1. INTRODUCTION

People use senses to gain information when interacting with products and then integrate the all information to form whole product image and experience. In general, for most people considered the imagery may be most vivid for the case of visual images（Kosslyn, 1994）. In addition, compared to other sense organs, vision has a dominant advantage, so that the effects and influences of other senses are often neglected. Therefore, previous studies on the product image mainly focus on visual images rather than other senses, especially on the sense of touch. However, some previous studies show that when evaluating the products, the sense of touch has a function not weaker than vision, both of which are regarded as the most important sensory (Schifferstein and Cleiren, 2005).

On the other hand, each perceptual mode can be considered as an independent channel accepting corresponding energies. Due to the different forms of stimulation, messages received by different senses may not be consist; they may present different meanings, even if the stimulus is from the same product. For example, signals like colors, appearances and sizes of the product received by vision might generate relatively more subjective preferences. However, touch will generate images of actual weight and of characteristics material. Thus, most previous studies on product images only focus the image brought by a single sense.

Although the human senses functions independently, the integrated information in the mind play a more important role on perception. When encountering certain stimulus, interaction will generate between sense organs (Schultz & Petersik, 1994). Another sensory feeling may be naturally caused by the stimulation of one sense, which is known as synesthesia (Cytowic, 2002). For example, if vision receives information from a shiny object, it will produce a smooth tactile perception indirectly, and both of which may elicit the simple and delicate images.

Sensory stimulation is accepted individually, and different stimuli will carry different messages. However, synesthesia makes different sensory trigger a common image. Since 80% of information accepted by human is owing to the vision (Berger, 1989), in terms of assessing product images, will vision still be dominant? Will vision show greater contribution than sense on which specific images? Or, what images share relatively high synesthesia between vision and touch? These questions deserve to be deeply explored. Therefore, this study utilizes the comparison of images assessment results between vision and touch, to learn the differences and classify the above issues.

2. METHOD

To achieve this goal, this study conducted a semantic differential (SD) evaluation on visual image of 35 products and a SD evaluation on tactile image of 37 materials. The factor analysis then was carried on the assessment data of both SD investigations to compare the difference between visual and touch images. This study used SPSS statistics (version 19) as the statistical tool. The SD evaluations are explained as follows.

2.1. Subjects

Thirty (13 males and 17 females) were recruited for both SD evaluations. Half of them are design background, the other are not. The age range of subjects is 21-25.

2.2. Stimuli

This study firstly conducted an interview on 11 design experts who have a master or doctoral degree, and more than 5 years of teaching or practical design experience. During the interview, the design experts were required to list clearly recognized product design styles as many as possible, and also to identify the representative products for each style. Then, the design experts were asked to describe the features, such as the sensory perception, image and association of each product. At the meantime, the experts were also asked to list the common materials fabricated in products. The interview lasts for 1~2 hours. The entire interview process was recorded in video, and the interview content was transcribed, integrated and summarized based on the questions asked in the interview.

According to the result of the interview, 35 representative products, as shown in figure 1, were selected as stimuli for further SD evaluation on visual image. The full color product pictures with eliminated background were used in the evaluation. The picture with size of about15*15cm was printed on the center of an A4 paper to show the product outlook and the original colors. From the interview this study further sorted out the representative material types commonly applied by industry. The identified material types mainly include: metal, plastics, stone, wood, leather, fabrics, glass and special. To make the stimuli for SD evaluation on tactile image including as various images as possible 3~4 materials with varied physical properties then were selected from each material type to constitute a set of 37 material samples, showed in Figure 2. These material samples were presented with size of 20cm*20cm in the further SD evaluation.

Figure 1: Pictures of representative products

2.3. Rating scale:

This study sorted the description of the perceived experience for each product mentioned by the experts in the interview. It works out 109 vocabularies related to product image, including physiological sense of vision and touch, as well as psychological perception dimension. And then we integrated, classified and screened them based on the content similarity, and finally obtained a set of 21 adjective pairs representing the perception and image, showed in Table 1, as rating scale for both SD evaluations on visual image and tactile image.

Table 1. Adjective pairs of image of three dimensions

Tactile images					
Cold-Warm	Hard-Soft	Rough-Fine	Frictional-Smooth	Low tactile-High tactile	Comfortable-Uncomfortable
Visual images					
Bright-Dark	Simple-Complex	Decorative-Plain	Pure-Mixed	Geometric(Regular)-Organic (irregular)	Pretty-Ugly
Psychological perception images					
Chill-Passionate	Intimate-Distant	Fabulous-Humble	Safe-Risky	Lively-Rigid	Like-Dislike
Conflicting-Harmonious	Bold-Conservative	Natural-Artificial			

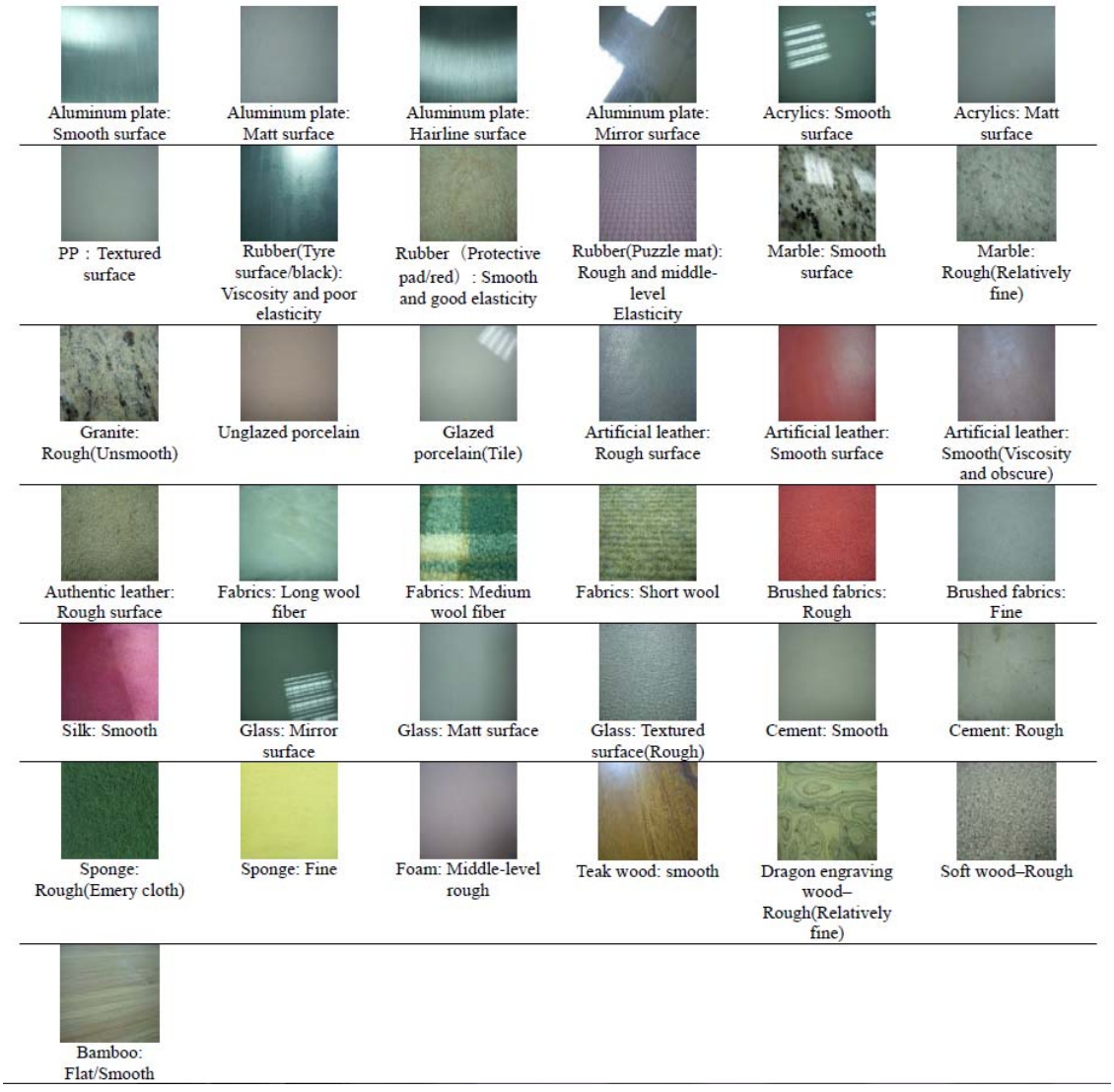

Figure 2: Material samples for tactile stimuli

2.4. Procedure:

In order to make sure all subjects would receive the same visual and tactile stimulations, we conducted the SD evaluation experiments in a room with constant lighting and temperature. At the experiment, researchers firstly explained experiment's purpose, method and steps. All subjects were asked to complete two kinds of SD evaluation experiments which including evaluating 35 product pictures by seeing and 37 material samples by touching. During the visual SD evaluation experiment, subjects were asked to conduct paper-pencil test. Here, 35 product pictures were presented to subjects one by one; subjects had to rate each product on each of the 21 image scales with the 7-point scale. During the touching SD evaluation experiment, all subjects were asked to blindfold their visual ability, and only using their hands and fingers to touch material samples. Here, 37 material samples were presented to subjects one by one; subjects had to rate each material on each of the 21 image scales, mentioned by researchers one by one, with the 7-point scale. Subjects could inquire questions and could adjust or correct their ratings in any time during the experiment. The order of stimuli and image scales presented to each subject for was randomly decided.

3. RESULT AND DISCUSSION

3.1. Factor Analysis results of the 2 experiments individually

After getting the mean value of the 30 subjects on the SD evaluations of the two kinds of stimuli, it worked out two evaluation matrixes. These two evaluation matrixes then were used to conduct factor analysis respectively. By adopting the principal component analysis method for extracting factors with the criteria of Eigenvalue larger than 1 and through the orthogonal varimax rotation, we obtained the results of factor loading of each image pairs for the two SD evaluations, as shown in Table 2 and 3 respectively.

As indicated in Table 2, four principal factors could be extracted for visual evaluation of product pictures, with explained variance of 29.64%, 26.92%, 20.21% and 9.39% respectively, as well as the total accumulated explained variance reaching 86.16%. The meaning of each factor is explained as below:

1) Factor 1: It includes 9 adjective pairs, namely, Pretty-Ugly, Like-Dislike, Rough-Fine, Pure-Mixed, Frictional-Smooth, Simple-Complex, Decorative-Plain, Comfortable-Uncomfortable, and Conflicting-Harmonious. These adjectives mainly focus on the visual shape and appearance of the object. Products with higher score in this factor may bring fine, pure and simple images to people, and may also arouse strong feeling of Pretty and Like; and vice versa.
2) Factor 2: It includes 5 adjective pairs, namely, Cold-Warm, Intimate-Distant, Hard-Soft, Chill-Passionate, and Low tactile-High tactile. These adjectives are inclined to the describing of tactile experience. Products with higher score in this factor may bring cold and hard images to people, and this kind of tactile feature may also arouse the feeling of Chill and Distant; and vice versa.
3) Factor 3: It includes 5 adjective pairs, namely, Bold-Conservative, Lively-Rigid, Fabulous–Humble, Geometric (Regular) - Organic (irregular), and Safe-Risky. These adjectives are mainly to reflect the emotional elements, such as surprising and exciting. Products with higher score in this factor may bring bold, lively and fabulous images to people, and also arouse the risky feeling; and vice versa.

4) Factor 4: It includes the last 2 adjective pairs, namely, Bright-Dark and Natural-Artificial. This factor may reflect the external glossy (shiny) of the object. Products with higher score in this factor may bring the bright and eye-catching images to people, and is also accompanied with man-made and artificial feelings; and vice versa.

Table 2. Factor analysis result of visual SD evaluation

	Factor			
	1	2	3	4
Pretty-Ugly	.903	-.161	-.074	-.204
Like-Dislike	.871	-.353	-.064	-.143
Rough-Fine	-.851	.101	.241	-.259
Pure-Mixed	.788	.325	-.334	.188
Frictional-Smooth	-.764	.018	.120	-.323
Simple-Complex	.733	.336	-.349	.211
Decorative-Plain	-.728	.059	.569	.146
Comfortable-Uncomfortable	.641	-.575	-.293	-.054
Conflicting-Harmonious	-.638	.467	.516	-.088
Cold-Warm	.035	.951	-.063	.139
Intimate-Distant	.225	-.930	.044	-.059
Hard-Soft	-.156	.870	.102	.079
Chill-Passionate	.355	.809	-.376	-.002
Low tactile-High tactile	-.109	.685	.023	.610
Bold-Conservative	-.277	.103	.925	-.001
Lively-Rigid	-.073	-.326	.903	.071
Fabulous-Humble	-.380	.052	.867	-.013
Geometric(Regular)-Organic (irregular)	.082	.529	-.596	.400
Safe-Risky	.505	-.543	-.557	.052
Bright-Dark	.317	.047	.046	.822
Natural-Artificial	.179	-.613	.061	-.619
Eigenvalue	8.624	6.161	2.057	1.251
Explained variance	29.64%	26.92%	20.21%	9.39%
Accumulated variance	29.64%	56.56%	76.77%	86.16%

Table 3 shows that four principal factors could be extracted for tactile evaluation of material samples, with the explained variance of 35.99%, 29.29%, 18.86% and 10.26% respectively, as well as the total accumulated explained variance reaching 94.39%. The meaning of each factor is explained as below:

1) Factor 1: It includes 8 adjective pairs, namely, Hard-Soft, Cold-Warm, Intimate-Distant, Safe-Risky, Chill-Passionate, Geometric (Regular)-Organic (irregular), Conflicting-Harmonious and Low tactile-High tactile. The adjectives under this factor mainly reflect the tactile feeling, which depends more on the hard and cold features among the physical properties. Products with higher score in this factor may bring strong hard and cold images, and may further arouse the corresponding psychological feelings, such as distant, risky and chill emotions; and vice versa.

2) Factor 2: It includes 8 adjective pairs, namely, Frictional-Smooth, Rough-Fine, Pure-Mixed, Pretty-Ugly, Simple-Complex, Comfortable-Uncomfortable, Like-Dislike and Bright-Dark. The adjectives under this factor mainly reflect the tactile feature as well, which focus on the roughness feature of the object surface. Products with higher score in this factor may bring obviously smooth, fine and pure images to people, and may also arouse the feeling of Pretty, Comfortable and Like; and vice versa.

3) Factor 3: It includes 4 adjective pairs, namely, Bold-Conservative, Fabulous–Humble, Decorative-Plain and Lively-Rigid. The adjectives under this factor are inclined to the psychological and emotional dimension. Products with higher score in this factor may bring bold and fabulous images to people; and vice versa.

4) Factor 4: It includes the last adjective pair, namely, Natural-Artificial. This factor clearly reflects the material composition; it is either organic or inorganic, and either highly processed or not. Products with higher score in this factor will give highly natural image to people.

Table 3. Factor analysis result of tactile SD evaluation

	Factor			
	1	2	3	4
Hard-Soft	.979	.006	.039	.060
Cold-Warm	.961	.121	.100	-.114
Intimate-Distant	-.959	.001	-.068	.227
Safe-Risky	-.958	.069	-.157	.031
Chill-Passionate	.929	.284	-.044	-.196
Geometric(Regular)-Organic (irregular)	.777	.441	-.059	-.328
Conflicting-Harmonious	.766	-.567	.246	-.074
Low tactile-High tactile	.595	.371	-.482	-.415
Frictional- Smooth	-.105	-.955	-.012	.164
Rough-Fine	.114	-.937	.041	.282
Pure-Mixed	.317	.901	-.102	-.203
Pretty-Ugly	.125	.893	.126	.317
Simple-Complex	.386	.739	-.334	-.401
Comfortable-Uncomfortable	-.594	.737	-.115	.172
Like-Dislike	-.432	.666	.008	.564
Bright-Dark	.483	.597	.525	-.256
Bold-Conservative	.145	-.119	.955	-.055
Fabulous-Humble	.202	.065	.933	.146
Decorative-Plain	.149	-.141	.886	-.219
Lively-Rigid	-.492	.118	.786	.184
Natural-Artificial	-.206	-.237	-.070	.912
Eigenvalue	8.511	6.050	3.830	1.431
Explained variance	35.99%	29.29%	18.86%	10.26%
Accumulated variance	35.99%	65.28%	84.14%	94.39%

3.2. Comparative analysis on the composition of visual and tactile factors

To compare the results of the two factor analyses this study then consolidated images (adjective pairs) in each factor shown in Table 2 and 3 to get a corresponding matrix as showed in Table 4. By reviewing these three tables we had the following comparisons:

1) The accumulated explained variance of factor analysis for visual SD evaluation is lower than that of tactile assessment（86.16%<94.39%）. In the visual SD evaluation, six images（Comfortable-Uncomfortable, Conflicting-Harmonious, Low tactile-High tactile, Geometric(Regular)-Organic (irregular)、Safe-Risky、Natural-Artificial） have related low factor loadings (less than 0.7) in their attributed factor but related high factor loadings (higher than 0.5) in some non-attributed factors On the contrary, there are only two images in tactile SD evaluation（Geometric(Regular)-Organic (irregular), Conflicting-Harmonious）under the same condition. The result shows that some visual images are relatively independent compared to tactile images.

2) Table 4 shows that the image compositions of factors in the two sensory are approximately

corresponded. The visual factor 1 is closely corresponding to tactile factor 2, with common images including: Pretty-Ugly, Like-Dislike, Rough-Fine, Pure-Mixed, Frictional-Smooth, Simple-Complex and Comfortable-Uncomfortable, which are images related to preference, style and composition. Visual factor 2 is similar to tactile factor 1 in composition with common images including: Cold-Warm, Intimate-Distant, Hard-Soft, Chill-Passionate, Low tactile-High tactile. They mainly reflect the tactile based experience and the corresponding psychological image. Both factor 3 of visual and tactile evaluations, including common images of Bold-Conservative, Lively-Rigid, Fabulous-Humble, are corresponded to mainly reflect psychological related feelings. Finally, both factor 4 of visual and tactile evaluations are corresponded containing the common image of Natural-Artificial. With these corresponding arrangements, 16 out of 21 images are shared by both visual and tactile evaluation; or we may say the corresponding rate of these two senses is about 76% (16/21).

3) The remaining five non-corresponded images include Conflicting-Harmonious （visual factor 2, tactile factor1）, Decorative-Plain（visual factor 1, tactile factor 3）, Safe-Risky and Geometric (Regular) - Organic (irregular)（visual factor 3，tactile factor 1）, Bright-Dark（visual factor 4，tactile factor 2）. Among them Conflicting-Harmonious and Geometric (Regular) - Organic (irregular) have relatively low factor loadings in the attributed factors of both factor analyses. Thus, they are somewhat incongruent with other images in the same attributed factors; they may belong to other factors not yet abstracted. Factor loadings of Safe-Risky and Decorative-Plain are low in attributed visual factors but high in attributed tactile factors. On the contrary, Bright-Dark has significantly high factor loading in attributed visual factor but low in attributed tactile factor. It shows that these three images have different meanings in visual and tactile sensory. According to the factor loadings and attributed factor of Safe-Risky in tactile sensory, this image is strongly and clearly associated with the toughness and felt temperature of the touched material. Bright-Dark is the image that can be felt clearly through vision but is not a clear feeling in tactile sense. Decorative-Plain image is clearly associated with some psychological feelings of activeness in tactile sense, while it is somewhat associated with feelings of evaluation or preference in visual sense.

4) Like-Dislike, Pretty-Ugly and Comfortable-Uncomfortable are the images related to preference used in the SD evaluations. They are closely correlated with Rough-Fine, Pure-Mixed, Frictional-Smooth and Simple-Complex images in both visual and tactile sensory. Visually or tactilely fine, pure, smooth, simple are important to make products preferred. Among these images roughness and smoothness are more tactile oriented perceptual feelings, whereas purity and simplicity are more visual oriented ones. This finding disagree with people's generally thinking that a soft and gentle (felt temperature) tactile is significantly related to the degree of comfort.

5) Through corresponding matrix of Table 4, it also shows another interesting phenomenon. In the touch-oriented images, Cold-Warm and Hard-Soft are integrated. However, integrated tactile is an important element influencing Low tactile-High tactile images. On the other hand, Rough-Fine and Frictional-Smooth can be integrated into one. As for vision, only Pure-Mixed and Simple-Complex show significant correlation and other vision-oriented images are distributed to various factors. At the same time, the tactile sense of Rough-Fine and Frictional-Smooth, and the visual sense of Pure-Mixed and Simple-Complex show high correlation with each other. The classification of these two sensory assessments is consistent. The result shows that the visual sense is significantly correlated to the roughness on material. By modifying the roughness of the materials, visual images can be affected, such as images of

simplicity and purity can be greatly enhanced.

Table 4 Corresponding matrix of factors abstracted in the two factor analyses

Visual factors / Tactile factors	Factor 1	Factor 2	Factor 3	Factor 4	Sum
Factor 1	Conflicting-Harmonious	Cold-Warm Intimate-Distant Hard-Soft Chill-Passionate Low tactile–High tactile	Safe-Risky Geometric (Regular)-Organic (irregular)		8
number	1	5	2		
Factor 2	Pretty-Ugly Like-Dislike Rough-Fine Pure-Mixed Frictional-Smooth Simple-Complex Comfortable-Uncomfortable			Bright-Dark	8
number	7				
Factor 3	Decorative-Plain		Bold-Conservative Lively-Rigid Fabulous-Humble		4
number	1		3		
Factor 4				Natural-Artificial	1
number				1	
Sum	9	5	5	2	21

4. CONCLUSION

In order to understand what images the visual or tactile sense may be dominant, as well as the association between sensory and images, the study performed visual and tactile SD evaluations with stimuli of product pictures and material samples respectively. We then conducted corresponding factor analyses on the data obtained from the two SD evaluations and compare the differences of resulted factors and factor composition. The result of this study can be summarized as below:

1) Through factor analyses, both visual and tactile SD evaluations can obtain 4 factors. Generally, the accumulated explained value of visual factor analysis is lower than that of tactile factor, which shows that some visual images are more independent and difficult to be classified than tactile images.

2) According to the significant similarity and difference in composition of factors derived from the two factor analyses, it can be found that the correlation between visual image and tactile image is high. As for the difference between these two sense organs, psychological images of the tactile sense are more closely correlated to objective perception on materials.

3) Tactilely felt roughness will affect the preference to the touched material and is closely correlated to the visual experience. This also shows that roughness is an image of complex

sensory and is equally dominated by both vision and touch.

4) As for roughness and temperature on the sense of touch, they are weakly correlated to vision, which show no strongly clear correlation to visual image. Therefore, these two images of the sense of touch also depend on the tactile assessment, without visual impact.

5) Finally, it is interesting that the results of imagery classification show a high relevance with tactile feeling and intimacy degree, which is not functioned by vision. Whether it indicates that the feeling of intimacy is generally not obtained and presented by vision. Therefore, in the process of visual assessment, the images can not be clearly classified. On the contrary, touch sense has great advantage in creating intimacy and intimate feeling. This advantage might come from the direct interaction between human and product or human and human, which is generated mainly due to physical contact.

The can be served as a reference for designer to transfer the image of tactile sense in product design. By introducing specific tactile feelings, the visual image can be strengthened to build overall characteristics of product. For future studies, the result of this study can also provide a basis of reference for investigation on the tactile image, especially on the research of synesthesia.

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