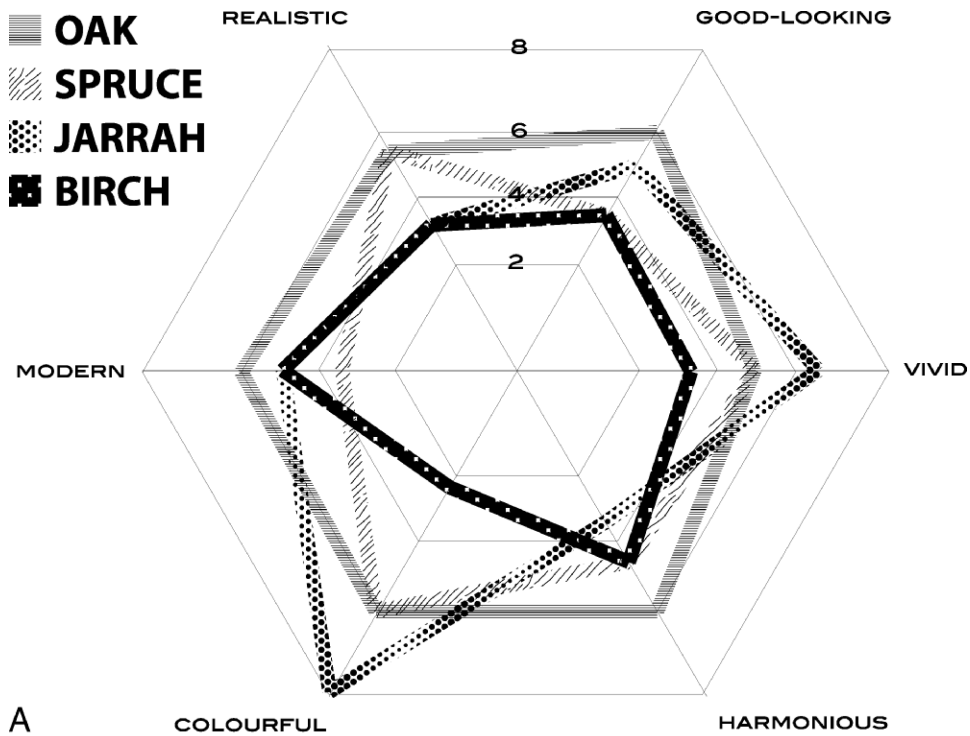
Selection of representative products.—Representative products (Table 1) were chosen to span the Space of Properties and to match the product traits (Table 3). The actual flooring product was not the focus of this study, but rather the digital picture of the flooring product in a room. The term *product,* as used in this article, refers to these pictures. KE-Soft (Kansei Engineering Software), developed by the Kansei Engineering Research Group at The University of Linköping, was used to determine that the chosen products spanned the Space of Properties.

Product pictures.—Normally, the goal for KE studies is to provide as complete a Kansei as possible, but since this was an investigation on visualization of wood interiors, the only affective flow channel used is the visual sense (Schütte 2006). Knowing that it is fairly impossible to create an neutral room (Broman et al. 2006), a rather ordinary living room was prepared and photographed from an appropriate angle (see Fig. 2), and with daylight providing different gleams and shadows. Using the visualization software, eight pictures were made with the eight floors in the same settings. All pictures were created within the software and then cropped and resized in image editing software to 529 by 397 pixels, which was the maximum that would fit on most computer screens. The pictures of the floors were examined on the pixel level to ensure the product trait variation values for color, lightness, and visual activity were acceptable. This was done using the numerical computing environment MATLAB (Gonzalez et al. 2003) by measuring the standard deviation and mean value for each color channel (RGB and HSV) and grayscale.

Software solutions

The software used for producing the pictures of the survey was ESIGN Floor Studio, the Web version of ESIGN Floor Studio from ESIGN Software GmbH, Hannover (a part of Eleco plc). The pictures were edited in the image editing software Adobe Photoshop CS from Adobe Systems, Inc. KE-Soft 2.0 (Kansei Engineering Software), developed

Figure 2.—The Web survey interface (with the floor variant oak).



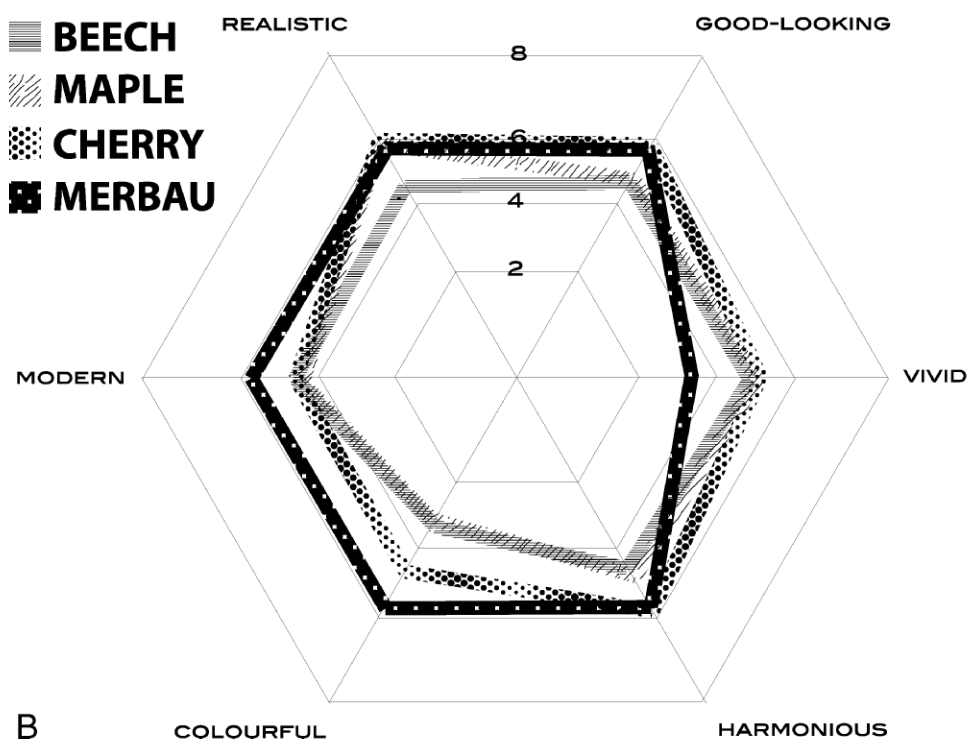


Figure 3.—Charts showing mean product scores before regression analysis.

by the Kansei Engineering Research Group at the University of Linköping, was used in the earlier and final phases of this study to facilitate and ensure the scientific quality. Tailor-made Perl and Common Gateway Interface (CGI) scripting for logging and adapting the results for KESo were conducted by a computer engineer from LTU, Campus Skellefteå. Picture color analysis was handled by MATLAB software from The MathWorks.

Data collection—user survey rating of products

The target group consisted of people buying new flooring, i.e., people in their late twenties and older. Since the survey had proven itself to be self-instructive, it was decided to promote the survey on the Internet to facilitate and speed up the data collection. The Internet community called Facebook (www.facebook.com, accessed August 24, 2008), which is geared toward slightly ''older'' people (i.e., in their thirties and older), was chosen as the platform. Here, 200 people were invited to join the survey, and 121 of them completed it. The bias risks when working with an uncontrolled environment (light, screen settings, color fidelity, etc.) were obvious, but the format also meant that people could conduct the study at their own chosen speed and time. The interviews took about 10 minutes and the respondents had to rank eight pictures in six aspects using Visual analogue scales (Heinrichs et al. 1984) on a Web site (see Fig. 2 for example).

Data analysis—connecting the data for Semantic Space and Space of Properties

A number of statistical procedures using mathematical and nonmathematical methods have been developed for use in Kansei studies (Nagamachi 2001). The use depends on the context. Linear multiple regression analysis is a way of finding correlation in a data set. Quantification Theory Type 1 (QT1) is a variation of linear multiple regression that uses dummy variables in binary levels, 0 or 1 (Komazawa and Hayashi 1976). The dummy variables are the same as seen in Table 3 but with light and dark replaced with 1 and 0, respectively. This makes it possible to identify factors that are important for a product as well as factors that are of negative influence. QT1 determines correlations between KEW rankings and different properties and is one of the most frequent used methods in KE (Nagamachi 1997). This analysis was handled by the KE-Soft software.

Scope and limitations

The term *product* in this study applies to the digital pictures of wood floorings in a certain context. No physical products were used, just pictures of them. All results were derived from a survey conducted on different computers and screens. The study was conducted with Swedish-speaking respondents only. All terms are therefore translated in this article.

Results

Results from survey

Of the 200 people invited to participate in the survey, 121 completed the survey. Most of the survey respondents (60%) were between 30 and 39 years old—thus fit within the target group from the choice of domain. Most (63%) stated that they were male. In the radar charts (Figs. 3A and 3B), showing the score per product, it is possible to see that the jarrah floor is evaluated as colorful and vivid, but not very harmonious or realistic. Birch on the other hand, is judged less colorful but more harmonious. The oak floor was considered to be the most good-looking (in the given environment).

Results from linear multiple regression analysis

The analysis using QT1 identifies the extent to which items contribute to each KEW. The result from the linear regression with QT1 is presented in Table 4, with the example of KEW *vivid*. It shows multiple correlation coefficient (MCC, equivalent to the R value in regression analysis), squared MCC (MCC^2), partial correlations coefficient (PCC), and Category Score for each KEW. The MCC^2 is the degree of explanation, and according to Nishino (2001) an MCC^2 greater than 0.5 is considered satisfactory for KE evaluation. The PCC is another important value. It quantifies the relative importance of an item for the factor of interest; the higher the PCC, the higher the importance. In the same way the Category Score shows in which direction and to which extent the factor is affected by a certain property.

Table 4.—Kansei score for KEW vivid.[a]

Item	PCC	Variation	Category score
Visual activity	0.74	High	0.64
		Low	−0.39
Color nuance	0.02	Yellow	0.01
		Red	−0.01
Lightness	0.67	Light	−0.42
		Dark	0.42
Pattern	0.54	2-Strip	−0.34
		3-Strip	0.34

[a] Vivid: MCC, 0.88; MCC^2, 0.77. MCC = multiple correlation coefficient, PCC = partial correlation coefficient.

In the example in Table 4, we see that *vivid* has a degree of explanation of 0.77. High visual activity and the dark variation of lightness, together with a three-strip lay-up pattern were most important in creating a sense of vivid. The item color nuance has a low PCC and whether a floor is red or yellow therefore has no impact on the KEW *vivid.*

The ratings are presented as mean values for the 121 participants of the study. When running the analysis, five of the original six KEW were found usable, i.e., generating an MCC of >0.5 and a regression probability of $P < 0.05$. These are as follows:

- Good-looking (MCC, 0.87), most associated with lightness and visual activity.
- Vivid (MCC, 0.88), most associated with visual activity but also lightness.
- Harmonious (MCC, 0.78), most associated with (low) visual activity.
- Colorful (MCC, 0.94), most associated with lightness (color, unexpectedly, had the third strongest association).
- Modern (MCC, 0.77), most associated with lightness.

Table 5 shows the positive or negative influence of the product trait on the Kansei score for each chosen KEW. The word *realistic* (MCC, 0.26) did not reach the required MCC limit of 0.50 and is therefore not usable. The reason for this likely is that people's definition of what realistic is, and what contributes to it, varies widely.

Test of validity and iterations

In this step, data from the synthesis is checked to see if the distribution is normal. Most KE studies are based on semantic data material that can be analyzed statistically, e.g., to treat with factor analysis. This is not possible here since the material comes from true qualitative work (Nordvik and Broman 2005, 2009), in which a single case can indicate more than several others (Glaser and Strauss 1967). The distributions were therefore plotted and subsequently visually inspected. All remaining KEW showed normal distributions.

Model building

The final model is the validated result from the synthesis. The model gives useful information about which properties

Table 5.—Influence of the product trait on the Kansei score for the chosen KEW.[a]

	Visual activity		Color nuance		Lightness		Pattern	
	Active	Calm	Yellow	Red	Light	Dark	1-Strip	3-Strip
Good-looking	−	+	+	−	−	+	−	+
Vivid	+	−	/	/	−	+	−	+
Harmonious	−	+	+	−	−	+	−	+
Colorful	+	−	−	+	−	+	/	/
Modern	−	+	+	−	−	+	−	+
Realistic[b]	/	/	+	−	−	+	−	+

[a] Slashes indicate insignificant influences (>0.1).
[b] Realistic = not usable due to low MCC.

that are linked to the KEW. A model is a simple representation of a more complex reality, and the MCC^2 describe how close this representation is. The models are a function of product properties and predict the Kansei score for a certain word (Eq. 1), i.e., the models try to represent the reality.

$$y_{\text{kansei}} = f(\text{product properties}) \tag{1}$$

The model reveals the following connections:

- Vivid flooring should have high visual activity, be dark, and be assembled in a three-strip lay-up pattern. Color nuance (red or yellow) is of no importance.
- Colorful flooring should be dark, have high visual activity, and be red. Pattern is of very small importance.
- Good-looking flooring should be dark, have low visual activity, be assembled in a three-strip pattern, and perhaps be yellow (not that important).
- Harmonious flooring should have low visual activity, be dark, yellow, and be in a three-strip pattern.
- Modern flooring should be dark, have low activity, yellow color nuance, and be in a three-strip pattern.

The model is only relevant for the room setting in which the flooring products were presented in the digital pictures. To get results that can be generalized, comparative studies must be made.

Discussion

Despite how unpopular it is among architects to develop an ''automatic recipe'' for guaranteed results, it seems possible to use KE for linking emotions to physical properties. Using statistical methods, KE can provide a mathematical connection between emotions evoked by a product and physical properties. The result is just a snap sketch—traits and items could change. However, using KE makes it possible to measure and predict, relatively quickly, how people experience different wood traits.

In the affective flow, described by Picard (1997), there are obstacles limiting the semantic flow between product traits and user senses. These obstacles are referred to as Proximity of Presentation and Proximity of Interaction (Eklund and Kiviloog 2003). The way a product is presented plays an important role; the Kansei of wood flooring may not be satisfactorily translated into a flat, soundless, and scentless picture. The aim here, however, was to investigate only the visual affective channel, since this is the way of the computer visualization. The reaction to a product's kansei is affected by the users' prior experiences, interests, and the interaction thereof, as shown by Eklund and Kiviloog (2003).

It could be argued that it is hard for the respondents to remember their exact choice of level (e.g., ''modern'') between the eight different pictures. Finding a way to combine the use of paired comparison and a reduced binary tree (Silverstein and Farrell 2001) with KE would perhaps give different and better results.

The generic room used was not perfect, but the neutral room does not exist. A larger study just working with different rooms and evaluations could be helpful to continue examining the influence of the room on a visualized product. Perhaps more levels of trait variations, instead of the binary high/low used in this study, would have made it possible to better compare the rankings and allowed a more detailed ''recipe'' to be possible. As mentioned earlier, factor analysis was not conducted to validate the results since the results were derived from true qualitative work.

One could argue that the KEW *vivid* and *harmonious* are nothing more than each other's opposites. While both words were strongly connected (PCC, 0.73 and 0.74) to the item *visual activity,* other aspects differed. *Lightness* was far more important for vivid (PCC, 0.67) than for harmonious (PCC, 0.41) and where color nuance had no importance at all (PCC, 0.02) for vivid, it was more important for harmonious (PCC, 0.29).

Conclusions

Based on the results, the combination of traits for a popular (good-looking) floor—in the given surrounding—should be calm, yellow, dark, and three-strip. No such floor was present in the survey, the closest was Oak Haro, but with a one-strip pattern.

The main objective of this study, however, was not to appoint a winner, but to examine the relationship between visualization of appearance properties of wood flooring and people's impressions of it. The study showed that it is possible to make pictures of floors that support a certain feeling. With KE, it is possible to determine what wood properties obtained from pictures, when combined, result in a high score among the affective value words.

This study is an example of using KE in the evaluation of a new product model. It is also an example of how new design solutions may be evaluated in terms of important and desired wood product properties.

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