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From theory to practice. A protocol for the experiential characterization of the expressive-sensory qualities of (native) woods (from Chile) | De la teoría a la práctica. Un protocolo para la caracterización experiencial de las cualidades expresivo-sensoriales de las maderas nativas de Chile

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Abstract

This paper presents the initial theoretical definition and subsequent implementation of an experimental protocol applied in a study conducted in Chile between 2019 and 2022. The study aimed to characterize the expressive-sensory qualities of 15 native wood species. This type of characterization, which complements the definitions of technical properties (such as hardness or strength), is significant for the Design discipline. Providing professionals with information on the perceptions, emotions and meanings that people attribute to materials, known as "materials experience".

Through literature review, expert consultation and a selection of methods previously used in this field, a characterization experience was developed by more than 200 participants, including students and professionals in the fields of design, architecture, decoration and craftsmanship. These participants, from a stratified sample proportional to the population by region of Chile, interacted multimodally with physical samples of wood to report their perceptions through a survey. In addition, biometric data were captured on their facial expressions and gaze position.

The results allowed the elaboration of comparative graphs showing the qualities of each species, which are freely accessible.

The article addresses the concept of experiential characterization of materials, focusing on wood and details the definition and implementation of the experience, documenting the process over the results, as valuable knowledge for researchers and design professionals.

Keywords: Wood, Industrial Design, materials experience, Design and emotions, Chile, Design research

Introduction

Characterizing "the other" aspects of the materials.

In the discipline of Product Design, where the material selection process is a relevant issue in each of the projects carried out, sensory, semantic or affective aspects are usually a priority. This is because the future users of a product will evaluate it not only for its ability to perform a specific function, but also for its appearance, comfort and socio-cultural meanings, among others. The latter aspects are usually the most relevant to generate deeper relationships between people and products (Camplone, 2024; Haug, 2019).

Along these lines, Ashby & Johnson (2014) state that the proper selection of materials based on technical criteria such as strength or hardness, or the performance of the basic function of a product are important, but ultimately the industrial design and the definition of its aesthetic qualities will determine, to a greater extent, people's preference for one product or another. Consistently, several authors (Camplone, 2024; Karana et al., 2009; Rognoli & Ayala Garcia, 2018; Zuo et al., 2016) have documented the relationship between sensory aspects and the creation of meanings in products and also more directly, between materials and emotions (Bertheaux et al., 2023; Crippa et al., 2012; Rognoli & Levi, 2004).

Characterization of wood.

In the case of wood, in its role as an important material for the design of products and living spaces, this is no different. For example, research has been conducted on the characteristics and properties of this material and of different species, which documents, from the perspective of biophilia, the beneficial effects for humans that occur with its use in interiors, or even with simple visual contact with wood (Ikei et al., 2017; Lipovac & Burnard, 2021; Nakamura et al., 2019; Nyrud & Bringslimark, 2010).

In addition, a positive attitude towards wood has been corroborated by a large majority of people, beyond their culture, consistently associating it with descriptors such as warm, comfortable, relaxing or natural (Browning et al., 2022; Rice et al., 2006). Studies addressing the characterization of non-technical aspects in this material have been conducted for quite some time (Blomgren, 1965; Broman, 2000a, 2001; Ratnasingam et al., 2007) and continue to be conducted today (Burnard & Kutnar, 2020; Lipovac et al., 2022; Wan et al., 2021).

Creating an experience for the characterization of Chilean native woods.

Through the definition and assessment of the expressive-sensory qualities (Rognoli & Ayala García, 2018) of 15 of the most used and commercially available Chilean native woods (plus Radiata Pine which was added as a foreign control species as it is the most used and known wood in Chile), and the identification of the perceptions that these provoke in people, the research in which this article is framed had the main objective of contributing to the optimization of the selection process of materials for Design, with the incorporation of the expressive and sensory qualities to the information available to Designers.

In order to achieve the above, it was necessary to build a "characterization experience" applicable to different people and types of wood. For this purpose, a protocol of actions and tasks that people had to perform, for example, exploring samples of materials, documenting their sensations, emotions, etc., was established based on a review of the associated literature and existing methods.

This protocol had to be implemented in practice. A process that was not free of difficulties and that determined modifications with respect to the initial plan. It is therefore considered of great importance for the dissemination of the knowledge acquired in this development, which could be useful to researchers and design professionals who wish to characterize other wood species, or other materials, to document the process of defining this characterization experience.

For the above, this article introduces the reader to the concept of experiential characterization of materials and its current state of the art, specifically in relation to wood.

Subsequently, it describes in detail the process of defining the experience carried out and its different stages and dimensions. This experience was carried out with more than 200 people and its results, available to the public at www.maderanativachile.cl, will be presented to the academic community in future works. This section defines the arguments used to define each of the parameters of this experience. Finally, a discussion and general conclusions are presented.

The experience created is thus considered one of the first results of the research process. This approach, related to the concept of Research through Design (Redström, 2020; Stappers & Giaccardi, 2018) has relevance for Design and the discipline's own research, by placing value not only on the results of research, but also treating as results of academic interest these "intermediate products" implemented to reach them. These are often of great methodological richness, born from practice, and valuable in themselves, even more so for a discipline that is still defining its own ways of researching and creating new knowledge.

Theoretical framework

Experiential characterization of materials.

It is possible to find references since the 40's of the last century regarding experiential characterization studies, mainly sensory or organoleptic analysis in the food industry (Heymann, 2019). However, the emergence of such studies in the field of Design (and materials) is more current and still somewhat scarce. In a recent review, Veelaert (2022) documents only 50 articles published between 2000 and 2019 that addressed this topic from the area of Design.

These various concepts and levels of materials interpretation have been referred to in different ways, and by different authors, while they have been gaining interest from the Design academic community (Jacob-Dazarola et al., 2019).

A more transversally accepted standard in this respect has been established from the core concept materials experience (Karana et al., 2014; Karana & Hekkert, 2008). This also considers a specific method and tools for the experiential characterization of materials (Camere & Karana, 2018), where people directly experience interaction with samples of the material under evaluation. They subsequently report their perceptions and interpretations to the researchers.

Giaccardi & Karana (2015) define four experiential levels in which materials can be characterized:

The performative level refers to those actions that the material "invites to perform", such as squeezing it, scratching it, hitting it, according to its nature and appearance. The sensory level deals with those aspects subordinated to the valuation made through the senses. The interpretative level corresponds to the meanings given to the materials, usually mediated by the culture and context of the users, while the affective level refers to the emotions and affections that people experience. These four levels interact and influence each other, so it is not possible to isolate them completely in the usual interaction between people and materials.

The experiential characterization of wood.

Considering these four levels, wood is a material that differs from metals or polymers. Each species is different, and each piece of wood, even from the same tree, is also different from another. Their grain, ring spacing, colors, grain, texture, weight, sound, aroma, create infinite possibilities of variation, which we perceive through the senses, and tell us the story of the tree they were once part of (Fujisaki et al., 2015).

People recognize in wood a sustainable, natural and close material, which does not require complex industrial processes to reach the final consumer. Even when it is processed or painted, its natural imprint persists to remind us that it was once alive.

According to Browning, Ryan & DeMarco (2022) and in partial coincidence with the four levels of experiential characterization defined by Camere & Karana, (2018), the natural biophilic preference registered for wood comes from a haptic, olfactory and visual experience (which would make up the sensory level) and from an associative (semantic) and interpretive processing (level of the same name). According to the authors, this approach to the material would provoke the positive emotions that relate to the material (in association with the affective level).

Assessment of sensory attributes and expressive qualities.

Studies that address the characterization of the expressive-sensory qualities of wood generally consider a small number of species. Among those consulted for this research process, between three to six species were analyzed, the most numerous reviewed being that of Fujisaki et al. (2015) with 14 species.

In addition, the findings are dependent, to a certain extent, on the context, i.e. the culture of the place where they were made. For example, the knottiness of wood is valued in very different ways depending on the culture in which the studies are conducted. Høibø & Nyrud (2010) mention a universal preference for a certain homogeneity in wood surfaces. Broman (2000) says that surfaces without knots are defined as more harmonious relative to those that are more irregular.

Masuda (1992) had previously stated that while in Japan knots are interpreted as defects, associating them with low quality wood, in Europe, the United States and Canada they are associated with descriptors such as natural or rustic, interpreting them positively.

According to Wan et al. (2021) the visual perception of a wood surface is mainly defined by three factors: color, grain and gloss. These authors state that, in general, dark wood (dark brown, dark reddish) is preferred to lighter (yellowish) or medium color (light brown, light red), and matte or definitely glossy wood is preferred to semi-glossy wood.

Previous studies have obtained equivalent results and suggested that there is a tendency to value woods similarly according to the predominant color. Bumgardner & Bowe (2002) in agreement with Wan et al. (2021) noted that darker woods have been described as expensive, formal, old and stately, while lighter woods have been described as cheap, informal, modern and modest.

Characterizing for Design.

Karana (2010) states that the conceptions people have about materials, where they usually consider wood as cozy, metals as cold and plastics as polluting or of low quality, are not really useful for the discipline of Product Design given their excessive generality.

Similarly, due to the enormous variability that exists among the different wood species and, especially, the role that context and culture play in the evaluation of their qualities, it seems possible to argue that, in order to contribute objectively to the material selection process in the design framework, the experiential characterization of wood must be much more specific. When designers select materials, it is not enough to know that people prefer dark woods or surfaces with few knots. It is necessary to know the species that could be useful in order to, for example, evoke a defined emotion, be associated with certain concepts, or provoke a certain perception in the users of a product or the inhabitants of a space (Jacob-Dazarola et al., 2019).

Another aspect to keep in mind, with respect to existing studies, is that the research processes used, as well as the methods and tools, differ significantly. For example, the descriptors used to evaluate the interpretative or sensory levels vary from one study to another. This makes it difficult to associate the results to build a common database that brings together different species, even from different geographical areas, and allows designers to select woods with a broader and more informed perspective.

Characterization of wood in Chile.

Regarding studies carried out on Chilean timber species, the situation is similar to that described above for materials in general.

In repositories and digital libraries open to the public, owned by entities dedicated to the field of wood, such as CORMA or INFOR it is possible to find, with ease, numerous physico-mechanical characterization studies of practically all native species relevant to the wood industry (Baradit et al., 2013; Karsulovic C. et al., 2000).

However, when it comes to the characterization of sensory, semantic or affective aspects, few publications were found (Alarcón Castro et al., 2019; Alarcón Castro & Di Bartolo, 2013; Brañes Alarcón et al., 2023; Briede W. & Alarcón Castro, 2012), only available in academic repositories and, together, considering five native species.

Materials and methods.

To establish a characterization experience applicable to 15 Chilean native woods, whose results would be really useful to designers in their material selection processes, it had to be consistent and repeatable at different times and in different scenarios and incorporate the most relevant aspects in terms of the levels and dimensions defined in this type of characterization.

The definition of this experience involved an extensive process that took place between 2017 and 2022 in two consecutive research projects.

To this end, a linear process was followed in the initial stages, which subsequently became iterative. It began with a comprehensive literature review, reflected in a previously published article (Jacob-Dazarola et al., 2019) and the current theoretical framework presented here. Subsequently, a consultation with experts from the world of Design, wood and materials, was carried out and a first version of the experience was elaborated, which was applied in the framework of the first project.

As a result of the knowledge acquired, and within the framework of a new research project, a new, more extensive and complex experience was proposed. This new experience included aspects that had been previously relevant or inadequately resolved: lighting uniformity, interaction with the stimuli, their format, etc.

This second experience was tested by the project executors themselves, modified again in several aspects, and implemented in a white march stage with 18 volunteers, where the last aspects in conflict were corrected.

Subsequently, it was implemented, first under controlled conditions at the Faculty of Architecture and Urban Planning of the Universidad de Chile and later in various places in the country, with the total participation of 311 people.

A relevant methodological reference used as a starting point was the Ma2E4 Toolkit (Camere & Karana, 2018) because, beyond its solid theoretical foundations, it presents concrete instruments that allow obtaining information from people as they interact with various materials, evaluating them at the four levels already mentioned.

Complementarily, the work of Chen et al. (2009), Veelaert et al. (2020) and Veelaert (2022) allowed access to previous systematizations of the different experimental parameters involved in the materials characterization processes. To these, some aspects that were considered relevant given the previous experience were incorporated.

Following the sections proposed by these authors (tables 1 and 2), the definition process for each parameter of the experience created is detailed below.

Table 1. Experimental parameters of experiential characterization of materials. Developed by the author based on Veelaert et al. (2020).

STIMULI		EXPERIMENTAL VARIABLES		MODE OF INTERACTION	PARTICIPANTS
Tangibles	Intangibles	Dependents	Independent	Unimodal guided	Quality
Materials	Renders	Sensory	Techniques	Multimodal guided	Demographics
Textures	Photographs	Interpretive	Of the product	Free muiltimodao	Training
Products	Images	Affective	Of the user		Experience

METHODS		
Scales	Discrimination	Free association
Semantic differential	Sorted napping	Associated words
Unipolar	Paired comparative analysis	Emotions evoked
Binary	Hierarchical grouping	Suggested uses
Ranking		

Stimuli. Type, size, shape, finish.

An valuable aspect in the experiential characterization of materials refers to the stimuli used, i.e. the samples that will allow people to interact with the material through one (unimodal) or more of their senses (multimodal). These stimuli can be tangible (real, flat or volumetric samples) or intangible (photographs, representations, images on a screen, virtual reality) (Bertheaux et al., 2023; Veelaert et al., 2019a, 2020a).

To start defining this aspect, a new, more specific literature review was carried out, which considered ten articles published between 2001 and 2019 on wood characterization. This review showed that, with respect to the stimuli, there are only two common aspects among the characterization experiments carried out: the use of physical samples of the woods under study defined by three fundamental aspects: dimensions, shape and surface finish, and the use of photographs of products, or computer representations of the different wood species, as a complement.

Nordvik & Broman (2009) point out that despite the implicit complexity of representing wood, since it implies the loss of many important and subtle attributes such as aroma or texture, differences in sound or temperature to the touch, the use of these resources allows to expand the scope of the stimuli. It is possible to illustrate various products made of different types of wood, large objects, interiors or exteriors of houses or buildings without added cost. In recent studies, virtual reality has been shown to be effective as a resource for unimodal sensory evaluation of some aspects of materials such as gloss or perceived softness (Bertheaux et al., 2023).

To define the dimensions, and in the absence of a clear agreement from experts or existing literature, three size alternatives were tested between the project team and ten students from the Design program at the Universidad de Chile, through a free and multimodal interaction. Actions such as lifting the piece of wood from a flat surface, extracting it from a compartment and manipulating it easily were key to finally define a size of 200x120mm. The thickness, 20mm, was defined considering the same aspects and the relationship between the thickness of the wood pieces and the perception of their quality (Pérez Mejía, 2010).

Regarding the shape of the samples, the experts consulted suggested irregular, circular or volumetric alternatives; however, the most frequently mentioned shape was rectangular. On the other hand, the studies consulted used only rectangular or square shapes. Complementarily, Veelaert et al. (2019) point out the importance of neutral stimuli, devoid of semantic value, to be able to perform a truly objective characterization. They also point out the possibility of reaching this neutrality through two strategies: simplicity or complexity. They argue that the latter increases the possibilities of exploration in the interaction with the materials.

Considering the above, a rectangular piece was defined as a base, which was modified by applying processes commonly used in the manufacture of wood products, such as sawing and milling, as shown in Figure 1. This generated a sample, still recognizable as rectangular, but capable of referring to several of the most common geometries of wood products, such as 90° and 45° angles, rounded and sharp corners and edges, or continuous perpendicular faces.

Bhatta et al. (2017) posit that natural, smooth wood surfaces are perceived more positively than surfaces with a finish or coating. They further suggest the importance of preserving the naturalness of the texture. However, in people's everyday relationship with wood products, these usually already have coatings or surface treatments such as lacquers, varnishes or oils. The occasions when people interact with bare wood are in practice rare, especially in the case of interior products (Scrinzi et al., 2011).

With this in mind, and to allow an assessment of the most common finishing options, each wood species was represented by three pieces of equal shape and size, one without any coating, the second with a satin finish given by an oil treatment, and the third coated with gloss varnish. The underside was left uncoated on all pieces so that people could perceive the sensory differences between the bare wood and the different coatings applied (Figure 1, images above).

For the complementary images, photorealistic rendering images were created using 3D Max software and the VRay rendering engine. Two image sheets were made for each of the 15 species, applying digital textures based on the Advanced Wood material to scenes with identical 3D models and lighting parameters. In this way, the only variable was the wood represented. For both products and spaces, we sought to offer alternatives that would allow us to broaden our view of the material's application possibilities (Figure 1, images below).

Experiential variables and methods.

Although the objective of this study was to obtain as complete a characterization as possible, comparing the woods at different levels and through all the senses, once the stimuli were defined, it was decided to discard the evaluation of the performative level. This was because, as the samples were the same in finish, size and shape, people tended to interact with them in virtually identical ways. However, some small differences were observed in species with very distinctive characteristics in terms of weight, surface porosity and aroma, which could be studied in future research.

With respect to the other levels, each one was associated with specific methods and techniques that were established in the initial design stage of the experience, which, based on the literature review and experience acquired in the previous project, were determined to be the most suitable in each case.

The sensory level was assessed using a tool commonly used in the experiential characterization of materials, the semantic differential scale, which presents different pairs of words with opposite meanings so

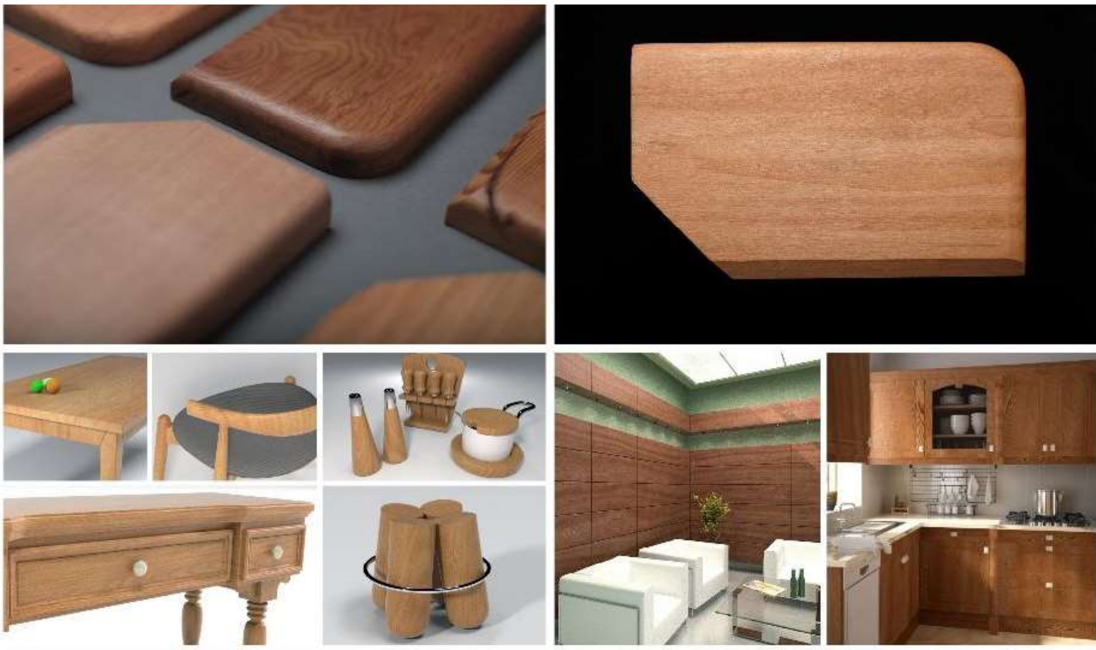

Figure 1. Physical and computer stimuli presented to participants. Photographs and images prepared by the authors.

that people can define their perception (Choi, 2016; Kelly & Stephenson, 1967; Osgood et al., 1957). This is similar to what was put forward in the toolkit proposed by Camere & Karana (2017) but the original word pairs were modified due to the specificity of the material. In all cases in which the semantic terms were modified, the dimensions associated with them were maintained so as not to vary the statistical significance of the tool and its internal consistency (Aros Beltrán et al., 2009; Osgood & Suci, 1969), which had already been evaluated during its development.

The affective level was evaluated by means of semantic differential scales and free word association. This word association sought to get people to mention the emotions evoked by each wood. For this purpose, they were presented with a poster with various emotions, based on Scherer's theory (2000), serving as a starting point for the participants to choose some of them, but they could also mention emotions that did not appear on the poster.

The adjective pairs of the semantic differential were also based on those proposed in the same toolkit but were significantly modified following the criteria expressed by the experts and the literature review conducted specifically on wood characterization.

One of the secondary objectives of the research was to compare, validate and/or discard methods commonly used for the experiential characterization of materials in a local context. Therefore, the affective level was additionally evaluated by means of biometry (measurement of physiological parameters of the human body) using the Facereading module of the Imotions software, capable of measuring, from the analysis of facial expressions, the intensity of seven basic emotions (joy, disgust, sadness, anger, surprise, fear and contempt). This was done by means of a camera that captured the participants' faces during the first interaction with the physical wooden samples.

The interpretative level was also assessed by semantic differential and free association. The adjectives of the semantic differential, as in the affective level, were based on the toolkit, but were modified based on the same criteria.

All semantic scales and free word associations were presented to participants on a 30-inch screen (and their responses automatically collected) with an interactive questionnaire created through the Survey module of the Imotions software.

To the evaluation of the three levels mentioned above, free association questions were added related to the possible uses and applications for each species and others focused on the processes and finishes associated with each of them, always from an expressive, sensory and perceptual point of view rather than a technical one.

In addition, two aspects were incorporated that contribute to the knowledge required by designers when selecting specific species for their projects: a general preference ranking of species and an assessment of the recognition of each species, i.e., whether people were able to associate its common name with the physical sample.

Complementarily, this potential preference for some species was evaluated using eyetracking technology to establish the position and permanence of people's gaze when observing all species at the same time. For the implementation of the eyetracking technology, we initially tried to use Pupil Labs Core model lenses and the native software provided by the manufacturer; however, the complex calibration process required for each participant made its massive use in the field unfeasible. They were then replaced by the Invisible model from the same manufacturer, which does not require prior calibration, thus allowing the procedure to be performed expeditiously and eliminating the "laboratory" experience.

Sense modality, stages and times of interaction.

Time is a key factor in this type of experiments as it is directly related to the attention span of the participants. Veelaert et al.(2020) define an average of 37 minutes based on their literature review. They conclude that experiential characterization experiments have a concentration limit of 40 minutes.

The authors point out strategies used to optimize the time and participation of individuals. For example, separating individuals by modality (visual, tactile or mixed) or dividing samples into groups of respondents with similar profiles. These groups evaluate different materials, but the characterizations are comparable.

In this case, the experience contemplated an initial multimodal and free interaction with the material, but restricted to a time of 30 seconds, and with the possibility of continuing the interaction freely throughout the experience.

A fundamental measure to safeguard the adequate duration of the procedure was to avoid each participant being obliged to characterize the 16 woods under study. For this purpose, the species were divided into four groups, considering the predominant color as an attribute to divide them (each group was formed by a species of dark reddish, light reddish, yellowish and grayish-greenish tones).

Thus, each participant had to evaluate only four species. As the time spent by people evaluating the first species presented to them was much longer than the second and this time was shorter than the third and fourth species, the order in which they were evaluated was randomized and the four groups of species were rotated every ten participants.

This meant that, in practice, there were four different experiences possible. Since many of the participants expressed their interest in evaluating more than one group of woods, it was decided that the same individual could participate up to four times if he/she wished, leaving an interval of one hour between each experience. This break allowed him/her to resume attention levels. The execution time of the experience performed for the second or third time was notoriously shorter than the first time.

After testing with the project team and during the white march, it was decided to separate the stage corresponding to the ranking of preferences and recognition of species, this stage being called experience 2. The characterization experience guided by the interactive questionnaire was then called experience 1. Each person was initially asked if he/she wanted to do one or both experiences, if he/she opted for both, at the end of the first one, he/she was asked again if he/she wanted to continue with the second one after a 15-minute break.

Priority was always given to experience 1, which was more extensive, provided more information and was more complex. In addition, this experience considered only four species per execution, while experience 2 was carried out with all the woods at the same time, requiring fewer participants to achieve the same number of responses per species. Experience 1 had an average duration of 33 minutes and experience 2 only 12 minutes.

A third part of the experience was constituted using the eyetracking equipment, which was performed in a separate process, where in only three minutes each, participants recorded their gaze position using the same layout as in experience 2.

Participants.

To define the sample of participants, we used the parameters proposed by Veelaert et al. (2020) regarding quantity, activity or profession, demographics and experience with the materials. Another important criterion was that the participants corresponded to people linked to working with wood, such as advanced students and professionals in the areas of Design and Architecture, decorators, craftsmen, carpenters. In this way, they had some familiarity with the material, which significantly facilitated the understanding of the proposed experience.

A stratified sample was established, proportional to the inhabitants of the different regions of Chile, selecting inhabitants from the Metropolitan region, due to its volume of inhabitants and movement in the timber market, as well as the regions of Biobío (Concepción), Los Ríos (Valdivia) and Los Lagos (Chiloé) due to their timber tradition, widely known in the country.

Among the criteria originally defined for the sample was also an age at which people were actively participating in work activities. Therefore, an attempt was made to maintain an average age greater than 30 years, but given the high number of students who participated, this could not be achieved. Priority was given to the number of participants, finally obtaining an average of 26 years of age. The details of the sample are shown in Table 2.

Experience 1 was finally carried out by 211 people who provided 52 responses for each species. Experience 2 was carried out by 211 people with an equal number of responses per species, both experiences were carried out over a period of seven months. The eyetracking experiment was carried out by 100 people in only two days.

Configuration. Instruments, environment and equipment.

An aspect that is also not clearly defined in the studies reviewed is everything related to the equipment, tools and instruments used in the characterization experiments carried out. Although photographs of the stimuli are common, few studies present any detail regarding the experimental layout, such as that of Veelaert et al. (2020).

For the realization of this experience, the use of two detachable photographic booths of 800x800x800 mm of textile material and aluminum skeleton, Led studio type CAIM model 201803, was defined.

Table 2. Sample segmentation according to gender, region, age range and activity.

GENRE		REGION		AGE RANGE		ACTIVITY	
M	95	Metropolitar	157	20-25	13	student/professional design	139
F	115	Biobic	32	25-30	48	architecture student/professional	30
O	0	Los Ríos	12	30-35	6	engineering student/professional	10
NS/NR	0	The Lakes	10	+35	26	other profession/activity	32

The cabins were equipped with two white LED luminaires (T°4000-4500K) with a color rendering index of 92 and a capacity of 12,000 lumens. These luminaires allowed a uniform illumination, independent of the surrounding light conditions, and a natural visualization of the color of the woods. The timbers were illuminated with 1575 lux measured at the center point of the booth.

The cabin of experience 1 contained the following elements:

- 1 Xiaomi 24" monitor where the various instructions and questions of the experience were displayed. The Imotions software (Survey module) allowed this to be set up according to specific times or interactive on-screen instructions as required.
- 1 Logitech C922 Pro webcam, Full HD, which recorded facial expressions for 30 seconds during the first contact with the woods.
- A wireless keyboard and mouse allowed participants to respond to on-screen prompts and advance through the experience.
- A specially constructed semi-rigid support box concealed 12 pieces of wood, 3 of each of the four species under characterization (matte without any treatment, semi-gloss treated with oil and glossy coated with varnish). Each species was identified by a number on them.
- An A3 sheet with a circumflex of emotions to help participants choose the emotions experienced.

The cabin of experience 2 contained:

- 16 samples of the species positioned on a rigid panel and inclined 20 degrees.
- 16 numbered plates that allowed participants to establish a preference ranking by manually placing the plates next to each sample.
- 16 plaques with the common names of the woods, which made it possible to establish the recognition of each species by positioning them next to each species.

Results.

The results presented here could be considered, in the total context of the research project carried out, only an intermediate step to obtain the outcomes, corresponding to the experiential characterization itself. Although this is true, from a process proposed as close to research through design, the protocols defined for the development of the experiences should also be seen as research results if they are registered under academic canons as we have tried to do here.

The protocols obtained are presented in tables 3, 4, and 5, disaggregating each one in stage, events and materials required, so that they can be replicated in other material characterization processes, whether wood or others, and if modified, these changes can be implemented gradually, stage by stage, without altering the others. The stages have been established the same for the three experiences created, being finally four: preparations for the experience, the beginning, the development and the end.

The events then describe chronologically each step necessary to carry out the experience and the materials, which refer to elements of easy implementation or to the specific equipment previously listed.

Along with the protocols presented, a rigorous preparation of each element and experience is also needed, as well as practice, through a stage of testing with people outside the research, to achieve the necessary fluency and mastery by the facilitators to optimize each step. The protocols are independent, because although the complete experience was necessary in the project carried out, the interests of each researcher may differ with respect to the objective of the characterization carried out and the search for data on the different levels and dimensions of each material.

Experience development

Table 3. Protocol of the experience 1.

Experience 1 - Experiential characterization		
Stage	**Events**	**Materials**
Preparations for the experience	* Layout of all the elements of the defined layout (Fig. 2A) * Participant reception * Brief review of the experience * Delivery of instructions * Signature of informed consent * Resolution of possible doubts * Positioning of the participant in front of the booth	* Elements of experience 1 previously mentioned * Person facilitating the experience * Informed consents (physical, A4 format, validated by the ethics committee of the faculty) * Chair * Computer with experience created with Imotions Survey (outside the booth, controlled by the facilitator). This experience can be created with any questionnaire creation software.
Beginning of the experience	* Home of the screens that guide the experience * Instruction to take the 3 pieces corresponding to the first species to be evaluated * Multisensory and free exploration of the parts (Fig. 2B).	
Development of the experience	* Follow the instructions on the screen * Response to semantic differentials, scales, open-ended and free-association questions covering the 3 levels to be characterized * New multisensory exploration of the following species (cycle of 4 species in total)	* A3 sheet with emotion circumflex was used in one of the question screens to more accurately identify the emotions experienced.
Completion of the experience	* Confirmation of completion * Request for the general perception of the activity performed * Resolution of doubts * Invitation to perform the experience again with other species or to perform experience 2, always after a break. * Record of the willingness to receive information on the results of the process)	* Computer for registration of final comments, registration of full participation, expression of interest in further participation and receiving further information (registration carried out online in Google Spreadsheets)

Figure 2. Layout of Characterization Experiences 1 (A and B), 2 (C and D) and 3 (Bottom picture). Own elaboration.

Table 4. Protocol of experience 2.

Experience 2 - Ranking and recognition of species

Stage	Events	Materials
Preparations for the experience	* Arrangement of all the elements according to the defined layout (Fig. 2C) * Brief review of the experience * Delivery of instructions * Signature of informed consent * Resolution of possible doubts * Positioning of the participant, standing in front of the closed booth	* Elements of experience 2 previously indicated, considering the samples treated with oil for each species (The position was modified every 30 participants with the criterion of not grouping woods that were too similar or too striking). * Informed consents (physical, A4 format, validated by the ethics committee of the faculty)
Beginning of the experience	* Cabin opening * Initial observation of samples	
Development of the experience	* Positioning of the numbers to define the preference ranking (Fig. 2C) * Positioning of signs to determine the level of recognition of each species (Fig. 2D).	
Completion of the experience	* Confirmation of completion * Request for the general perception of the activity performed * Resolution of doubts * Invitation to perform experience 1 again with other species, always after a break * Record of the willingness to receive information on the results of the process	Computer for online registration of preferences expressed by each participant Camera to capture preferences in a confirmation photo

Table 5. Protocol of experience 3. Own elaboration

Experiencia 3 - Eyetracking

Stage	Events	Materials
Preparations for the experience	* Arrangement of all elements according to the defined layout (Fig. 2, photo below). * Brief review of the experience * Delivery of instructions * Signature of informed consent * Resolution of possible doubts * Positioning of the eyetracking lenses on the participant * Positioning of the participant, standing in front of the closed booth at the exact predefined distance	* One sample of each species treated with matte finish oil (The position was modified every 50 participants with the criterion of not grouping woods that were too similar or too conspicuous to focus visual attention). * Informed consents (physical, A4 format, validated by the ethics committee of the faculty) * Pupil Labs Invisible eyetracking lenses and a device to control and automatically record data (cell phone with software included by the manufacturer). * 4 QR codes 10x10 cm targets, predefined by the lens manufacturer, printed in high contrast and glued on a hard acrylic surface
Beginning of the experience	* Cabin opening	
Development of the experience	* Free observation of the samples for 45 seconds (Fig. 2, lower photograph). * Confirmation of completion * Resolution of doubts and registration of the willingness to receive information on the results of the process	

Discussion

The protocols obtained have considered for their construction most of the previously cited studies, which have given support and academic value to the decision processes presented in the materials and methods section. There are, therefore, common aspects with some of the studies. Particularly the work of Camere and Karana (2018) and Veelaert (2022; 2020) has served as a reference for the initial establishment of experimental guidelines. Despite this, a series of new procedures and changes had to be implemented from theory to practice to complete the experiment successfully. It is precisely this complex work, which requires numerous instances of often tedious and repetitive tests, that we seek to simplify for future research in the area with the registry presented here.

As previously outlined, there are very few studies that provide details of the experimental process at the level that has been attempted, making it difficult to repeat the experiments in conditions at least similar to those already tested by other researchers. The definition of the size of the stimuli, their finishes, the levels or dimensions of interest to be characterized also do not appear as completely standardized aspects. Studies that can be considered cornerstones of the area, specifically regarding wood characterization (Broman, 2000; Høibø & Nyrud, 2010) give little information on which parameters were considered. Added to this are the cultural differences and the timber species themselves, since most of these studies have been carried out in Nordic countries or North America, which increases the number of variables to be considered and the definition of an effective experimental design, which allows to reduce or control them to focus the results on the characterization sought.

As for the participants, most studies report only the number of participants and some analyze the differences in perception by age or gender (Bumgardner & Bowe, 2002; Mynttinen, 2009). It has been preferred here to provide as much data as possible regarding the people who participated in the experience created so that future studies can take this information into account, establishing adequate sample selection criteria according to the required characterization.

Regarding the virtual stimuli, relevant to provide the participants of the experience with a variety of products and spaces where each type of wood is the only variable to consider, more recent studies provide more information (Lipovac & Burnard, 2021; Nakamura et al., 2022), and it is possible to argue that the process to obtain each image (type of software used, rendering or lighting parameters, among others) is not too relevant for the characterization itself, beyond the necessary image quality in terms of realism, image sharpness and above all, the fidelity of the representation of the wood itself.

The parameters provided from this study should therefore be understood as initial guidelines for those involved in the challenge of characterizing materials, whether wood or others, since the particularities of each situation, and as previously mentioned, the context, especially the cultural and social context, will determine differences in each case. Even so, it is expected that they will contribute significantly to standardize this type of procedures in what can be common, leaving the people and the materials themselves as the only relevant variables. This will also allow the development of universally valid databases, at least partially, that can be consulted online by designers from anywhere in the world.

Conclusions and projections.

The experience with materials and the expressive-sensory qualities that we sought to characterize in this research are often considered purely subjective in nature and there is not usually great care in their definition processes by the professional and academic design community. It is common for designers to conceptualize the meanings, emotions and interpretations of the materials they use in their projects according to their own individual criteria or by conducting small informal surveys among colleagues or people close to them.

In this regard, the participants in the experience, who were also direct representatives of the design community and of the timber material, reported very positive feedback after participating in the experience. Most of the participants were often surprised by the rigorousness of the process, its uniformity each time it was carried out, the diversity of areas addressed, and the methods used, which integrated the traditional with new technologies in a harmonious and easily understandable way.

It is important to emphasize that when performing these procedures, any prejudice or stereotype regarding the understanding that people may have of the aspects under evaluation should be abandoned, but at the same time, the experience should be simplified so that it is smooth and quick to perform. The design of this experience, structured and clear in its approach, as well as its dissemination in the professional and academic community, also seeks to contribute to the adoption of these experiences for the characterization of materials as a more common resource for the discipline of Design, tending to its incorporation into the curricula of undergraduate programs in the area, something today just incipient (Papile et al., 2022; Pedgley et al., 2016; Zhou, 2021). The training of design professionals who have a greater awareness of the relevance of these areas seems necessary in a context where new materials, artificial and natural, appear every day in the market and become options for the design and development of new products, and where at the same time technologies such as artificial intelligence could largely replace materials experts who only consider their technical aspects (Maqsood et al., 2024).

Connected to the above, it seems possible, allowing for the experience created and the results obtained, to establish criteria that tend to standardize and unify these experiences at a more global level. Although this is not free of very relevant complexities, such as cultural differences or the need to have a minimum of technological resources to optimize and standardize some aspects of the experience, it is necessary to provide design professionals with more universal databases, such as those that group the physical-mechanical or technical characteristics of different materials. In the case of databases of expressive and sensory qualities, they should also incorporate aspects such as collaboration, associativity or open access among academics, professionals and institutions, allowing their continuous improvement and an organic process of growth. In this line, it should be noted that the defined experience has already been successfully used, with minimal modifications, for the experiential characterization of artificial and natural materials, other than wood, in other Latin American countries. Although it proved to be adequate in that instance, an important area, still little explored and to be developed in future research, is related to the definition and standardized presentation of the results obtained after carrying out the experience itself.

Finally, and from the perspective of research and new knowledge arising from the discipline, it is important to highlight the value of the projective and empirical processes that have always characterized the profession and that, in its transition to an academic discipline, it would not be desirable to lose. As Findeli et al. (2008) point out, in research through design there is a communion between theory and practice that helps to build an authentic design theory capable of adopting an epistemological stance consistent with what is distinctive of Design: the project. This tacit knowledge that arises from doing is not usually registered by the conventional means of the academy and therefore is not easily recognized as valuable by it. For this reason, and in the search for a change of paradigm in this aspect, this article seeks to record the process carried out to define a procedure, thus converting it, it is hoped, into useful knowledge for designers, at the same level of relevance as the results arising from the application of the procedure itself, which can be reviewed on the project's website.

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References.

Alarcón Castro, J., & Di Bartolo, C. (2013). Bionic methodology and affective engineering applied to texture design for Pinus radiata-based boards. Interciencia, 38(9), 664-668.

Alarcón Castro, J., Llorens Vargas, A., & Ormeño Bustos, G. E. (2019). Kansei engineering applied to a study referred to five commercial timbers from Chile. Madera y Bosques, 25(1). https://doi.org/10.21829/myb.2019.2511553. https://doi.org/10.21829/myb.2019.2511553.

Aros Beltrán, M., Narváez, G., & Aros, N. (2009). THE SEMANTIC DIFFERENTIAL FOR DESIGN DISCIPLINE A TOOL FOR PRODUCT EVALUATION. XIII Congreso Internacional De Ingeniería De Proyectos, 1679-1690.

Baradit, E., Niemz, P., & Fernández-Pérez, A. (2013). Physico-mechanical properties of some Chilean native coniferous and broadleaved woods by ultrasound. Maderas. Science and Technology, 15(ahead), 0-0. https://doi.org/10.4067/S0718-221X2013005000019. https://doi.org/10.4067/S0718-221X2013005000019

Bertheaux, C., Zimmermann, E., Gazel, M., Delanoy, J., Raimbaud, P., & Lavoué, G. (2023). Effect of material properties on emotion: a virtual reality study. Frontiers in Human Neuroscience, 17(January), 1-17. https://doi.org/10.3389/fnhum.2023.1301891. https://doi.org/10.3389/fnhum.2023.1301891

Bhatta, S. R., Tiippana, K., Vahtikari, K., Hughes, M., & Kyttä, M. (2017). Sensory and emotional perception of wooden surfaces through fingertip touch. Frontiers in Psychology, 8(MAR), 1-12. https://doi.org/10.3389/fpsyg.2017.00367.

Blomgren, G. W. (1965). The psychological image of wood. Forest Products Journal, 15(4), 149-151.

Brañes Alarcón, J., Brañes Alarcón, J., & Alarcón Castro, J. (2023). Designing materials for transition, valorizing waste from the wood manufacturing sector. Cuadernos Del Centro de Estudios de Diseño y Comunicación, 203. https://doi.org/10.18682/cdc.vi203.9761

Briede W., J. C., & Alarcón Castro, J. (2012). Sustainable strategies applied to the regional context: Design of wood panels and non-conventional raw materials for decorative cladding. Interscience, 37(12), 927-933.

Broman, N. O. (2000b). Means to measure the aesthetic properties of wood [Doctoral dissertation]. Lulea University of Technology.

Broman, N. O. (2001). Aesthetic properties in knotty wood surfaces and their connection with people's preferences. Journal of Wood Science, 47(3), 192-198. https://doi.org/10.1007/BF01171221

Browning, D., Ryan, C., & DeMarco, C. (2022). The Nature of Wood- An exploration of the science on biophilic responses to wood. Terrapin Bright Green, LLC. http://www.terrapinbrightgreen.com/wp-content/uploads/2022/01/The-Nature-of-Wood_Terrapin_2022-01.pdf. http://www.terrapinbrightgreen.com/wp-content/uploads/2022/01/The-Nature-of-Wood_Terrapin_2022-01.pdf

Bumgardner, M. S., & Bowe, S. A. (2002). Species selection in secondary wood products: Implications for product design and promotion. Wood and Fiber Science, 34(3), 408-418.

Burnard, M. D., & Kutnar, A. (2020). Human stress responses in office-like environments with wood furniture. Building Research and Information, 48(3), 316-330. https://doi.org/10.1080/09613218.2019.1660609.

Camere, S., & Karana, E. (2018). Experiential characterization of materials: Toward a toolkit. Proceedings of the International Conference on Design Research Society (DRS). https://doi.org/10.21606/drs.2018.508

Camplone, S. (2024). Sensory and expressive qualities of materials for design. Theoretical Issues in Ergonomics Science, 1-11. https://doi.org/10.1080/1463922X.2024.2364173

Chen, X., Barnes, C. J., Childs, T. H. C., Henson, B., & Shao, F. (2009). Materials' tactile testing and characterisation for consumer products' affective packaging design. Materials and Design, 30(10), 4299-4310. https://doi.org/10.1016/j.matdes.2009.04.021.

Choi, J. (2016). Material selection by the evaluation of diffuse interface of material perception and product personality. International Journal on Interactive Design and Manufacturing (IJIDeM). https://doi.org/10.1007/s12008-016-0320-9

Crippa, G., Rognoli, V., & Levi, M. (2012). Materials and emotions: A study on the relations between materials and emotions in industrial products. 8th International Conference on Design and Emotion: Out of Control - Proceedings, September, 11-14.

Findeli, A., Brouillet, D., Martin, S., Moineau, C., & Tarrago, R. (2008). Research Through Design and Transdisciplinarity: A Tentative Contribution to the Methodology of Design Research. "FOCUSED" - Current Design Research Projects and Methods Swiss Design Network Symposium, January, 67-91.

Fujisaki, W., Tokita, M., & Kariya, K. (2015). Perception of the material properties of wood based on vision, audition, and touch. Vision Research, 109(PB), 185-200. https://doi.org/10.1016/j.visres.2014.11.020.

Giaccardi, E., & Karana, E. (2015). Foundations of materials experience: An approach for HCI. Conference on Human Factors in Computing Systems - Proceedings, 2015-April, 2447-2456. https://doi.org/10.1145/2702123.2702337

Haug, A. (2019). Psychologically Durable Design-Definitions and Approaches. Design Journal, 22(2), 1-25. https://doi.org/10.1080/14606925.2019.1569316

Heymann, H. (2019). A personal history of sensory science. Food, Culture and Society, 22(2), 203-223. https://doi.org/10.1080/15528014.2019.1573043

Høibø, O., & Nyrud, A. Q. (2010). Consumer perception of wood surfaces: The relationship between stated preferences and visual homogeneity. Journal of Wood Science, 56(4), 276-283. https://doi.org/10.1007/s10086-009-1104-7

Ikei, H., Song, C., & Miyazaki, Y. (2017). Physiological effects of wood on humans: a review. Journal of Wood Science, 63(1), 1-23. https://doi.org/10.1007/s10086-016-1597-9

Jacob-Dazarola, R., Venegas Marcel, M., & Donoso Cisternas, S. (2019). Towards an experiential characterization of wood as a material for product design. Legado de Arquitectura y Diseño, 25(June), 62-71.

Karana, E. (2010). How do Materials Obtain Their Meanings? METU Journal of Faculty of Architecture, 27(2), 271-285. https://doi.org/10.4305/METU.JFA.2010.2.15

Karana, E., & Hekkert, P. (2008). Attributing meanings to materials. 6th International Conference on Design & Emotion, 1, 1-18.

Karana, E., Hekkert, P., & Kandachar, P. (2009). Meanings of materials through sensory properties and manufacturing processes. Materials and Design, 30(7), 2778-2784. https://doi.org/10.1016/j.matdes.2008.09.028

Karana, E., Pedgley, O., & Rognoli, V. (Eds.). (2014). Materials Experience. Fundamentals of Materials and Design (Vol. 3). Elsevier. https://doi.org/10.1162/DESI_a_00335

Karsulovic C., J. T., Gaete M., V. H., & León G., A. (2000). Feasibility Study of the Use of Chilean Native Woods in the Construction of Musical Instruments. Revista de Ciencias Forestales Universidad de Chile, 14, 28.

Kelly, R. F., & Stephenson, R. (1967). The Semantic Differential : An Information Source for Designing Retail Patronage

Appeals Retail Patronage Appeals : An Information Problem. 31, 43-47.

Lipovac, D., & Burnard, M. D. (2021). Effects of visual exposure to wood on human affective states, physiological arousal and cognitive performance: A systematic review of randomized trials. Indoor and Built Environment, 30(8), 1021-1041. https://doi.org/10.1177/1420326X20927437.

Lipovac, D., Wie, S., Nyrud, A. Q., & Burnard, M. D. (2022). Perception and Evaluation of (Modified) Wood by Older Adults from Slovenia and Norway. Wood and Fiber Science, 54(1), 45-59. https://doi.org/10.22382/wfs-2022-05. https://doi.org/10.22382/wfs-2022-05

Maqsood, A., Chen, C., & Jacobsson, T. J. (2024). The Future of Material Scientists in an Age of Artificial Intelligence. Advanced Science, 2401401, 1-11. https://doi.org/10.1002/advs.202401401. https://doi.org/10.1002/advs.202401401

Masuda, M. (1992). Visual characteristics of wood and the psychological images. Mokuzai Gakkaishi Journal Of The Japan Wood Research Society, 38(12), 1075-1081.

Mynttinen, S. (2009). Young people's perceptions of the wood products industry : a relational view [Doctoral dissertation]. The Finnish Society of Forest Science.

Nakamura, M., Ikei, H., & Miyazaki, Y. (2019). Physiological effects of visual stimulation with full-scale wall images composed of vertically and horizontally arranged wooden elements. Journal of Wood Science, 65(1), 55. https://doi.org/10.1186/s10086-019-1834-0

Nakamura, M., Ikei, H., & Miyazaki, Y. (2022). Effects of visual stimulation using wooden-wall images with different amounts of knots on psychological and physiological responses. Wood Science and Technology, 56(6), 1869-1886. https://doi.org/10.1007/s00226-022-01419-5.

Nordvik, E., & Broman, N. O. (2009). Looking at computer-visualized interior wood: A qualitative assessment using focus groups. Journal of Wood Science, 55(2), 113-120. https://doi.org/10.1007/s10086-008-1008-y

Nyrud, A. Q., & Bringslimark, T. (2010). Is indoor wood use psychologically beneficial? A review of psychological responses toward wood. Wood and Fiber Science, 42(2), 202-218.

Osgood, C. E., & Suci, G. (1969). Factor analysis of meaning. In C. E. Osgood & J. G. Snider (Eds.), Semantic differential technique - a source book (pp. 42-55). Aldine Publishing.

Osgood, C. E., Suci, G., & Tannenbaum, P. (1957). The Measurement of meaning (1a). University of Illinois Press.

Papile, F., Sossini, L., Marinelli, A., & Del Curto, B. (2022). Emerging Material Research Trends: Fostering Critical Material Research in Design Students. Proceedings of the Design Society, 2(May), 2353-2362. https://doi.org/10.1017/pds.2022.238

Pedgley, O., Rognoli, V., & Karana, E. (2016). Materials experience as a foundation for materials and design education. International Journal of Technology and Design Education, 26(4), 613-630. https://doi.org/10.1007/s10798-015-9327-y

Pérez Mejía, M. (2010). Wooden Roofs - Perception v/s Material Volume [Master Thesis]. Polytechnic University of Catalonia.

Ratnasingam, J., Ioras, F., & Macpherson, T. H. (2007). Influence of wood species on the perceived value of wooden furniture: the case of rubberwood. Holz Als Roh- Und Werkstoff, 65(6), 487-489. https://doi.org/10.1007/s00107-007-0186-4

Redström, J. (2020). Certain Uncertainties and the Design of Design Education. She Ji: The Journal of Design, Economics, and Innovation, 6(1), 83-100. https://doi.org/10.1016/j.sheji.2020.02.001. https://doi.org/10.1016/j.sheji.2020.02.001

Rice, J., Kozak, R. A., Meitner, M. J., & Cohen, D. H. (2006). Appearance wood products and psychological well-being. Wood and Fiber Science, 38(4), 644-659.

Rognoli, V., & Ayala García, C. (2018). Emotional matter. Materials in our emotional relationship with objects. RChD: Creación y Pensamiento, 3(4), 1-15. https://doi.org/10.5354/0719-837X.2018.50297

Rognoli, V., & Levi, M. (2004). Emotions in Design through Materials: An Expressive-Sensory Atlas as a Project Tool for Design of Materials. 4th International Conference on Design & Emotion, 1-11.

Scherer, K. R. (2000). Emotion. In M. Hewstone & W. Stroebe (Eds.), Introduction to Social Psychology (3rd ed., pp. 151-191). Blackwell.

Scrinzi, E., Rossi, S., Deflorian, F., & Zanella, C. (2011). Evaluation of aesthetic durability of waterborne polyurethane coatings applied on wood for interior applications. Progress in Organic Coatings, 72(1-2), 81-87. https://doi.org/10.1016/j.porgcoat.2011.03.013. https://doi.org/10.1016/j.porgcoat.2011.03.013

Stappers, P. J., & Giaccardi, E. (2018). Research through Design. In M. Soegaard & R. Friis Dam (Eds.), The Encyclopedia of Human-Computer Interaction (2nd ed.). The Interaction Design Foundation.

Veelaert, L. (2022). Express your material self: Experiential material characterization in product design [Doctoral dissertation]. Universiteit Antwerpen.

Veelaert, L., Du Bois, E., Moons, I., & Karana, E. (2020). Experiential characterization of materials in product design: A literature review. Materials & Design, 190(February), 108543. https://doi.org/10.1016/j.matdes.2020.108543. https://doi.org/10.1016/j.matdes.2020.108543

Veelaert, L., Moons, I., Rohaert, S., & du Bois, E. (2019). A neutral form for experiential material characterisation. Proceedings of the International Conference on Engineering Design, ICED, 2019-Augus(AUGUST), 1743-1752. https://doi.org/10.1017/dsi.2019.180

Wan, Q., Li, X., Zhang, Y., Song, S., & Ke, Q. (2021). Visual perception of different wood surfaces: an event-related potentials study. Annals of Forest Science, 78(2). https://doi.

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