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A product semantic study of the influence of the sense of touch on the evaluation of wood-based materials

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ABSTRACT

Based on product semantics, this study investigated how the tactile attributes of wood and wood-based composites are perceived and interpreted semantically. The wood-based samples included ash, birch, elm, oak, pine, OSB (oriented strand board), two wood pulp-reinforced polylactide composites, Comp A and B and one wood–fiber reinforced polypropene composite, Comp C. The subjects rated the samples by the descriptive words *natural*, *exclusive*, *eco-friendly*, *rough*, *inexpensive*, *reliable*, *warm*, *modern*, *snug* and *solid*. The most significant differences between the samples were found for *roughness* and for the descriptors, *reliable*, *natural and solid*. A principal component analysis yielded three attributes based on the tactile perceptions: *reliable*, *old-fashioned* and *smooth*. The solid wood pieces were perceived as natural and oak was perceived as being exclusive. The composite materials presented a greater variation in terms of perceived attributes than the wood specimens.

1. Introduction

Humans are surprisingly good at differentiating natural from synthetic materials. Natural materials are often perceived as being more valuable and desirable. Wood surfaces, for example, are generally appreciated by people for interior design or artifact production and are often associated with quality, craftsmanship and exclusivity. Fabricated materials, although sometimes cheaper, more durable and more prevalent than their natural counterparts, are often perceived as inferior and are therefore sometimes rejected by consumers. Jonsson et al. [1] found that solid wood was preferred over wood–polymer composites and that this material preference was associated with the properties: natural, pleasant, smooth, living and good value. This preference for authentic wood surfaces was also corroborated by Roos and Hugosson [2]. However, as the growing consumer demand for natural materials puts pressure on the limited natural resources, the increased use of wood composites may present a more resource-efficient alternative.

Previous preference studies have compared wood and wood–plastic composites (WPCs). In this study, we introduced a new and completely renewable and biodegradable material that combines wood pulp and polylactide (PLA) [3], a thermoplastic aliphatic polyester derived from renewable resources, such as corn starch. In the development of such new materials, it is important to understand how they will be perceived by consumers. Wood has been described as a natural material with a surface texture, pattern, color and feel that cannot be substituted by other materials [4] [p. 73]. Several WPCs, on the other hand, are described as inexpensive, plastic and imitations. Although these WPCs are easily colored and molded, their gloss can be scratched and their colors fade. A hybrid material, such as wood composites from pulp and PLA, may combine properties from wood as well as properties from paper and bioplastics. The question, however, is: Will this affect the material's identity? Will some of the properties associated with solid wood also be recognized in wood-based composite materials? Will they be perceived as natural or as plastic? If we can understand the properties that determine whether a material is perceived as natural, we may also be able to design bio-based materials that also look and feel natural. Due to differences in appearance, solid wood and wood-based composites have different uses in interior and furniture design and thus, a direct comparison may be unfair on behalf of the composites. However, to investigate a composite material's identity, a composite comparison with solid wood is justified for the assessment of its similarities and differences compared to wood. Ashby and Johnson [5] states that there is a character hidden in a material even before it has been made into a recognizable form, " – a sort of embedded personality, a shy one, not always obvious, easily concealed or disguised, but

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one that, when appropriately manipulated, imparts its qualities to the design".

Most perception studies on solid wood and wood-based materials have focused on the material's visual aspects [6] or combined tactile and visual attributes [1,7]. However, as people frequently touch wooden surfaces and their substitute materials, e.g., in furniture and interior applications [8], it is essential for the wood-based industry to know more about the tactile qualities of the materials. Analyses of tactile perceptions in the literature include warmth [9] [10], dryness [8], or physiological and subjective reactions [11,12]. One conclusion drawn from these studies is that wood provides good tactile warmth, regardless of the season. In addition, when compared to some other non-natural materials, wood seems to have good stress-relief effects [11,12]. Overvliet and Soto-Faraco [13] found that participants' accuracy in classifying natural vs. synthetic materials was usually greater than chance-factors alone, but they also discovered that accuracy dropped when heterogeneity in the sample set increased. The authors concluded that both unimodal visual and tactile examination were highly correlated predictors for overall perception of naturalness. Georgiev and Nagai [14] focused on in-depth impressions resulting from users' tactile interactions with a set of common materials and found that wood presents a "network with in-depth impressions that are connected with both artifacts and natural objects".

Product semantics is the study of perceived meanings and impressions of man-made shapes [15]. Theoretically, products make a statement based on color, shape, form, texture and gloss. The purpose of the design process, according to product semantics theory, is to make sense and meaning of things, and the designers communicate and create meaning, e.g., in the selection of materials used to manufacture objects. A goal in product semantics is to develop a suitable language to talk about the symbolic qualities of products. Petiot and Yannou [16] described a procedure for how product semantics can be used in product development. The procedure involves the definition of a semantic space and, by means of multivariate methods, explorations how different designs can communicate specific meanings [17]. Linking product semantics with design tools, such as Kansei engineering, allows the marketer to evaluate the success of an offer [18].

According to the product semantics approach, a product (e.g. a surface), through its color and patterns, creates meaning for the user. This meaning can, to some extent, be captured by different associations or descriptive terms. To serve the product development process of exposed surfaces, it is important to investigate these tactile associations when they are separated from other, e.g., visual, sensations.

The main objective of this study is to investigate the tactile perceptions and associations of different types of wood-based materials and to determine how new materials created from wood composites are perceived in relation to solid wood materials. A secondary purpose is to initiate the investigation of the opportunities to transfer perceived subjective ratings to objective material specifications for bio-based materials.

2. Method

2.1. Materials

Nine samples of solid wood and wood-composites were used. The wood samples included ash, birch, elm, oak and pine. The composite samples included three fiber-reinforced polymers (Comp A, Comp B and Comp C) and oriented strand board (OSB) from poplar and pine. Comp A contained unbleached softwood craft pulp (60% weight) in polylactide (PLA) – no finish, hot pressed. Comp B contained fully bleached birch craft pulp (60% by weight) in PLA – no finish, hot pressed. Comp C is a wood polymer composite, WPC, roughly 50% wood fibers in polypropene (PP), extruded and slightly ribbed. The wood samples were free from knots and were planed and sanded. The samples were cut into pieces of $16 \times 6 \times 2$ cm (except for the OSB, which was slightly thinner) (see Fig. 1).

The wood species constitute the most typical wood-types for interior and furniture design. The other wood-based materials were selected to represent varying types of panels and composites in terms of application, structure and production process.

2.2. Descriptive words

The descriptive words used in the study are in part based on previous elicitation studies on wood [6,1,7,19]. To identify the most relevant descriptors, focus group discussions were conducted with seven people: three were wood researchers, one was a psychologist and three were wood industry representatives. The goal was to select words that were based on previous research and also currently relevant to the product industry companies in their market communication and product development. The words related to both perceptions, i.e., what is perceived from the surface (e.g., in terms of its roughness), and to cognition, i.e., what associations are made in terms of naturalness, exclusiveness, etc. The final set of words included two categories, perceptual (*rough*, *warm*, *solid*) and cognitive (*natural*, *exclusive*, *eco-friendly*, *inexpensive*, *reliable*, *modern*, *snug*). This study did not make use of antonyms. For example, the adjectival opposite of *natural* is not necessarily *unnatural* and adjectives, such as *snug*, may lack appropriate complementary antonyms. Instead, *not* is prefixed to the descriptor to create the other end of the perceptual spectrum. The words and sources are shown in Table 1.

2.3. Respondents and procedure

Overall, 30 novice respondents, 18 women and 12 men, participated in the test. For age and gender distribution, see Table 2.

Wood and composite samples were presented in random order, one at a time. The respondent was allowed to freely touch the sample, but vision and hearing were blocked by black painted goggles (UVEX) and noise-cancelling headphones (PELTOR Optime III headset with audio input). A soft pad was used on the table to avoid sounds by knocking or vibrations from wood against the wooden

Fig. 1. Wood and composites used in the tactile study. Top row from left: Comp A 60% unbleached softwood craft pulp in PLA, Comp B 60% fully bleached birch craft pulp in PLA. Comp C Wood polymer composite, Extruded, wood fibers 50% in PP, OSB, Oak. Second row from the left: Elm and birch. Bottom row from the left: Pine and Ash.