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The study of tactile feeling and It's expressing vocabulary

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ABSTRACT

Tactile feeling is an important sense of people's use of products in our daily life. However, how people express and verbalize their tactile feeling has hardly been systematically studied. Thus, the purpose of this study is to investigate how people describe their tactile feeling and how this expression will be affected by visual experience. To achieve the purpose a focus interview was conducted for this study. A set of 51 samples of various textures based on a literature review and a pilot study was prepared as reference stimuli in the interview to evoke respondents' tactile feeling and experience. Six blind and 5 blindfolded respondents were recruited for the interview. In each interview session the respondent was guided and encouraged by the interviewer to exhaustively describe his/her tactile feeling on freely touching the reference samples only, without the aid of vision. The Kawakita Jiro method (KJ method) then was used to sort, classify and analyze the collected vocabularies of tactile feeling. The results showed that the expressed vocabularies of tactile feeling can be classified into five dimensions: "objective/measurable", "evaluative/aesthetic", "social status and positions", "emotional" and "interface quality". Among them, vocabularies of "objective/measurable" and "interface quality" were the most frequently mentioned by respondents, while those of the "evaluative/aesthetic" were the least. The expressed vocabularies between the blind and the blindfolded respondents were also found to be significantly different in the five dimensions.

Relevance to industry: The results of this study can help researchers to further understanding tactile feeling and help designers in selecting appropriate vocabularies of tactile feeling to express in their product designs.

1. Introduction

With increasing emphasis being given to product emotion, designers no longer have a need to satisfy only functional requirements, but also to meet emotional needs as well (e.g. Cardello and Wise, 2008; Malnar and Vodvarka, 2004; Schifferstein and Desmet, 2008; Van Egmond, 2008). However, most of the emotion design approaches in the past focused on product appearance, through which emotional appeal was achieved. Although the visual sense is the primary channel for absorbing information from the outside, recent researchers have pointed out that other senses (such as the tactile sense) are also important or are even more important factors during a product experience. For example, according to the research conducted by Schifferstein (2006), the relative importance of the different senses is determined by the product type. When visually evaluating and judging the quality of a lamp, the visual sense may be the most important sense; when sensing perfume, the sense of smell is the most important; when using a hand tool, the tactile sense is the most important. Even, the tactile feeling can affect the manipulation of hand-held object (Jones & Piateski, 2006; Kilbreath et al., 1997; Augurelle et al., 2003; Cadoret & Smith, 1996).

The majority of product uses are operated through physical contact with products. Hence, the tactile sense is generally considered as the most important, while the visual sense has a key influence only when the consumer makes a product purchase. According to the research conducted by Millar and Tesser (1986), when the consumer's overall evaluation of a product is formed through a direct experience, a higher emotional evaluation will be produced. Breckler and Wiggins (1991) also believe that the more product-related direct experiences the consumer has, the higher his acceptance toward product recognition, emotion, and image will be. The tactile sense is often people's direct product experience. The importance of the tactile sense affecting people's purchase behaviors was found in Peck and Childers's investigation on the tactile sense in decision-making (Peck and Childers, 2003, 2006).

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The importance of the tactile sense in product design has been recognized over time. Relevant researches have also been conducted as a result, many of which focus on investigations of the relationship between touch and material, or investigations of materials and feelings of materials through the three senses; the tactile sense, the visual sense, and the mixed senses (visual sense and tactile sense). For instance, Heller (1982) explored the feeling of materials through the visual and tactile sense. Hollins et al. (1993) on the other hand conducted investigation on materials felt through the tactile sense. Picard et al. (2003) studied people's descriptions of tactile sensations of common textures from memory based on tactile stimuli. Picard (2006) investigated the perceived visual sense and tactile sense of texture, which served as a basis for research on equal (equivalent) material information. Karlsson and Velasco (2007) investigated the relationship between surface structure and preference, etc. These researches generally explored tactile sense experiences through emotional wording. It was found that the emotional vocabulary used for the tactile sense in these researches was mostly collected from relevant literature, newspapers, and magazines. Then, through experts or focus groups, screening and filtering were done to obtain the vocabulary instead of directly obtaining first-hand information from the user. Thus, the emotional vocabulary used usually has a similar framework and scope. The vocabulary acquired through these methods can accurately and comprehensively describe the tactile sense experience, however, lead to some common questions, too. First, where has the emotional vocabulary originated? Have the vocabularies been collected and compiled based on the tactile sense related characteristics rather than borrowing from other senses (visual sense)? Also, do they fully cover the tactile sense experiences, and have they been systematically organized and classified? Furthermore, according to numerous relevant researches, a sensory experience is interactive (Katz and Krueger, 1989; Klatzky et al., 1993; Kosslyn, 1994; Reisberg, 1992). For example, the visual experience will influence tactile expressing and tactile experience will create an expected of visual expression on product colors (Dagman et al., 2010). For most people, when expressing a sensory experience, their visual sense experience has an effect on the tactile sense experience, and the visual sense experience usually dominates. Therefore, past researches only targeted regular people (individuals with normal vision), thus whether or not the implementation of research on tactile feelings to evaluate the tactile feelings can be steered clear of the visual sense experience is yet to be verified. At present, researches on this aspect are not available.

Thus, in this study we want to systematically investigate how people describe their tactile feeling and how this expression will be affected by visual experience. Then through systematic compilation and classification on data a more accurate and all-around tactile sense related emotional vocabulary will be constructed to serve as a reference for follow-up research. On the other hand, Karlsson (1996) indicated that congenitally blind people can use the sense of touch to make up their visual sense function in getting information from real world. This phenomenon of making up for the deprived visual sense of blind individuals through their tactile sense is called sensory compensation (Kuo, 2007). Thus, to see how this phenomenon of sensory compensation affects the expression of tactile feeling this study also proposed to compare the differences in tactile sense experiences of blind and sighted respondents.

2. Method

To achieve the purpose of understanding how blind and sighted people express and verbalize their tactile feeling and how this expression will be affected by visual experience a focus interview was adopted in this study as the main data collection method. The respondents in this focus interview were individuals with a keen tactile sense so that they could express their tactile sense experiences easily and clearly, including blind individuals and sighted individuals with a keen tactile sense, such as sculptors.

The tactile sense experiences of the totally blind, the half blind, and those with congenital and acquired blindness vary. The research of Monegato et al. (2007) on comparing the effects of congenital and late visual impairments on visuospatial mental abilities showed congenital blindness could process visuospatial more efficiently than acquired blindness. This implied that congenital blindness had better ability on sensory compensation than acquired blindness. Furthermore, individuals with acquired blindness may still retain memories of their visual experience. Therefore, the totally blind individuals with congenital blindness are mostly suitable for the blind respondents in this study. However, since the born blind individuals are comparatively rare, the congenitally blind individuals or individuals became blind at a young age were selected as blind respondents in this study. On the other hand, sighted individuals who relied on their keen tactile sense at work, such as modelers, sculptors, or material designers, were selected as sighted respondents in this study.

In the research process, the interview outline and script were first developed. Then pre-test interviews were conducted on 3 respondents: two totally blind individuals and one blindfolded individual with a keen tactile sense. The interview content included items designed to: 1. understand the importance and significance of the tactile sense for individuals with a keen tactile sense; 2. understand the items and characteristics of the vocabulary used to express and describe the tactile sense; 3. understand how the interviewees touch a given material on exploring it; 4. determine the materials corresponding to various tactile feelings; and 5. determine the characteristics of the preferred tactile feelings. Based on the pre-test interview results, the researcher modified the interview outline and script for use during the formal interviews. It was also found from the interview results that without any prompts or references as stimuli, it was difficult for the respondents to express their perceived tactile sense. Hence, in accordance with the pre-test interview results and literature reviews, 51 tactile sense stimuli with different physical characteristics, as shown in Fig. 1, were collected as prompts for the formal implementation of the focus interviews in order to elicit the respondents' expressions of their perceived tactile impressions. Except for the stimuli of special materials such as bamboo which is cylindrical and other natural materials which retained their natural shapes, the remaining stimuli were set as the size of a piece of A4 paper (210 mm × 297 mm).

Under the condition that the visual sense was excluded, the formal interviews of the tactile sense stimuli were implemented using 6 individuals with total blindness and 5 blindfolded individuals with a keen tactile sense. The interview process was divided into two stages as follows.

1. The respondents were requested to describe and share their tactile sense experiences, according to the interview outline. This part was conducted for approximately 1 h. Voice and video recording were used to record the respondents' dialogs, intonation, and facial expressions. The recordings were then used for transcript compilation and content analysis.
2. With the stimuli samples as an aid, the respondents were requested to mention their tactile sense and association for every stimuli sample. In this interview stage, the respondents with normal vision wore goggles in order to obscure their vision. As the tactile sense may have included perceived cold and heat, the temperature of the interview room was maintained at 27 °C.

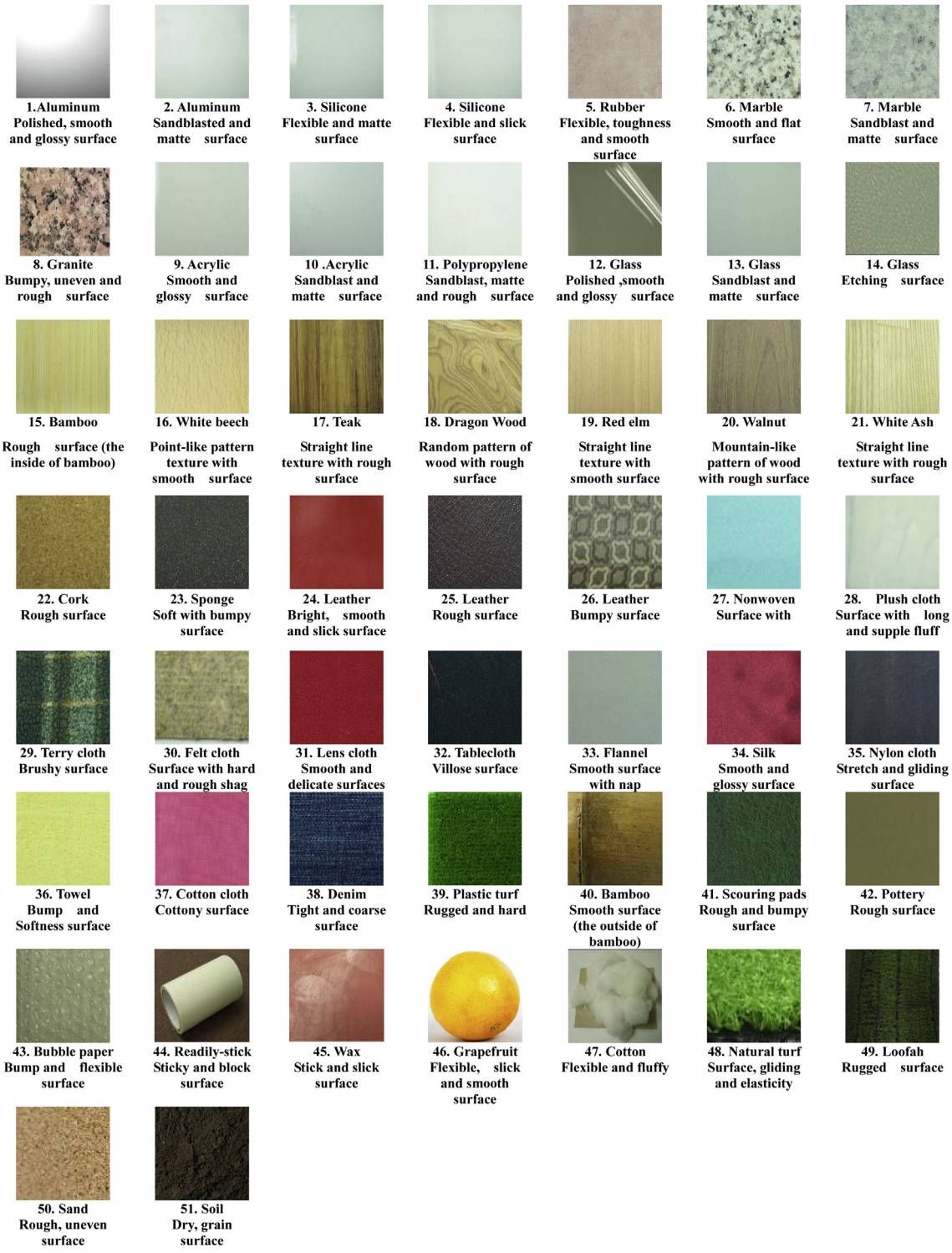

Fig. 1. 51 tactile sense stimuli with different physical characteristics.

All the stimuli materials were presented to the respondents randomly, and the respondents were requested to freely touch the stimuli surface with their hands and fingers and describe their feelings. Voice and video recordings of the respondents' dialogs, touch behaviors, intonations, facial expressions, etc., were again made and used in follow-up analysis. This stage of interview was approximately 2–3 h. As the entire interview was 3–4 h in length, the respondents were allowed to request breaks during the interview process, and they were allowed to touch the samples again to compare and describe them.

The interview process was video recorded for data analysis purposes. The tactile sense experiences mentioned by the respondents were extracted, integrated, and classified to form the vocabulary in this study. First, from the transcript of the interview records, descriptions of the feelings, perceptions, images, and styles

were extracted as descriptive vocabulary. Then, similar descriptive terms were integrated. If the respondent provided the same description, such as "it feels smooth" for the different material stimuli samples felt (e.g. metal and plastic), the researcher integrated them under the "smooth" feeling vocabulary category and counted the frequency accordingly. Conversely, if the respondent mentioned "smooth", "slippery", or other similar tactile sensations perceived when touching the same stimuli, these words were retained as the individual haptic terms without integrating them. The representative tactile sensations related to the haptic feeling vocabulary term were identified, according to the occurrence frequencies of the vocabulary terms.

Since Wikström et al. (2011) had adopted Krippendorff's five sensory experiences: "objective/measurable", "evaluative/aesthetic", "social status and positions", "emotional" and "interface quality" (Krippendorff, 2005) to collect vocabulary and derive a richer and more comprehensive product experience dimension, the identified representative tactile sensations were accordingly classified into these 5 categories in this study. Objective/measurable means the physical characteristics that can be objectively described and the physical characteristics that can be measured and examined and which are inclined toward the tactile sense related physiological experience. Evaluative/aesthetic reflects the respondents' aesthetic viewpoints or aesthetic feelings which highlight the principles of evaluating beauty. Social status and positions represents a certain personal value, identity, status, or trend of the respondent in terms of the tactile sense perceived, while emotional represents an individual's emotional feelings, mood, etc. Finally, interface quality expresses the respondent's use experience and use characteristics in response to his tactile experience.

In this study, the tactile feeling vocabulary was classified in detail through the KJ method to determine the important items of tactile sense experiences from the different categories. The KJ method was devised by Jiro Kawakita and is sometimes referred to as the affinity diagram. The KJ method clarifies important but unresolved problems by collecting verbal data from disorganized and confused situations and analyzing that data by mutual affinity. Through the following steps included: collecting narrative data, transferring narrative data onto cards, sorting he cards and labeling the cards, this method can systematically organize collected data. These steps can be iteratively used to sort large clusters into subgroups for further classification and analysis. Once completed, the affinity diagram may be created for easier management (Mizuno, 1988). The tactile sense experiences for all the material samples were collected and compiled to find the corresponding tactile feelings. Finally, from the analysis of the interview video records, the totally blind and blindfolded individuals with a keen tactile sense were compared for their tactile feelings and behaviors.

3. Results and discussion

3.1. Quantity of expressed tactile feeling vocabulary

In the pre-test without stimuli provided as an interview tool, the respondents proposed 43 tactile sense adjectives on average. After providing stimuli in the formal interview, the average number increased to 161 indicating that through stimuli prompts more extensive tactile feelings and experience descriptions were obtained from the respondents.

From the comparison of the formal interview results, it was found that the 6 blind respondents proposed an average of 61.3 tactile sense related vocabulary adjectives; while the 5 blindfolded respondents proposed 154 on average. The Independent Sample *t*-Test result in Table 1 also shows the significance of this difference ($t = -3.829$, $df = 4.690$, $p = 0.014$) (i.e. blindfolded individuals obviously had more tactile sense expressions than the blind individuals). Additionally, the interview results also show that educational level had a significant impact on the expressive and descriptive ability. In the formal interview, respondents with 3 senior high school (or lower) level proposed an average of 42.67 tactile sense adjectives, while the 8 individuals with college (or higher) level proposed an average of 130.00 adjectives. The group receiving a higher educational level showed a significantly greater expressive ability in terms of quantity ($t = -3.249$, $df = 8.479$, $p = 0.011$), as shown in Table 2. In addition to quantity, individuals with higher educational level also used a wider range of vocabulary and had a better ability to associate (such as personification and use of metaphors), thus indicating that learning experience and the degree of learning have a positive impact on the ability to describe the tactile sense experience. The quantity of the male respondents' tactile feeling vocabulary was generally less than the females' and their content association ability was relatively weaker compared to the women as well. The Independent Sample Test statistical analysis results in Table 3 shows the significance of this difference ($t = -2.642$, $df = 9$, $p = 0.027$) (i.e. females obviously had more tactile sense expressions than the males).

Table 1
Independent Sample Test of comparison of the average quantity of vocabulary adjectives expressed by the 6 blind and 5 blindfolded individuals with a keen tactile sense.

Group	*N*	Average	*t* value	*df*	*p*
The blind	6	61.33	−3.829	4.690	0.014
Blindfolded people	5	154.00			

In the interview process, some of the male respondents believed that men are more rational and the contents expressed are more practical. For this reason, the scope of the male respondents' feeling association was perhaps smaller in size.

3.2. Categories of the tactile feeling vocabulary

Integration was conducted of the expression vocabulary of all 11 respondents' tactile feelings. Then, the descriptive content of their tactile sense experiences was classified based on the five feeling categories put forth by Krippendorff, as shown in Table 4. In terms of quantity distribution, similar situations were encountered in the 5 categories for the tactile sense related emotional vocabulary proposed by the blind individuals and blindfolded individuals. The Crosstabs statistics and scale maps compiled are shown in Fig. 2 and Table 5.

It was found after further data review that the blind and blindfolded individuals showed differences in the quantity and percentage of their expressions of tactile feelings. Through the Crosstabs statistical analysis results shows that the differences between blind and blindfolded respondents is statistically different in each category, but not very significant ($\chi^2 = 9.052$, $df = 4$. $p = 0.06$).

The quantity and percentage of the tactile feelings related feeling vocabulary proposed by the blind individuals in the objective/measurable and interface quality categories were higher than

Table 2
Independent Sample Test of the average vocabulary quantity proposed by the formal respondents of different education levels.

Group	*N*	Average	*t* value	*df*	*p*
Senior high school (lower)	3	42.67	−3.249	8.479	0.011
University (higher)	8	130.00			

Table 3
Independent Sample Test of the average quantity of vocabulary adjectives expressed by the 7 males and 4 females.

Group	*N*	Average	*t* value	*df*	*p*
Male	7	71.57	−2.642	9	0.027
Females	4	166.75			

those proposed by the blindfolded individuals; in the evaluative/aesthetic, social status and positions, and emotional categories, the quantity and scale were lesser than those proposed by the blindfolded individuals.

Through the KJ method, the five categories of tactile feeling related vocabulary were further subdivided into sub-categories based on the contents described. Among them, objective/measurable includes 13 sub-categories: texture, temperature, lint, particles, rough/smooth, soft/hard, light/heavy, elasticity/resilience, thick/thin, humidity, viscosity, bending and density. The evaluative/aesthetic includes 4 sub-categories: quality, perception style, form style and principle of beauty. Social status and positions include 6 sub-categories: role positioning personality, condition, prevalence, price, status, and special uses. Emotional includes 5 sub-categories: high spirited and positive mood, calm and positive mood, high spirited and negative mood, calm and negative mood and the preference. Interface quality includes 9 sub-categories: usability, strength, comfort, cleanliness, malleability, temperature, waterproof and water absorbency, slip-proof/slip-resistant and post-processing. The respective sub-classifications are compiled and described as shown in Table 6.

Worth noting is that the feeling vocabulary proposed by both the blindfolded and blind respondents during the interviews generally included visual feeling descriptors; the visual feeling descriptors were used to replace the tactile sense experience, such as directly describing a certain stimuli as: “it looks beautiful, shiny, transparent, glossy, bright, or good-looking, not good looking, etc.” These vocabularies could only be evaluated through the visual sense. The influence of another type of visual experience is to simultaneously propose the visual and tactile feelings, such as moist (smooth in the tactile sense and moisturized smooth in the visual sense), smooth (shiny in visual sense, level and smooth surface in tactile sense), etc. In this stage of the compilation, the visual feeling vocabulary mentioned above was not excluded in order to find out what the greatest impact the visual sense had on the five categories.

The result shows that the tactile feeling vocabulary in the evaluative/aesthetic category was subject to the greatest impact from visual sense. In the follow-up questioning process, most of the respondents expressed that the proposed tactile feeling vocabulary in this category was based on descriptions they had seen or heard, such as ugly, beautiful, elegant and in good taste, pretty, cute, rustic, dark and gloomy, etc., and other feelings for the external form of a stimulus. The vocabulary even included: classic and elegant, artistic, natural style, Chinese style, Japanese style, Zen style, simple style, and other specific image integrations of styles, forms, and characteristics.

Table 4
The frequencies and percentages of the expression vocabulary in the tactile feelings category.

Number and name of Krippendorff category	Frequency	Percent
1. Objective/measurable	245	31.5
2. Evaluative/aesthetic	68	8.7
3. Social status and positions	144	18.5
4. Emotional	134	17.3
5. Interface quality	187	24.0
Total	778	100.0

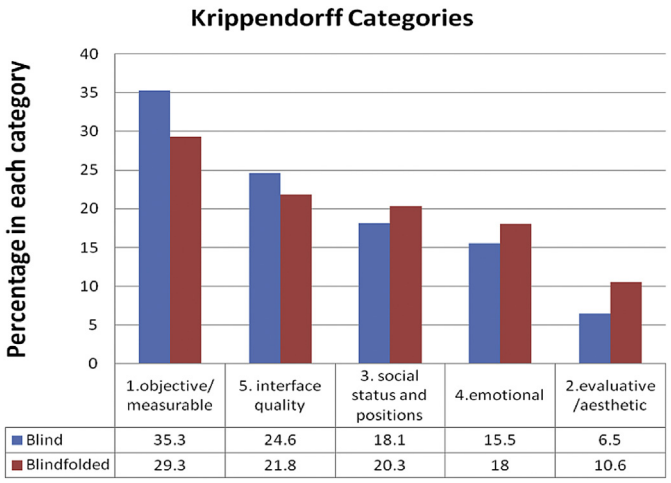

Fig. 2. Percentages of blind and blindfolded individuals' tactile sense vocabulary adjectives arranged in descending Krippendorff Categories.

3.3. Difference of tactile feeling vocabulary between the blind and blindfolded individuals

The blind and blindfolded individuals were also compared for their descriptions of the tactile feeling. It was found that in the objective/measurable category, the major perceptive difference between the blindfolded and blind individuals lay in the texture characteristics of the material surfaces. For example, in the determination of the shapes and styles of material surfaces, the blind individuals gave further descriptions of the texture directions and particle shapes of the material surfaces while the blindfolded individuals only described their feeling of the extent of roughness. In other words, the blind individuals had stronger feelings of the characteristics of the material surfaces and they had a greater ability to express it. On the other hand, the blindfolded individuals were better in further associating and expressing the variability of the materials, such as the proposed flexibility of materials or fineness of texture (density).

In the evaluative/aesthetic category the blind individuals were better than blindfolded individuals in producing specific associations due to certain characteristics; thereby they are better in expressing the content of specific aesthetic experiences, such as directly expressing certain materials perceived as natural style, Chinese style, Japanese style, Zen style, and simple style. However, when being further asked about the implications of the aesthetic feelings proposed, the blind individuals generally were unable to explain further. Even more often, due to the blind individuals' lack

Table 5
The percentage and Crosstabs of the expression vocabulary for the tactile feelings category for 6 blind individuals and 5 blindfolded individuals (Show Krippendorff categories all in lower case (as in Fig. 2 and Table 4)).

Krippendorff Category	Blind ($N = 6$)		Blindfolded ($N = 5$)	
	Frequency	%	Frequency	%
1.Objective/measurable	162	35.3	130	29.3
5. Interface quality	113	24.6	97	21.8
3. Social status and positions	83	18.1	90	20.3
4. Emotional	71	15.5	80	18.0
2. Evaluative/aesthetic	30	6.5	47	10.6
Total	459	100.0	444	100.0

Table 6
The description of the classifications of all respondents' tactile sense perception related feeling vocabularies in the five main items.

Category	Attribute	Subcategory
1. Objective/measurable	Physical characteristics that can be objectively described and physical forms whose physical features can be measured and examined.	Texture: used to describe the physical shape, direction of texture, or the style presented as perceived after touching the sample surface. Coldness and warmth: the coldness or warmth of materials due to the varied specific heat and thermal conductivity when in contact with the stimuli samples. Lint: respondent's feeling of the features of fibers or hair attached to the surface of the objects. Particles: the "non-sample" surface material perceived, which is composed of small particles (sand, soil, etc.) that can be cleaned away (dirt) or removed (sand, soil, etc.). Coarseness and smoothness: the tactile sense of the highs and lows perceived when the fingers start moving across the surface. Softness and hardness: the degree of force exerted and the extent of surface compressive changes due to the steely characteristics of the materials when pressure is applied by hands. Lightness and heaviness: the respondent's "weight association" produced when holding the sample and triggered by other physical characteristics. Elasticity and resilience: resilience force or extension of the state of original material perceived when pressed with fingers. Thickness: "Thickness association" caused by touching the object side (cloth) as well as by other physical features of the sample. Humidity: the feeling of tactile sense through touch to determine whether an object has water. Viscosity: the property of a surface requiring effort to remove the finger once it touches the surface and that will generate a suppressing feeling during movement. Bend ability: the degree that the sample material itself can be bent, but cause no real action, belonging to the material association. Density: the tightness of the sample (solid, fluttering) associated with the material.
2. Evaluative/aesthetic	Aesthetic perception, principles, or perspective to express the sample can be evaluated.	Quality: to express the aesthetic "good or bad" quality of the samples, with no specific style or pattern. Perception style: an imaginative picture caused by a specific style or pattern to perceive its atmosphere. Form style: presentation of a specific style or pattern to be formed with specific elements in the design of the shape. Aesthetic principles: a form of expression, presentation, and constitution without a specific style or pattern.
3. Social status and positions	Evaluation of its positioning, condition, and status, reflecting the values of the respondents.	Role-positioning personality: with people's characteristics as the vocabulary to describe the sample material, such as figurative, anthropomorphic, personalized applications. Condition: association with a modern trend and the processing methods. Universality: to express the universality and common aspects in the application of the material in daily life. Value: reflects the people's substantial value feeling toward the material itself, which can be measured by the amount of money. Status: classification of degree and hierarchy, and a clear class distinction. Others: to judge the material as useful materials, and guess its particular usage or special purpose.
4. Emotional	The state of emotional ups and downs caused by sample; the preferences of the sample	High and positive emotional ups and downs: the "positive high-level" mood of ups and downs (exciting, attractive, surprising) caused by "like". Low and positive emotional ups and downs: the "positive low-level" mood of ups and downs (relaxed, calm, stable) caused by "like". High but negative emotional ups and downs: the "negative high-level" mood of ups and downs (nausea, fear, irritability, startled) caused by "do not like". Low but negative emotional ups and downs: the "negative low-level" mood of ups and downs caused by "do not like"; also including doubts (questioning, puzzlement) against "unknown tactile sense". Preferences: the subjective feelings of liking and disliking the samples.
5. Interface quality	According to the physical properties of the sample, and quality characteristics in the use, reflecting the features of use or features of feeling in use.	Usability: physical features perceived when touching the sample, and the past cognitive impression of the material to imagine the benefits of its use. Strength: the strength in the use (ruggedness − hardness, resistance to scratch − density, resistance to being stepped on − thickness) granted by physical features such as surface hardness, density, thickness, etc. Comfort: whether or not it will be a burden to the body when in use. Cleanliness: the tendency of foreign bodies to attach to the surface (easy to get dirty, dust-proof). Malleability: the feeling that touching the surface can physically shape the material. Temperature: according to the specific heat of the material, whether it has the property to maintain the temperature (insulation) or withstand high temperatures (heat resistant). Waterproof and water absorbency: physical properties of the surface density can lead to moisture absorption and resistance. Slip-proof and slip-resistance: physical properties of surface roughness can lead to slip-resistance effect. Post processing: material is easy to cut, shape, or manipulate by other processing methods.

of visual sense experiences, they based their feeling of the tactile sense aesthetics on their limited visual sense experiences before they became blind or on secondhand visual experiences described by others. The blindfolded individuals, on the other hand, adhered to a more conservative way of describing their aesthetic experiences and they were inclined to describe more generalized style principles, such as geometrical, balanced, harmonious, rhythmic, and continuous. As for the association of the beauty or ugliness of

materials, the blind individuals generally based it on the texture of the materials they touched. The finer the surface (such as silk), the more likely it was to elicit their tactile feelings of beauty. On the other hand the blindfolded individuals expressed beauty in terms of their imagination of it in actual applications; so corresponding relationships with the physical characteristics of the stimuli were less obvious.

Then, in terms of the category of social status and positions, the contents described by these two types of individuals did not vary much. However, from the content of interview, it was found that compared to the blindfolded individuals the blind individuals preferred using "personal" traits to describe things such as: male, female, old age, young, etc. Although the blindfolded individuals also used these terms in their descriptions sometimes, they used trend-based feelings and statuses in their descriptions more. Additionally, concerning the determination and feeling of the prices and value of items, the blind individuals were obviously weaker than blindfolded individuals. Although the blind individuals knew the meanings of expensive, precious, low price, and cheap, they were not able to clearly determine the possible price characteristics of the materials they touched, nor were they able to explain which materials felt expensive or cheap based on certain physical characteristics. The blind individuals' lack of consumption experiences in real life mainly contributed to the difference. They had limited access to materials in life and relied on explanations of others regarding the value of the materials. For instance, some blind respondents said that they did not have to personally purchase items in real life. Regarding the description of the tactile sense in the emotional category, the two did not differ much; but in terms of the description of preference for materials they touched, the blindfolded individuals tended to verbally describe whether they liked or disliked the materials as a whole, while the blind individuals only reflected on whether the characteristic of it was good to the touch or not.

Furthermore, the differences in the life experiences of the two groups were also manifested in the physiological and emotional responses when touching the materials. The blind individuals were more likely to express feeling in physiological and emotional terms such as fright and pleasure, so these feelings were expressed in more multiple-layered descriptions.

Finally, in interface quality, it was found that both the blindfolded and blind individuals put emphasis on the description of the tactile feelings during use. The only difference is that, compared to the blindfolded individuals, the blind put more emphasis on the strength of the materials in use, thus producing descriptions such as durable and not likely to break. The blindfolded individuals, on the other hand, gave more importance to comfort. In addition, since the blind individuals were unable to visually determine the surface characteristics of the materials, they were sensitive about whether or not the material surfaces had particles and attachments, thus they particularly emphasized the feeling of cleanliness of the materials in use. This feeling generally has an impact on the preference feeling of whether a material is good for touching or not.

The blind respondents and blindfolded respondents also showed differences in the degree of emphasis on the tactile feelings. The blind individuals had a higher degree of identification for objective feelings and gave more detailed descriptions of the feelings. For example, in the objective/measurable feeling category, the descriptions for the perceived coldness include cold, cool, and lower than body temperature, near body temperature, freezing, and other detailed and distinctive descriptions. Additionally, the blind individuals' focus on material descriptions lay in the determination and identification of objects. They confirmed their feeling of touch through the tactile sense and inferred what actions were appropriate, what tools could be made, or what functions there were based on the physical characteristics of the materials they touched. The blind individuals also put more emphasis on the feeling of interface quality. On the contrary, the majority of blindfolded respondents said that they had not paid much attention to the tactile feelings, though some blindfolded respondents said that they gave extra attention to the tactile feelings, mostly because they wanted to touch objects that they found unique. This shows that the tactile feelings are considered secondary for blindfolded individuals; they may actually pay attention subconsciously. However, blindfolded individuals can have a more extensive expression of objects they touch and perceive.

Overall, in terms of the content of the related descriptions of tactile feelings, the blind and blindfolded individuals showed little difference, but the content of emphasis somewhat varied. The expression on the evaluative/aesthetic aspect of the tactile feelings by both groups failed to fully reflect their tactile sense experience, but is always influenced by their visual experience or the visual experiences of others; they described the feeling of material mostly by their visual sensations. Thus, among the tactile feeling vocabulary categories the objective/measurable category, stimulated largely by the physical characteristics which are visual related, is the most important category.

3.4. The correspondence between the stimuli materials and tactile feeling vocabulary

Based on the analysis of the 51 stimuli of material samples provided and the tactile feelings elicited by both blind and blindfolded respondents, the corresponding relationship between the physical characteristics of the material and the mentioned vocabulary of tactile feelings was compiled and summarized. Each respective material has its corresponding tactile senses based on the specific physical characteristics of the material. Blind and blindfolded respondents showed little difference on the corresponding tactile senses to materials. Metal reflects the tactile senses of hardness and coldness, which in turn reflects exquisiteness, fineness, practicality, durability, and other images. For plastic, the perceived feeling of temperature ranged from cool to warm, which was a relatively moderate tactile sense perception for temperature; plastic material also felt "hard" and the corresponding psychological feelings included "cheap, prevalent, and regular", while it also had the perceived value of "useful and durable". Compared to general plastic materials, the physical characteristic of silicon rubber is quite different in hardness aspect, thus the apparent difference reflects in tactile feelings. For instance, associations brought about by the physical characteristic of elasticity of silicon rubber are generally application-based feelings, especially anti-collision and waterproof feelings. The physical characteristics of glass are similar to those of metal, especially glass with a level and smooth surface, thus the feeling elicited is likely to be confused with metal. Wood materials almost always elicit feelings of "warmth, coarseness, roughness, and striped" which correspond to the images of nature and environmental protection and brings psychological feelings such as "rustic and peace of mind". The physical characteristics of fabric, on the other hand, generally elicit the feelings of "soft", "warm", "light", "cute", "feminine" and "childlike", as well as feelings such as "happiness", "mildness", and "affinity". Leather materials produced feelings of flexibility and warmth; they also produced a feeling of delicate quality, which easily elicited fashion related associations. The stone materials clearly corresponded to the feelings of "hard, cold, and heavy" at the same time creating the feelings of "natural", "reliable", "stable" and "peace of mind".

Other special materials such as sponge mainly directly reflected the experience of its use. Almost all the respondents were able to

directly determine the material type of sponge and feel its physical characteristics of "soft, concave, convex, and warm". The associations of these physical characteristics were mostly "cheap" and "common" feelings. In regards to the characteristic of softness, the psychological feelings such as "cute", "safe", "fun", and "interesting" were elicited. Similarly, scouring pads were also a material easily identified by the respondents. They clearly produced "hand pricking" feelings, such as being thorny, flexible, and rough. However, the preference of this material shows two extremes among respondents. Cotton cloth has the similar surface as fabric surfaces with long hair, thus the tactile feelings elicited are common, which are warm, soft, fluffy, and are intuitively associated with feelings of lightness, happiness, fun, and interesting. The difference however lies in the fact that fabric with the long hair characteristic is more likely to elicit associations such as "cute", "feminine" and "expensive" than cotton, and the respondents had more obvious mood swings. The physical characteristics of oily wax gave the respondents the feeling of "stickiness", thus prompting them to produce negative emotional words, such as gray, dislike, and unpleasant. Similarly, the respondents responded to the product of "readily-stick" almost in the same way as they did with wax, which included "dislike" and "unpleasant touch". With the special plant samples, such as grapefruit skin, the respondents produced feelings of "grainy", "soft", "resilient" and "textured", while the psychological feelings were two extremes, include negative feelings of "boring" and the positive one of "anticipation". As for the respondents' feeling of loofah skin, they clearly responded to the surface characteristics of "coarse", "grainy", and so on. Meanwhile, they also responded the "natural" feeling but with the negative psychological feelings of "dislike" and "afraid". Natural turf gave the respondents feelings of "flexibility" and "resilience", which also possessed "natural" feeling and generated psychological feelings such as "comfortable", "relaxing" and "fun". This finding is contrary to the feelings brought about by the plastic turf. Plastic turf produced feelings of "thorny", "sharp" and "dislike". The respondents clearly perceived the "grainy" physical characteristic of sand and found it fun to touch, relaxing, and comfortable to step on. However, the feelings for the natural and artificial ones also show two extremes. More specifically, damp soil gave the respondents the feelings of "wet", "sticky" and "soft", but the respondents did not develop feelings of disgust as they did with the wax; instead, they perceived it with the images of "natural", "lively", "happy", "comfortable".

Finally, worth noting is that the same material sometimes produced different tactile sensation feelings due to different physical characteristics of the surfaces. For example, the elicited tactile feeling of stone with the level and smooth surface characteristic would be confused with that of metal. On the other hand, samples with the same material but with different characteristics such as with different degree of levelness, smoothness and matted treatment may produce different levels of cold/warm feeling to the touch. The level and smooth surfaces were felt colder than the matted and rough surfaces. For example, smooth plastic gave the "cold" feeling, while the matted plastic elicited the "cool" or even "warm" feelings. Materials felt cold in tactile sense, no matter they are metal, glass, plastic, stone, or fabric (silk), always elicited a "delicate" image simultaneously. The respondents adopted hardness related descriptors, such as "soft", "tender" and so on, to describe their tactile feelings on all fabric samples. They also used coldness/warmth related descriptors to describe their tactile feelings on some fabric samples, but not on all fabric samples. Although great differences of physical characteristics existed among the samples of the natural material category, such as sand, fruit, and turf, the feeling vocabulary of "soft" appeared as a common descriptor of touch feeling in almost all of them. In addition, except for soil, the materials with the physical characteristic of "stickiness" were all perceived as "dislike", "do not like to touch" or "hate". Overall, the people's fixed impressions on the commonly used industrial materials were more consistent, because of their experiences of shared use. On the contrary, natural materials or materials with fewer applications generally produced inconsistent responses, or even leading to descriptions of opposite feelings among people.

3.5. The respondents' behavior and expressive characteristics

In this study, through analyzing the recorded audio and video data of the interview, the respondents' behavioral characteristics and patterns while touching the materials were identified. According to Lederman and Klatzky (1987), people can use their wisdom and hands to systematically extract the nature or attribute of objects (entities) by adopting four typical and inertial exploratory actions, such as lateral motion, pressure, contour following, and enclosure. However, in this study, since the respondents were allowed to touch the samples' surfaces (most are flat) only, an additional action was also adopted by the respondents to explore the samples; the respondents often tapped the material surfaces with the their finger tips to enhance the feeling sensibility of the materials and to recognize the physical characteristics such as hardness and flexibility. Also, through the sounds produced from tapping the samples, the material types of the samples were judged. This also indicates the existence of compound effect of the tactile sense and other senses (in this case the sense of hearing).

In touching materials, blind individuals often have stronger physiological and psychological responses than blindfolded individuals. For example, when the blind respondents touched the matted sandblasted aluminum, they had a chill and quickly spoke out "cold" response. In the descriptive process, many blind individuals more directly and determinately responded their tactile feelings and had bolder and more subjective associations to these feelings. This phenomenon is particularly evident in the description of the aesthetic experience. For instance, when touching the sample of matted sandblasted aluminum, some of the blind respondents directly and immediately responded that the sample gave them the aesthetic feeling of "minimalism". At the same time, they expressed that "the texture of this sample is not too imposing, because it is matted". They continued to express that, unless it was treated to simulate the appearance of antique copper, its application should be in stripe form, at the most in spiral form, so it is not too complicated. However, when further inquiring about the reason for eliciting such feeling, they failed to provide further explanation.

In terms of the identification of materials, all the respondents confused the three types of material, metal, glass and stone if their surfaces had the similar level of smoothness. This shows the effect of material processing on touch feeling and implies that perhaps by manipulating the physical characteristics of materials, different materials with equivalent tactile feeling can be created. It was also found in this study that, in terms of the ability to express feelings, men and women showed different characteristics. Women used richer expression than men to describe their tactile feelings. Women used more imaginative descriptors, while men used more practical descriptors, to describe their tactile feelings. This may reflect that women are more emotional, men are more rational. Furthermore, the respondents' backgrounds and personalities resulted in their using specific or preferred expressions for tactile feeling. For example, some respondents with pessimistic personality (especially some blind respondents) tended to describe their tactile feelings with negative manner of expression, such as using without temperature, without grains, rather than using cold, smooth to describe their feelings on some samples.

4. Conclusion

In this study, 11 respondents (6 blind individuals and 5 blindfolded individuals with a keen tactile sense) were requested to touch 51 stimuli of material samples with different physical characteristics in the focus interviews for exploring the life related tactile sense experiences and the tactile feelings of people.

From the interview records, tactile feeling related vocabularies were extracted. The five classifications of linguistic experience dimensions put forth by Krippendorff then were adopted for classification on these vocabularies. The tactile feeling related vocabularies covered in the five categories in order of quantity are: objective/measurable which accounted for the majority, followed by interface quality, social status and positions, emotional, and evaluative/aesthetic. The tactile feeling vocabulary covered in the five categories was further subdivided into detailed classes as shown in the classification result in Table 6. This result will help us gain a deeper insight into the tactile feelings for further study.

A comparison of the tactile feeling vocabulary expressed by blind and blindfolded individuals show that the blindfolded individuals proposed more tactile feeling adjectives than the blind individuals, which is likely because the blindfolded individuals had extra visual sense experiences. In the comparison of the order of quantity of expressed tactile feeling vocabulary in the 5 categories, the blind individuals and blindfolded individuals had the same order, but in terms of ratios, the proposed tactile feeling adjectives of the blind individuals were concentrated in two categories: objective/measurable and interface quality; less tactile feeling expressions had been proposed in the other three categories. This may indicate that due to the blind individuals' lack of life experiences and visual sense experiences they had limited tactile sense expressions in the evaluative/aesthetic, social status and positions, and emotional categories. In view of the content of the feeling vocabulary, both the blind individuals and blindfolded individuals showed consistency in their feelings for material hardness, roughness, coldness and warmth, and use. It indicates that these consistent feelings are somewhat determined by people's physiological mechanism which is similar among people. Other than vision, they will not be affected by personal visual experiences. On the contrary, some psychological feelings and associations corresponded to the materials may vary from person to person.

In terms of the differences of focus, the blind individuals clearly used tactile sense as a replacement for the visual sense, and they focused more on using it to recognize and identify objects. To the blind individuals, the tactile sense is of more use and function oriented and has a higher dominance. On the other hand, to blindfolded individuals, the tactile sense is one of the sources of experiential and verification information. They sometimes use other senses, such as visual and auditory senses, to aid the tactile sense experience. Hence, to these people, the tactile sense is more feeling and aid oriented. Additionally, when the blind individuals touched material samples they had more intense psychological responses than the blindfolded individuals. The blind individuals had more direct expression of the tactile feelings on touching a sample and had bolder and more subjective associations to the tactile feelings.

A further insight into the various categories of tactile feeling vocabulary shows that texture, degree of coarseness, degree of hardness and degree of coldness/warmth are the four major subcategories in objective/measurable categories of vocabulary. This result is in agreement with other researches on the tactile feelings of object surface characteristics (Heller, 1982; Monegato et al., 2007; Schifferstein and Desmet, 2008).

The tactile feeling vocabulary in the evaluative/aesthetic category not only was the smallest in amount but was also confounded with some visual sense related experiences. The blindfolded individuals generally expressed their evaluative/aesthetic related tactile feeling based on their visual sense experiences while the blind expressed their feeling also based on their visual experience which was the one they experienced before becoming blind. This clearly indicates the dominance of the visual sense experience as well as the influence of the multiple senses' compound experiences on evaluative/aesthetic related tactile feeling. People's descriptions of felt beauty are usually based on vision or hearing. In terms of tactile sense, the base of beauty feeling remains unclear; there is no reference of principles summarized from the physical characteristics of touched objects.

As revealed in the pre-test of this study, past life experiences and imagination will not be enough to derive clear and rich tactile feeling related description; actually touching samples is fundamental for describing tactile feeling. This finding is similar to that of Dagman et al. (2010). This also shows that whether or not the tactile sense experience includes aesthetics remains as a question. Thus, issues such as “What are the aesthetic characteristics that constitute the tactile sense?” and “What vocabularies actually describing the aesthetics of tactile sense?” are worthy of further study.

In this study, the tactile feelings corresponding to the 51 materials were also summarized. The materials in the respective categories did have their corresponding feeling descriptions. The corresponding tactile feelings were determined by the physical characteristics and processing characteristics of the materials. Through appropriate selection of materials and processing methods, the specific tactile feelings could be elicited. Therefore, this summary will be helpful for designers to design products with the desired tactile feelings.

It was also found in this study that educational level had an impact on expressing tactile experience, too. The respondents with higher education were better to express their tactile experience. This may due to that they are able to understand and grasp the interview content. However, whether the impact is only on the expression aspect or can be extended to include other aspects of tactile feeling will require further study. In addition, gender, personality, and life background seemed to have influence on tactile feelings and their corresponding expressions as well, but because the number of the respondents in each demographic group was not large enough in this study, the exact impact may require follow-up research. On the other hand, whether or not the materials in different countries would have the same feeling is also an open question. For example, plastic material in Asia will be felt cheap but this may not be true in western countries (Chi, 2012). This brings up the interesting question of possible cultural differences.

To sum up, the research results confirm that for the tactile sense, like for other senses, people have a specific set of vocabulary for expression. Through the compilation of the tactile feeling vocabulary, the context of people's tactile sense experiences was explored. The research results should serve as a basis for follow-up research on tactile feelings and as a reference for related study on tactile feeling images to select proper image words for semantic differential evaluation. Through the analysis we also concluded the correspondence between physical characteristics of materials and the specific tactile feelings they may elicit. Designers can adopt this result as a reference for selecting proper materials to create products with desired tactile feelings and image. It is suggested that further researches on the contents and expressions of tactile feeling can address on different ways of respondents to contact objects, for example, allowed respondents to grab and pick up the objects and to manipulate and “play with” objects. Finally, due to the experiment design and planning, most of the blindfolded individuals recruited in this study were artists. They may have an expanded vocabulary as compared to ordinary people and this issue should be

considered for future study. In another way, comparing the resulted vocabulary from the repeated experiment allowing sighted subject to see the object to the obtained vocabulary from sighted subject blindfold will be considered in our further study.

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