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AN APPROACH TO ANALYZING USER IMPRESSIONS AND MEANINGS OF PRODUCT MATERIALS IN DESIGN

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ABSTRACT
To approach the essence of design for emotion and experience, this paper focuses on tactile interactions with product materials. We propose a framework for analysing tactile interactions based on human association-based in-depth impressions and interpretation-based created meanings. The aim of the study is to answer how in-depth impressions activate created meanings in tactile interaction and how do they affect human preference with regards to product materials. To detect and identify in-depth impressions and created meanings, this study applies original methods that analyse concept networks. To collect human freely expressed impressions and preferences we conducted an experiment that involved seven material samples. The identified in-depth impressions and created meanings are connected with preference evaluations during a tactile interaction with product materials. According to the findings, the generation of fewer in-depth impressions activate diverse and original created meanings with respect to a material; and positively affects preference evaluation. These findings should contribute to design that leads to users' emotional bonds and meaningful experiences.

Keywords: Tactile interaction with materials, design for emotion and experience, user integration in design, in-depth impressions

1 INTRODUCTION
This paper focuses on products that are expected to align with and harness human behaviour [1, 2]; professionals involved in creative product design must provide such designs according to users' emotions, based on product experiences [3, 4]. Emotions and experiences have been approached in previous studies as components of users' impressions of a product. Many attempts have been made to understand the impressions that products generate, but most fail to grasp the changing nature of such impressions.
In-depth impressions (IDIs) comprise an inner associative layer of humans' expressed impressions [5, 6]; as such, IDIs underpin explicit and however superficial impressions. Given the nature of IDIs, they form within basic interactions. Thus, this study focuses on the most basic form of users' interactions with products—namely, tactile interaction with the material of a product—in order to investigate them. Tactile interaction with materials is more central to the formation of a user's impressions than are interactions involving the product's visual form and colour [7]. E.g., the results of behavioural research point out that colour plays an essential role in helping one distinguish natural versus man-made objects [8], however, tactile information involves the recognition of preference and impressions (Table 1). Therefore, tactile interactions serve as a sound research target, in terms of examining impressions and the inner associative layer thereof.
Moreover, in this study, we see that IDIs serve as a basis for activating created meanings (CMs) with respect to materials and products. Such meanings, from the standpoint of users' emotions and experiences, are critical to the designer's understanding and eventual exploitation of materials preferences; this has been the focus of recent research [9, 10]. Thus, creative design can be considered to generate such original CMs.
Two research questions arise: (A) 'How do IDIs activate CMs?' and (B) 'How do IDIs and CMs affect users' preferences *vis-à-vis* product materials?' The experiment within this study seeks to answer these questions and gain insights into users' interactions with product materials. In order to answer these questions we pay attention to characteristics of the links (associations and interpretations) of IDIs and CMs. We make the assumption that human preference with regards to product materials is connected with number of the IDIs and CMs experienced during tactile interaction. Indeed, a fuller understanding

of IDIs and CMs will contribute to design that better aligns with or gives rise to positive consumer emotions and product experiences.

Table 1. Aspects of user interaction and their central roles

Aspects	Central roles
Colour	Appeal, original information, naturalness, etc.
Outline/shape	Man-made, style, fashion, etc.
Tactile	Preference, impressions, real vs. virtual, etc.

2 IMPRESSIONS AND MEANINGS

Unlike materials-selection approaches that are based on those materials' directly measurable technical characteristics [11], approaches that defer to users' product-material preferences are based on emotions and experiences [1]. It is clear that emotions themselves are based on personal experiences; consequently, personal attachments or aversions are difficult to analyse and comprehend and are therefore difficult to consider when designing new products [12]. Notably, emotions based on experiences can be investigated by examining the impressions that play an important role in users' interactions with and preferences for certain products [6, 13].

Materials preferences are thought to be influenced by the nature and characteristics of the IDIs generated by those materials [13, 5]. They are central to users' CMs, which are generated through interactions with the materials. This viewpoint aligns with basic theories concerning the creation of meaning; it is also accords with theory on image schemas [14]. IDIs, particularly of tactile interaction, play a major role in forming deeper and long-term meanings that are, in turn, attributed to the material and the product itself. Users' interactions with materials are affected by the impressions, associations, and meanings related to the product material [2, 5, 8, 9]. In product design, materials should not only adhere to technical requirements; they should also appeal to users' senses and thus, derive an intended meaning related to the final product [10]. Thus, the analysis of consumer impressions is essential to product design.

Research into tactile interaction points to the presence of an important associative aspect that arises in tactile interactions with materials [5]—namely, consumer preferences and impressions are related to the tactile sensations associated with the product materials. Moreover, in existing research, associative and latent factors have been found to be critical to analysing human sensitivity [12, 13]. However, along with such an associative aspect, users' interpretative aspects during interactions with product materials play a role in the whole of that user's attitude towards the product and thus, in its selection in preference to competing products. This study therefore challenges to explore both the associative and interpretative aspects of interaction, introducing a formal approach to the study of associative and interpretational aspects of users' interactions with product materials.

Framework of users' interaction with product materials

This study uses the following definitions:

- 'In-depth impressions' (IDIs) are based on associations that evoke explicit impressions of the material
- 'Created meanings' (CMs) are based on interpretations based on explicit impressions evoked by the material

To analyse product materials, this study proposes a framework of human interaction (Figure 1). To identify IDIs, attention was paid to theories on mental models, which support the view that humans need to recognise, predict, and explain the behaviour of the world around them and that mental models allow humans to interact with their environment [15]. The proposed framework describes such a structure. The explicit impressions that humans derive from materials are affected by personally held associations; in this way, they form certain meanings for those individuals. Materials are interpreted by way of both association-based IDIs and interpretation-based CMs: association-based IDIs as connected with the visceral part of the interaction and, on the other hand, interpretation-based CMs are connected with the reflective part of the interaction [1]. Both IDIs and CMs contribute to a recognition of certain materials and the products of which they are made. Thus, IDIs and CMs serve as rational bases of the framework through which one can understand the changing characteristics of human impressions—an understanding that is critical to successful design.

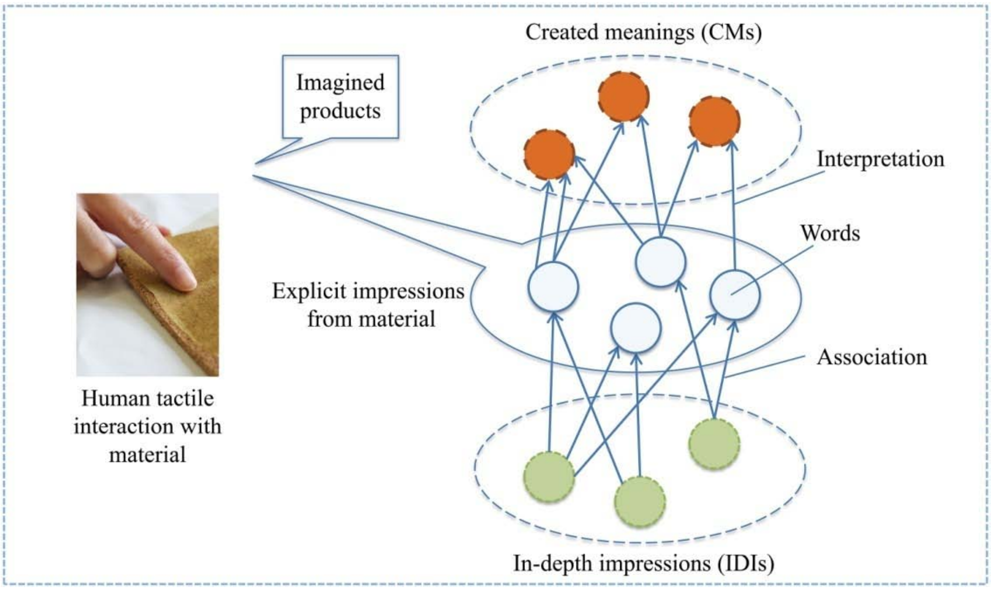

Figure 1. Framework of users' tactile interactions, based on impressions and meanings

3 METHODS AND TOOLS

Methods of identifying IDIs and CMs

To detect and identify IDIs and CMs, this study makes use of methods that analyse concept networks (Figure 2). The concept networks were used as tools for identifying the IDIs in previous studies [5, 6]. In practical terms, IDIs and CMs can be considered nodes that initiate and attract, respectively, higher numbers of connections in these concept networks. The number of connections can be assigned as weights. Thus, in the networks, IDIs and CMs can be identified as highly weighted associations. Explanations of the methodology follow.

After the explicit human impressions of a material are collected, the steps for identifying IDIs are as follows (Figure 2):

- Explicit impressions are thought to associate from certain associative words
- All common pairs of such words (from associative to explicit) are detected using a tool (as explained in 'IDI analysis tool', below)
- Case-specific concept networks based on all the detected pairs are created (see the final sub-section of this section)
- Highly weighted associative words are identified as IDIs
- The list of IDIs is analysed

In this way, this study identifies IDIs that are based on associations, which are behind each of the explicit impressions evoked by the person interacting with the material. (Associations are the stimulus words used to evoke the explicit impressions.)

For CMs, the steps are as follows:

- Explicit impressions are thought to interpret certain words
- All common pairs of such words (from explicit to interpretative) are detected, using a tool (as explained in 'CM analysis tool', below)
- Case-specific concept networks based on all the detected pairs are created
- Highly weighted interpretative words are identified as CMs
- The list of CMs is analysed

In this way, this study identifies CMs that are based on interpretations of explicit impressions, which had in turn been evoked by the person interacting with the material. (Interpretations are the words generated by the explicit impressions.) Using these methods, lists of IDIs and CMs were identified; they can be analysed quantitatively and qualitatively, to derive a greater understanding of the characteristics of human impressions—an understanding that is essential to design that fits to human impressions. These methods allows for a consideration of research question (A).

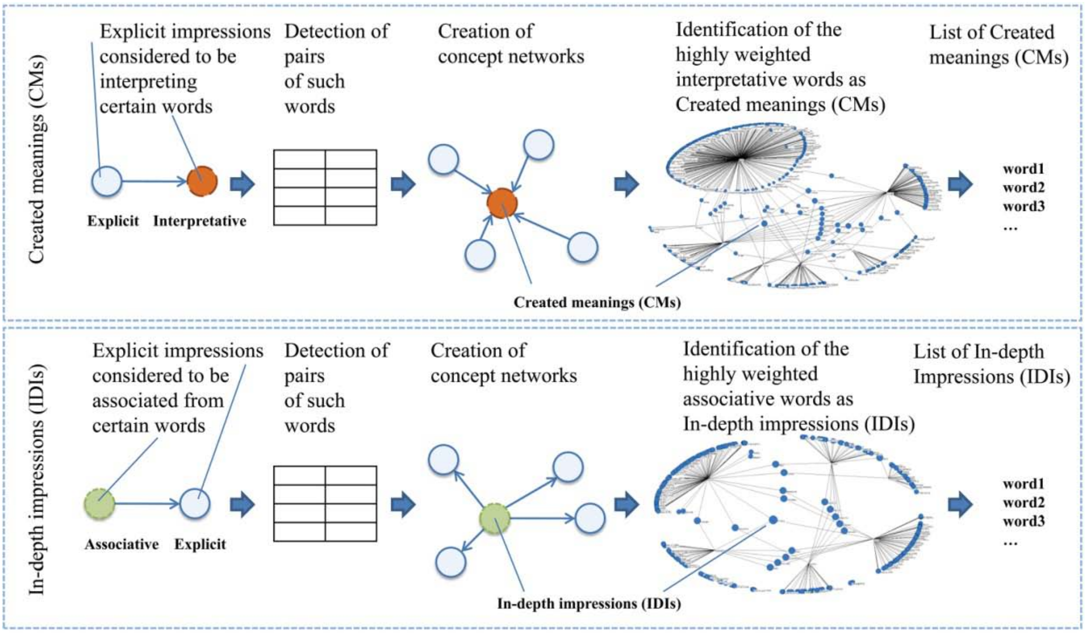

Figure 2. Proposed methods to identify the IDIs and CMs

Concept networks

Concept networks depict human memory as an associative system, wherein a single idea can lead to many other ideas. As structures that comprise words and the semantic relationships among them, they are suitable for exploring and identifying the links among concepts. As computational structures, these networks can be used to model conceptual associations [16]. The idea of the concept network has its origins in the field of psychology: concept networks depict human memory as an associative system, wherein a single idea can lead to many other ideas. Thus, both the associative portion underpinning impressions and the interpretation part above impressions (Figure 1) can be analysed independently with concept networks, as shown with the methods in Figure 2.

On the other hand, graphs are a suitable means of constructing and visualising such concept networks. They are often used to visualise and analyse networks in terms of network theory [17]. The current study makes use of graph-based visualisations, in a later part of its methodology (Figure 2).

IDI analysis tool

To detect IDIs, a universally applicable associative analysis tool (i.e. concept dictionary) was used. The ‘University of South Florida free association, rhyme, and word fragment norms’ by Nelson, McEvoy and Schreiber [18, 19] (referred to in this paper as the USF Database) is considered the database that contains the largest number of English-language associative words [20]. It consists of 72,000 word-pair associates. Such extensive coverage is suitable for searches of word-association pairs, and it is used in the current analysis.

CM analysis tool

To detect CMs, a universally applicable meaning analysis tool was considered. WordNet is a very large electronic lexical database that contains information about the manner in which humans process concepts and language [21, 22]; it contains more than 150,000 words. The current study made use of the ‘glosses’ of this database, which are descriptions of the words’ meanings. To detect CMs, two parts can be used: the first part of the gloss, in which the word is explained as a specific instance, and the second part of the gloss, in which the word is used in an example. The glosses are lexicographically limited, but they systematically follow the standard principles of dictionary definitions and are thus applicable to analyses of meaning.

Concept networks tool

To construct concept networks specific to each case, the visualisation software Pajek [17, 23] was used. Using Pajek, the concept networks can be visualised as graphs and further used in the detection of IDIs and CMs.

Preference evaluation

The method by which research question (B) is addressed involves placement in an order of preference—simulating selection, as it were, as it occurs in daily life. In such a situation, a human preference evaluation is not framed by scale descriptors, such as semantic scales; a preference evaluation is usually based on a comparative, rather than a formative, evaluation scale or ratings.

4 EXPERIMENT

Setting

An experiment was conducted to investigate hypotheses and thus gain insights into human interactions with materials; this experiment focused on, but was not restricted to, tactile interactions. Attempts were made to analyse the interaction in a manner that simulated, as close as possible, daily-life situations, where humans choose products based on comparisons of products or materials, rather than on scores or semantic scales. Thus, the study included a collection of humans' freely expressed impressions and rankings (i.e. ordered placements), instead of scores.

The experiment involved seven material samples, as well as questions and rankings pertaining to them. The purpose of the experiment was to address the two aforementioned research questions.

To answer question (A) and identify IDIs and CMs, the following were collected from human individuals:

1. Freely expressed impressions upon tactually interacting with each of seven material samples (i.e. regarding touch, look and feel)
2. Imagined products comprising these material samples (in order to understand what products are related to the IDIs and CMs)

To answer question (B) and obtain preference evaluations, in addition to these two inquiries, the following were also collected:

3. Evaluations (ordered placements, from high to low) of the seven material samples in terms of (3a) visual preference, (3b) tactile preference, and (3c) feeling preference

The instructions for the first two areas of inquiry were as follows: 1. 'Think about the texture of the material that you are touching. What are your impressions and image of this material?' 2. 'What product or object did you want to create from this material, when you looked at and touched it?' The instruction for the third area of inquiry, with regards to rankings, was as follows: 3. 'Please order these materials according to your preference, based on their look and touch; please order these materials, according your feelings.

There were eleven participants (five females and six males; age range from 22 to 43 years; mean age, 28.6 years). All were students, staff members, or researchers from a university. The participants provided answers in separate sessions for the two inquiries, as well as three rankings, for the seven material samples that had been presented in random order.

All the words from the verbalised protocols (total of 774 expressed impression words and imagined products for the first and second questions) of the verbally expressed free impressions were recorded and further transcribed into files, whereupon they were used in the analysis.

Samples of product materials

The seven material samples were sized approximately 20 × 10 cm each, allowing participants to tactually interact freely with the samples.

Selections included materials with a wide application in products (i.e. in products that are frequently touched): aluminium, white plastic, wood. There were also materials with a narrower application in products (i.e. in products that are sometimes touched): cork, glass, rubber, steel net.

The selections constituted materials commonly used in products used in daily life, limiting the set to seven; this limitation was set, to keep participants from becoming bored and their impressions 'exhausted'.

5 ANALYSIS AND RESULTS

Analysis of IDIs and CMs

This part of the analysis looks to successfully identify IDIs and CMs from the verbalised protocols of all the participants' answers, with respect to the first area of inquiry.

To detect IDIs, the aforementioned method was employed, together with the USF Database. Highly weighted associative words were considered IDIs. The weighting limit was set to approximately the upper 50 percent of word groups, based on the number of connections they initiated (i.e. if groups of words were initiating eight, seven, six, five, four, three, two, and one connection, then all of the words from the groups initiating eight, seven, six, and five connections were taken as IDIs). This weighting limit can be considered as universal and not depending on the complexity of the concept network.
Samples of lists of identified IDIs are shown in Table 2, for each material that was tactually assessed. Given this paper's size limitations, only a sample of the most highly weighted IDIs is given. The total number of IDIs is shown in the second column.
To detect CMs, WordNet glosses were employed for all word meanings, including example uses of these words. Not all of the identified interpretative words in the glosses can be considered as CMs—some of these words are not significant as interpretations. Thus, to identify the significant parts of the meanings, a filtering rule was applied as follows. From a pool of words, we omitted connecting words such as prepositions (e.g. 'of', 'on', 'for', etc.), a few general verbs (e.g. 'is', 'are', etc.), articles (e.g. 'a', 'an', and 'the'), and pronouns (e.g. 'I', 'me', 'she', etc.). Also, a small group of words typically used in explanations—e.g. 'anything', 'something', 'especially', 'lacking', 'consisting', 'rather', etc.—were excluded, as they were found to change meanings outside of their original context and are present in many glosses.
The CMs identified through this method are shown in Table 2, for each material that was tactually assessed. The total number of CMs is shown in the second column.

Table 2. Identified IDIs and CMs

Material sample	In-depth impressions (Tool: USF Database) and Created meanings (Tool: WordNet 2.1)	
	Number	List (sample)
Aluminium	IDI: 52	Defrost, Steel, Harsh, Rigid, Accident, Ease, Extreme, Rough, Marble, Climate, Weather, Mild, Ambulance, Bumpy, Compact, Damage, Economy...
	CM: 27	Body, Water, Light, Physical, Act, Work, Book, Good, Room, Heat, Car, Force, New, Person, Human, Energy, Money, Move, Stock, Time, Power…
Cork	IDI: 26	Plug, Bottle, Mild, Rug, Gentle, Spring, Stopper, Delicate, Soft, Comfortable, Cosy, Quilt, Beam, Glow, Sun, Sunshine, Fireplace, Panel, Room, Cuddle…
	CM: 36	Small, Country, City, Body, Good, Life, Act, Car, Put, Force, Voice, Children, Water, Face, Sound, Room, Line, Man, Object, Road, Piece, Heat, Manner…
Glass	IDI: 46	Marble, Defrost, Pool, Shutter, Glass, Crisp, Detach, Extreme, Metal, Steel, Stone, Uncomfortable, Shatter, Windshield, Wipe, Delicate, Basement, Beer...
	CM: 44	Light, Time, Room, Physical, Clothes, Air, Glass, Good, Heat, News, Old, Place, Terrible, Water, Person, Small, Catch, See, Book, Country, Day…
Rubber	IDI: 63	Tread, Rigid, Leather, Bicycle, Bike, Car, Clamp, Curb, Flat, Truck, Valve, Crunchy, Felt, Harsh, Lubricate, Marble, Suede, Velvet, Crisp, Shoulder…
	CM: 49	Light, Cause, Great, Rubber, Strength, Life, Little, Physical, Time, Force, Wheel, Played, Good, Quickly, Object, Child, Rain, Get, Manner, Sound…
Steel Net	IDI: 43	Display, Clear, Defrost, Glass, View, Blind, Screen, Wipe, Computer, Blinds, Curtains, Door, Shade, Sill, Vent, Wall, Windshield, Bay, Bedroom…
	CM: 29	Time, Light, Long, Keep, Like, Country, Man, Hair, Water, Room, Children, Screen, Course, Book, Fine, Weather, Right, Sound, Table, Living, Thin…
White Plastic	IDI: 32	Marble, Mild, Concrete, Influence, Delicate, Dense, Intensity, Soft, Scrub, Harsh, Steel, Corner, Respect, Confidence, Felt, Godliness, Grace, Hero…
	CM: 39	Person, Surface, Good, Room, People, Act, Light, Object, Physical, Water, Force, Heat, Time, Quality, Child, Colour, Sound, Part, Effect, Long, Small…
Wood	IDI: 44	Delicate, Mild, Wood, Power, Soft, Stage, Dense, Natural, Beam, Bedroom, Ceiling, Corner, Energy, Fair, Glow, Intensity, Lit, Sun, Sunshine, Tower…
	CM: 39	People, Force, Room, Person, Physical, Body, Business, Effect, Light, Manner, Move, Quality, Take, Water, Become, Sound, Thin, Act, Children…

The IDIs and CMs have quantitative differences, depending on the material sample. For example, the sample of aluminium material had given rise to fewer CMs, compared to the number of IDIs with which it was associated; also, the sample of cork material had given rise to fewer CMs, compared to the number of IDIs.

Moreover, the impressions arising from the sample of aluminium material were associated with IDIs like Harsh, Rigid, Accident, Extreme, and Rough, leading to the following interpreted meanings: Body, Physical, Act, Work, Book, and Energy. On the other hand, impressions arising from the sample of cork material were associated with IDIs like Mild, Gentle, Spring, Cosy, and Sunshine, leading to the following interpreted meanings: Country, Body, Life, Force, and Voice.

Results: Imagined products

This section presents participant answers from the verbalised protocols, *vis-à-vis* the second area of inquiry.

Participants stated the products they imagined, as a result of interacting with the material samples. The total list of products as indicated by the participants is provided in the last column of Table 3. The total number of imagined products is shown in the second column.

Table 3. Imagined products as indicated by the participants

Material sample	Imagined products	
	Number	List
Aluminium	25	Bin, Box, Car Parts, Glass, Kitchen Knife, Lunchbox, Machine Parts, Penholder, Rain Collecting Thing, Roof, Roof Tray, Shelf, Structure, Tableware, Toy, Umbrella Stand, Wall, Canned beer, Trash, Card, Curve, Incense, Sound, Strange shape, Objet
Cork	27	Block, Board, Board, Book Cover, Building Blocks, Coaster, Cork, Cork Board, Diorama, Document Box, Flowerpot, Gift, Glass, Illumination, Mat, Mobile Cover, Mouse Pad, Objet, Paper, Photo Frame, Picture, Picture Board, Pot Stand, Puzzle, Stationary Object, Three-Dimensional Object, Wall
Glass	16	Box, Canvas, Glass, Glass, Light effects, Mirror, Ornament, Picture, Picture, Picture frame, Portable display, Showcase, Stained glass, Coffee boiler, Window, Window
Rubber	25	Cushioning material, Glasses part, Grip, Handle, Mobile, Notebook surface, Pen, Penholder, Racket, Sandals, Scrap, Seat Surface, Shoe, Shoulder massage device, Skid, Skid, Sport Equipment, Tire, Toy
Steel Net	25	Blindfold, Box, Car, Clothing, Clothing, Colander, Colander, Curtain, Decorate Hat, Filter, Filter, Flower, Hat, Lamp, Muffler, Pillow, Remote Control, Shoes, Skid, Spoon, Wrap, Cleaner, Cooking tool, Shade, Mobile
White Plastic	25	Bath, Block, Chair, Chest, Cover, Decoration, Decoration, Figure, Fly box, Frame, Furniture, Interior, Kitchen, Lighting, Name card, Notebook, Penholder, Plastic model, Puzzle, Shelf, Shape, Toy, Toy, Vase, Washroom
Wood	34	Board, Boat, Bookshelf, Box, Box, Building Blocks, Chair, Display, Chopsticks, Floor, Foundation, House, Keyboard, Log Cabin, Model, Mouse, Name Plate, Pen, Pet Hut, Photo, Pocket, Puzzle, Sculpture, Shelf, Shelf, Shelf, Shelf, Table, Table, Table, Partition, Scale, Split, Print

The indicated products show diversity (i.e. a number of different types of products). For example, from the sample of aluminium material, participants cited imagined products like Box, Kitchen Knife, and Roof; these products represent existing applications of this material to the home environment, which humans often touch. On the other hand, from the sample of cork material, the participants imagined products like Diorama, Flowerpot, and Illumination, which were more imaginative and diverse.

Results: Preference evaluation

This section presents all participants' rankings relating to the third area of inquiry. The participants placed the seven materials in order of preference, from high to low. These evaluations were averaged across all participants.

Figure 3A shows the average scores of the visual-preference evaluation/tactile-preference evaluation, as indicated by the participants. Further, Figure 3B shows the average scores of the feeling-preference evaluation, as indicated by the participants.
All material samples with a wide array of product applications (e.g. aluminium, white plastic, and wood) ranked consistently in the visual-, tactile-, and feeling-preference evaluations. Meanwhile, material samples with a narrow array of product applications (e.g. cork, glass, rubber, and steel net) ranked rather inconsistently in the visual/tactile- and feeling-preference evaluations.

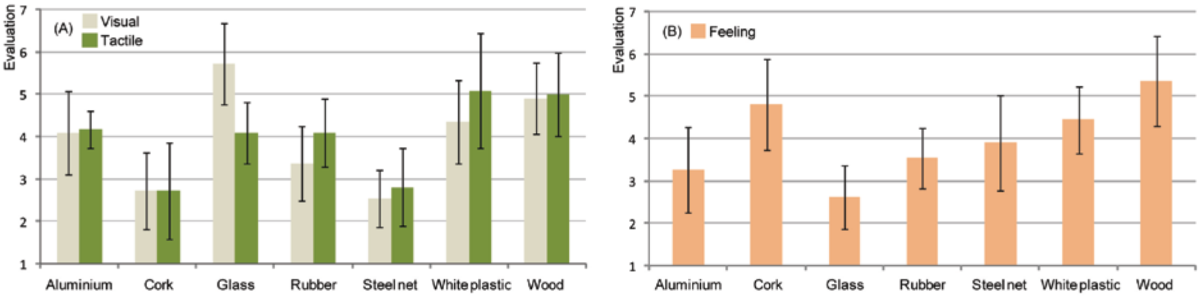

Figure 3. Average visual-preference and tactile-preference evaluations (A); and average feeling-preference evaluation (B) of material samples (from 1 [Low] to 7 [High])

An observed correlation was: the number of imagined products positively correlated with the feeling-preference evaluation results (0.881, p=0.009) (Table 3, Figure 3B).
Other relationships among variables were observed: the number of IDIs negatively correlated with the feeling-preference evaluation results (–0.538, not significant) (Table 2, Figure 3B). The number of CMs was connected with the tactile-preference evaluation results (0.339, n.s.) and visual-preference evaluation results (0.353, n.s.) (Figure 3A).

6 DISCUSSIONS

The observed connection between the visual/tactile- and feeling-preference evaluations with the number of imagined products, identified IDIs and identified CMs explains how IDIs activate CMs during a tactile interaction with product materials. Possible interpretations of these findings with respect to design are rather complex. In order to achieve a high feeling-preference evaluation for a product material (we assume to be connected to design emotions), a material’s impressions need to be associated with fewer IDIs (we assume to be connected via associations and previous user experiences) and have to contribute to a rich imagination of products (we assume to be connected to user experiences). Moreover, in order for a product material to be highly evaluated in terms of tactile and visual-preference, the material impressions need to give way to a set of more diverse CMs (we assume to be connected via meaningful product experience). The IDIs probably activate original CMs within them. These results provide an answer to question (A), regarding how IDIs activate CMs.
Regarding question (B) and how IDIs and CMs affect user preferences *vis-à-vis* product materials, the preference is connected via fewer number of IDIs and a set of diverse and original CMs.
This verifies the assumption regarding number of CMs—namely, a preference towards a material correlates positively with the number of CMs from that product material in tactile interaction. In other words, the more and diverse the human CMs from the product materials are, the higher the user’s feeling-preference evaluation for that material will be.
However, the preference is connected to fewer IDIs; this finding does not accord with the assumption regarding number of IDIs. Users’ tactile-preference evaluations of materials (Figure 3) were connected to fewer in number IDIs from the product materials (Table 2). The feeling-preference evaluation tended to be lower in cases where there were more IDIs. For example, the white plastic material sample ranked highly on the visual/tactile- and feeling-preference evaluations and had fewer IDIs. The steel net material sample, meanwhile, had more IDIs, but was connected with a small range of products in the home (see Table 2). Overall, the feeling-preference evaluation relates to rich imagination *vis-à-vis* products and fewer IDIs; also, tactile-preference evaluations relate to the diversity and number of CMs. Thus, from the user’s viewpoint, a ‘successful’ product material should involve fewer—albeit strong—IDIs and diverse and original CMs. This finding should contribute to product design that leads to users’ emotional bonds and meaningful experiences.

Implications of the findings

The research outcomes can be justified in terms of deeper understanding users' emotions and product experience; moreover, in terms of new material selection. The main result of the findings is the creation of method for selecting product materials. The successful selection of product materials should involve a successful combination of IDIs and CMs. The results of this study provide the first insights into such a selection method, which can be developed as a tool for selecting materials in product design.

The implications of this research include two directions in product design: design that appeals to emotions and design that appeals to product experience. The IDIs and CMs of a product material can, in part, contribute to emotions and experiences, and designer should be mindful of these contributors to the design process. Further implications can also be seen with regards to the design of more sustainable products.

This study has limitations, including those derived from the limited number of material samples used therein. A wider range of materials and a higher number of subjects need to be assessed, to verify the findings prior to implementing them in the material-selection stage of a product design process. Future work should include: a deep qualitative analysis of IDIs and CMs; experiments that examine combinations of materials, while investigating the users' IDIs and CMs with regards to various materials for design; and the development of a method and tools for product material selection, for use by designers.

7 CONCLUSIONS

In this study we tried to clarify the ways in which users' impressions of product materials are formed and the implications thereof. A framework was proposed that took into account users' interactions with product materials, based on their impressions and interpretations. This framework allowed the application of rational concept network methods to analyse users' impressions derived from tactile interactions. The original analysis methods look to identify association-based In-depth impressions (IDIs) and interpretation-based Created meanings (CMs).

These methods were adopted to identify users' IDIs and CMs resulting from tactile interactions, within the context of a study involving seven material samples. Consideration was placed on the ways in which users' preference evaluations were influenced by these impressions and meanings, en route to creating a total impression of the material. Use of the proposed analytical method confirmed its effectiveness in identifying essential aspects of user interaction, thus answering key questions about how IDIs activate CMs. The nature and characteristics of IDIs and CMs can provide clues as to what can be considered a 'successful material impression' from the users' perspective. The generation of fewer IDIs possibly gives rise to diverse CMs with respect to a material; this condition was found to positively affect preference evaluation and thus influence a user's overall stance with regards to a material. Creating a successful material impression should be the target of designers; indeed, 'tapping' into user's emotions and experiences in this way will result in successfully designed products. Doing so is one step towards the design of ideal products.

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