

A Study on the Tactile Styles of Products

Taking Visual Product Design Style as an Example

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Abstract: In the interaction of human and product, the importance of tactile is gradually recognized. However, researches on using experience between tactile and product are relatively scarce, especially on tactile styles. In this study, as the exploring phase of the investigation, we firstly conducted interview on 11 design experts for identifying visually distinct design styles of product as references for tactile styles. Seven design styles were identified. The descriptions on design styles of design experts were then coded and sorted by the KJ method to result a set of 21 pairs of Image words as evaluating scale for semantic differential (SD) evaluation. These design experts were also asked to figure out representative products for each design style. Thirty five representative products, 5 products for each of 7 styles, were summarized. These representative products were prepared as visual stimuli of pictures. A comprehensive set of 37 material samples were also prepared as tactile stimuli. Thirty subjects were recruited for a SD survey by using a 7-point scale to evaluate three sets of stimuli: concept of 7 styles by thinking, 35 product pictures by seeing and 37 tactile samples by touching, on each of the 21 Image scales. The data collected in the SD survey were analyzed by using factor analysis and cluster analysis. A common image space and style groups were derived for these three sets of stimuli. This result will be further analyzed by approaches of Kansei engineering to obtain the correspondence between material properties and tactile styles in the next phase.

Key words: *Tactile styles, semantic differential evaluation, image space, image mapping, Kansei engineering*

1. Introduction

During the interaction with products, humans obtain product information through sensation and then integrate sensory information to get the overall image and perception towards the products. The sense of touch is next important to the sense of vision during this process. Generally, people firstly see product appearance by eyes, and achieve the product use and experience by contacting and using products through the body. Among the studies related to tactile sense of products, most of them focus on the correlation between the material and touch, or the discussion of image and perception to the material and texture under the three conditions of sense of touch, sense of vision, and touch-vision sense [4,5,6,7], while some others emphasize on the identification of material, texture or shape without seeing [3,8]. Moreover, the studies related to the overall tactile style are rare. Therefore, this study is going to innovatively discuss the correlation between the tactile style and product image. It's learned from the literature review that human senses don't only work independently, but also interact with each other [8]. One kind of sensory stimulus will result in another sensory perception naturally, namely, synesthesia [2], which also

takes place during the product image evaluation by sense of vision and sense of touch. Thus, the purposes of the discussion in this study are as the follows: Whether sense of touch shares the same style with the sense of vision, whether the visual product design style could be taken as the foundation of tactile style, and finally what correlation exists between the tactile style and image of the product. Therefore, this study is to investigate the clear visual design styles and the representative products, which will be taken as the reference to explore the tactile style of products. Finally through a series of experimental comparisons, the tactile styles, the corresponding perceptions and images will be obtained.

2. Method

2.1 Expert interview

This study conducts interview on 11 design experts who have a master or doctoral degree, and more than 5 years of design teaching or practical design experience. During the interview, the design experts are required to list the product design styles resulting in deep and clear perception as many as possible, and also to describe the features, such as the sensory perception, image and association of each style. At the meantime, the experts are also asked to list the shape, type and common material of the representative products for each style. The interview lasts for 1~2 hours or so.

2.2 Sorting the representative product design styles

By sorting the styles proposed by all the 11 experts, it is to select the representative design styles for subsequent experiment. It finally gets a total of 22 design styles, as shown in Table 1. The number attached to each style is the times mentioned by the experts. The styles with the number larger than 4(mentioned by the more than four experts) include 9 ones: Trans Hi-tech, Scandinavian modern, hi-tech, archetype, Memphis, modernism, minimalism, Ready-made and green design. This study further reviews the description content of these 9 styles, and finds out the content and description of the styles of Ready-made and green design don't comply with the subject discussed in this study, which value the acquisition of raw material and elements during the product design process rather than the shape and composition of the product itself. Apparently, they don't show the shape design style of the product itself, so they are excluded from the discussion of this study. Finally, this study only takes the remaining 7 styles listed in upper side of the table as the major evaluation items.

Table 1. Table of design styles proposed by experts

Trans hi-tech(5)	Scandinavian modern(4)	Hi-tech(8)	Archetype(5)	Memphis(5)	Modernism(4)	Minimalism(7)
Ready-made(5)	Green design(6)					
Internationalism style(2)	Japanese Zen(3)	Retro(1)	Bio mimicry(3)	Pop art(2)	Alchimia(1)	Postmodernism(3)
New Nouveau-Glasgow(1)	Art Nouveau design(2)	Design humor(1)	Thai style(3)	Bauhaus (2)	Streamline(2)	

* The sequence of styles is not prioritized. () indicates the times mentioned by the experts.

2.3 Select products representing each style

For the product design styles sorted from the expert interview, it records the product description mentioned by most experts, including the product name, shape, brand and other information. It selects five products for each style as the representatives. A total of 35 experimental stimulus samples are obtained as shown in Figure 1, which are taken as the product stimuli for formal experimental evaluation. For the convenience of written test, the product pictures used in this stage are printed on A4 paper colorfully. The picture size is about 15*15cm(slight

adjustment dependent on the product shape), and placed in the center of the paper to show the product outlook and the original colors.

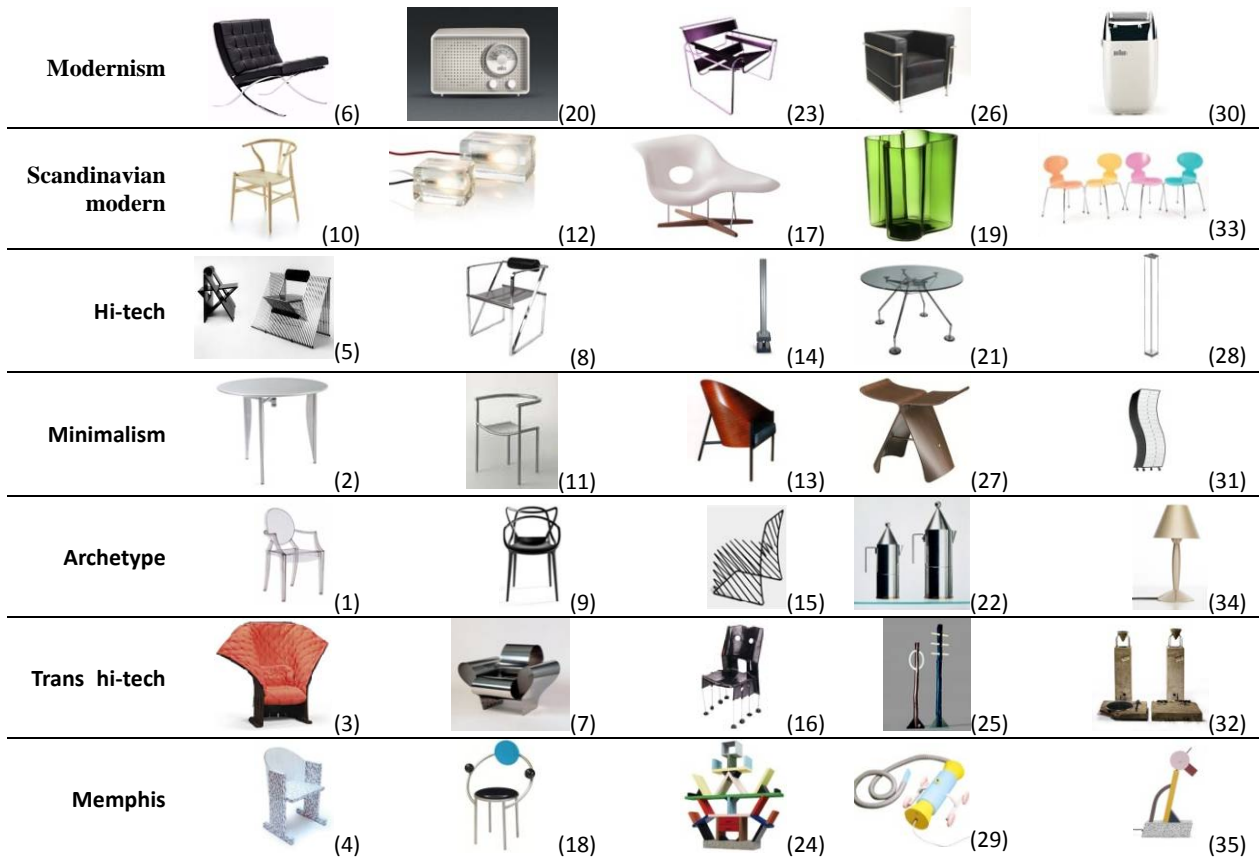


Figure 1. Pictures of representative products for the design styles in the formal test. The number in () is the product number for subsequent analysis

2.4 Summarizing the representative material samples

Based on the connotation of the representative products proposed by the experts, it further sorts out the representative material types commonly applied by these styles. The material types mainly include: metal, plastics, stone, wood, leather, fabrics, glass and special materials. Based on these 8 types of material, this study further sorts the materials with different physical properties and textures as the tactile stimuli for SD investigation. To make the stimuli selected from each item meet the images of various styles better, the experiment tries best to find out 3~4 types of texture samples from the same material. In this way, it may arouse different tactile perceptions. Finally 37 material samples are figured out, as shown in Figure 2, which are taken as the tactile stimuli of the experiment. The materials sorted out in this stage will be all converted into the size of 20cm*20cm during SD evaluation experiment, which will be offered for the respondents to touch by palm and figures.

2.5 Constructing the 7 evaluable styles to obtain Kansei vocabularies

Finally, the study sorts the description of the perceived experience for each style mentioned by the experts in the interview. It works out 109 vocabularies related to the image, including physiologic sense of vision and touch, as well as mental perception dimension. And then it integrates, classifies and selects them based on the content similarity, and finally obtains a total of 28 adjective pairs representing the perception and image of each style. Based on these 28 pairs, taking the aforementioned style concepts, product pictures and touch samples as stimuli, it conducts SD pretest on the 10 respondents (5 with design background, while the other 5 without design

background). The adjectives with low identification rate are eliminated. Finally it obtains 21 pairs of adjective which represent the perception and image of each style, as shown in Table2.

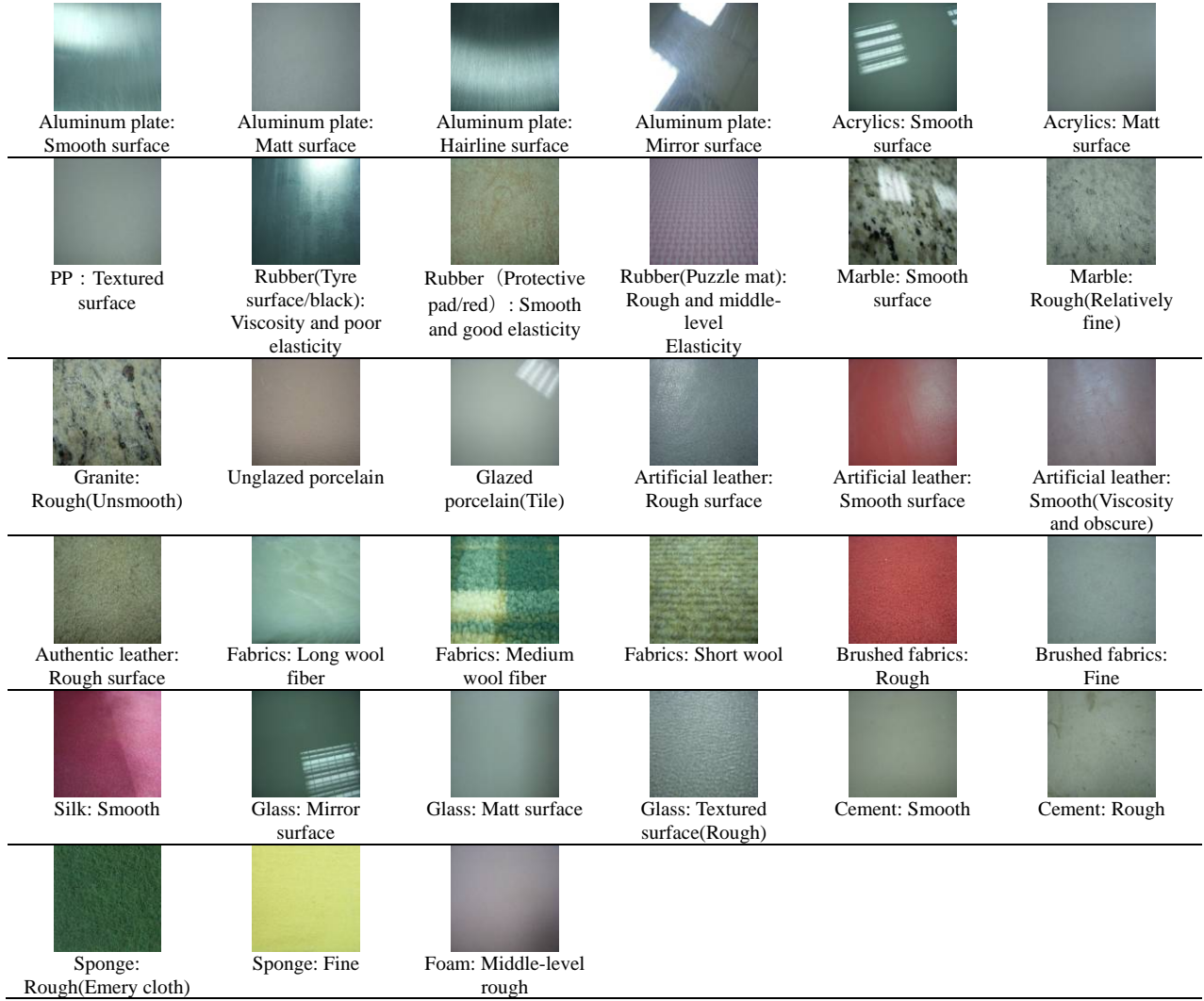


Figure 2.Tactile stimulus sample types (The materials are ranked as metal, plastics, stone, wood, leather, fabrics, glass and special material)

Table 2.Adjective pairs of perception and image

Cold-Warm	Pretty-Ugly	Rough-Fine	Hard-Soft	Like-Dislike	Bright-Dark	Conflicting -Harmonious
Pure-Mixed	Lively-Rigid	Fabulous – Humble	Assured-Risky	Unsmooth-Smooth	Decorative-Plain	Comfortable-Uncomfortable
Bold-Conservative	Chill-Passionate	Intimate-Distant	Simple-Complex	Natural-Artificial	Low tactile–Touch-oriented	Geometric(Regular)-Flexible(Changing)

2.6 SD semantic evaluation investigation

The experimental investigation in stage 2 is to conduct SD evaluation experiment on 30 respondents (15 with design background, while the other 15 without design background). During the experiment, the respondents are required to use the 7-point scale to grade the SD evaluation of the perception and image on the following three stimuli: 1) 7 style concepts; 2) 35 representative product pictures for all styles; 3) 37 representative material samples, all of which use the 21 pairs of image evaluation concluded above. During the test, the perception adjectives for evaluation on each stimulus are presented in different order, so as to avoid the impact on the test results.

3. Analysis and discussion on the experimental results

3.1 Analysis results of the 3 experimental factors individually

After getting the mean value of the SD investigation results on the style concepts from the 30 respondents, it works out three evaluation matrixes. It then conducts factor analysis on them respectively, adopts the principal component analysis method to extract the factor with the feature value larger than 1. Finally, through the orthogonal varimax rotation, it obtains the factor loading of each image, as shown in Table 3, 4 and 5.

As shown in Table 3, through the concept evaluation results, three principal factors could be extracted, with the explained variance of 50.7%, 34.71% and 9.05% respectively, as well as the total accumulated explained variance reaching 94.46. Each factor is explained as below:

- 1) Factor 1: It includes 10 adjective pairs, namely, Like-Dislike, Pure-Mixed, Fabulous–Humble, Decorative-Plain, Pretty-Ugly, Comfortable-Uncomfortable, Conflicting-Harmonious, Assured-Risky and Simple-Complex. These adjectives are mainly about mental perception and visual image, and also contain some tactile descriptions. Higher score of this factor may bring simple, plain and harmonious images, which are often with such feelings as like, pretty, comfortable and even assured; and vice versa.
- 2) Factor 2: It includes 8 adjective pairs, namely, Cold-Warm, Geometric (Regular)-Flexible(Changing), Low tactile-Touch-oriented, Chill-Passionate, Hard-Soft, Intimate-Distant, Lively-Rigid and Natural-Artificial. These adjectives focus on the description of mental and tactile experience, such as cold and hard, which also reflect the intimacy with humans. Higher score of this factor may bring the cold and hard images, and this kind of tactile feature will make people feel distant; and vice versa.
- 3) Factor 3: It includes 3 adjective pairs, namely, Rough-Fine, Bright-Dark and Unsmooth-Smooth. These adjectives purely reflect the fineness shown on the object surface, including the visual and tactile perceptions. Higher score of this factor will bring the image of fine surface; and vice versa.

As shown in Table 4, through the visual evaluation results of product pictures, four principal factors could be extracted, with the explained variance of 29.64%, 26.92%, 20.21% and 9.39% respectively, as well as the total accumulated explained variance reaching 86.16%. Each factor is explained as below:

- 1) Factor 1: It includes 9 adjective pairs, namely, Pretty-Ugly, Like-Dislike, Rough-Fine, Pure-Mixed, Pure-Mixed, Unsmooth-Smooth, Pure-Complex, Decorative-Plain, Comfortable-Uncomfortable, and Conflicting-Harmonious. These adjectives mainly focus on the visual shape and appearance of the object. Higher score of this factor may bring fine, pure and simple images, and also arouse strong feeling of Pretty and Like; and vice versa.
- 2) Factor 2: It includes 5 adjective pairs, namely, Cold-Warm, Intimate-Warm, Hard-Soft, Chill-Passionate, and Low tactile-Touch-oriented. These adjectives are inclined to the description of tactile experience. Higher score of this factor may bring cold and hard images, 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)-Flexible(Changing), and Assured-Risky. These adjectives are mainly to reflect the emotional elements mentally, such as surprising and exciting. Therefore, higher score of this factor may bring bold, lively and fabulous images, 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 features reflecting the external gloss of the object. Higher score may bring the bright and eye-catching images, and is also accompanied with man-made and artificial features; and vice versa.

Table 3 Rotated matrix of evaluation factor of style concept

Adjectives	Component		
	1	2	3
Like-Dislike	.985	-.039	.075
Pure-Mixed	.971	.220	-.032
Fabulous –Humble	-.964	-.150	.155
Decorative-Plain	-.961	-.090	.251
Pretty-Ugly	.956	-.063	.218
Comfortable-Uncomfortable	.941	-.212	.180
Bold-Conservative	-.930	.034	.283
Conflicting-Harmonious	-.898	.338	-.098
Assured-Risky	.887	-.427	.089
Simple-Complex	.838	.490	-.075
Cold-Warm	-.220	.963	.080
Geometric(Regular)-Flexible(Changing)	.306	.927	.049
Low tactile-Tactile-oriented	-.091	.912	.012
Chill-Passionate	.455	.865	.202
Hard-Soft	-.418	.849	-.073
Intimate-Distant	.513	-.837	-.118
Lively-Rigid	-.391	-.831	.161
Natural-Artificial	.641	-.706	-.289
Rough-Fine	-.028	-.585	-.737
Bright-Dark	-.400	-.463	.677
Unsmooth-Smooth	-.636	-.293	-.667
Feature value	10.678	7.309	1.849
Explained variance	50.7%	34.71%	9.05%
Accumulated explained variance	50.7%	85.41%	94.46%

Table 4 Rotated matrix of evaluation factor of product pictures

	Component			
	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
Unsmooth-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-Tactile-oriented	-.109	.685	.023	.610
Bold-Conservative	-.277	.103	.925	-.001
Lively-Rigid	-.073	-.326	.903	.071
Fabulous –Humble	-.380	.052	.867	-.013
Geometric(Regular)-Flexible(Changing)	.082	.529	-.596	.400
Assured-Risky	.505	-.543	-.557	.052
Bright-Dark	.317	.047	.046	.822
Natural-Artificial	.179	-.613	.061	-.619
Feature value	8.624	6.161	2.057	1.251
Explained variance	29.64%	26.92%	20.21%	9.39%
Accumulated explained variance	29.64%	56.56%	76.77%	86.16%

As shown in Table 5, through the concept evaluation results, four principal factors could be extracted, with the explained variance of 35.44%, 30.04%, 18.95% and 9.86% respectively, as well as the total accumulated explained variance reaching 94.29%. Each factor is explained as below:

- Factor 1: It includes 8 adjective pairs, namely, Hard-Soft, Cold-Warm, Intimate-Distant, Assured-Risky, Chill-Passionate, Conflicting-Harmonious, Geometric (Regular)-Flexible(Changing) and Low tactile- Touch-oriented. The adjectives under this factor mainly reflect the tactile feeling, which value the hard and cold features among the physical properties. Higher score of this factor may bring strong hard and cold images, and further arouse the corresponding mental feelings, such as distant, risky and chill emotions; and vice versa.
- Factor 2: It includes 8 adjective pairs, namely, Unsmooth-Smooth, Rough-Fine, Pure-Mixed, Pure-Complex, Comfortable-Uncomfortable, Like-Dislike, and Bright-Dark. The adjectives under this factor mainly reflect the tactile feature as well, which focus on the rough feature of the object surface. Higher score of this factor may bring obviously smooth, fine and pure images, and also arouse the feeling of Pretty, Comfortable and Like; and vice versa.
- Factor 3: It includes 4 adjective pairs, namely, Bold-Conservative, Fabulous–Humble, Lively-Rigid, and Decorative-Plain. The adjectives under this factor are inclined to the mental and emotional dimension. Therefore, higher score of this factor may bring bold and fabulous images; 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. Higher score of this factor will result in highly natural image.

Table 5 Rotated matrix of evaluation factor of material touch samples

	Component			
	1	2	3	4
Hard-Soft	.978	-.007	.046	.057
Cold-Warm	.961	.130	.088	-.113
Intimate/Distant	-.959	-.007	-.068	.227
Assured-Risky	-.954	.089	-.168	.035
Chill/Passionate	.926	.292	-.056	-.192
Conflicting-Harmonious	.766	-.564	.248	-.081
Geometric(Regular)-Flexible(Changing)	.763	.466	-.087	-.319
Low tactile-Tactile-oriented	.575	.392	-.507	-.397
Unsmooth-Smooth	-.080	-.961	.021	.148
Rough-Fine	.134	-.940	.074	.260
Pure-Mixed	.286	.912	-.134	-.185
Pretty-Ugly	.108	.896	.111	.320
Simple-Complex	.344	.760	-.368	-.369
Comfortable/Uncomfortable	-.597	.732	-.124	.175
Like-Dislike	-.440	.670	-.006	.555
Bright-Dark	.471	.630	.490	-.254
Bold-Conservative	.157	-.106	.943	-.068
Fabulous-Humble	.220	.032	.935	.125
Decorative-Humble	.174	-.188	.871	-.224
Lively-Rigid	-.471	.090	.808	.169
Natural-Artificial	-.211	-.228	-.068	.913
Feature value	8.313	6.379	3.713	1.395
Explained variance	35.44%	30.04%	18.95%	9.86%
Accumulated explained variance	35.44%	65.48%	84.43%	94.29%

Table 6 Overall factor analysis of three experiments

	Component			
	1	2	3	4
Hard-Soft	.950	-.052	.092	-.012
Cold-Warm	.943	.106	.029	-.196
Intimate/Distant	-.916	.092	-.034	.292
Chill/Passionate	.839	.346	-.262	-.141
Assured-Risky	-.810	.259	-.406	.073
Geometric(Regular)-Flexible(Changing)	.664	.380	-.298	-.389
Conflicting-Harmonious	.636	-.614	.374	-.081
Rough-Fine	.096	-.897	.023	.273
Unsmooth-Smooth	-.045	-.893	.029	.181
Pure/Mixed	.270	.860	-.255	-.081
Pretty/Ugly	.003	.830	-.119	.463
Simple-Complex	.311	.749	-.405	-.200
Like/Dislike	-.318	.744	-.072	.490
Comfortable/Uncomfortable	-.554	.658	-.275	.226
Bright-Dark	.334	.579	.436	-.284
Bold-Conservative	.162	-.105	.939	-.062
Fabulous-Humble	.148	-.191	.926	-.023
Lively-Rigid	-.262	.049	.916	.087
Decorative-Plain	.105	-.378	.801	-.336
Natural/Artificial	-.340	-.095	-.154	.837
Low Tactile/Tactile-oriented	.576	.261	.013	-.578
Feature value	7.415	6.688	3.083	1.277
Explained variance	29.11%	28.16%	20.15%	10.5%
Accumulated explained variance	29.11%	57.27%	77.42%	87.92%

3.2 Comparative analysis on the composition of image space factors

Summarizing the content in above composition tables of factor analysis, it could find the difference of image composition between the style concept, visual perception and tactile perception under the product design style, and its correlation with the perception and image could be detailed as below respectively:

- 1) Firstly, in terms of the factor composition in the three experiments, we could find the main features of different sensory experiences towards the factor composition. On the whole, the composition of factor 1 under concept and sense of vision is similar to that of factor 2 under sense of touch, which mainly reflects the preference image and visual image of shape and components. However, regarding the difference, this factor under concept adds more mental feelings like 『**Fabulous-Humble**, **Assured-Risky** and **Bold-Conservative**』, while it clearly reflects the visual feature under sense of vision. When it comes to the sense of touch, it further classifies the image of 『**Bright-Dark**』 under the same category of 『**Unsmooth-Smooth** and **Rough-Fine**』, which shows great difference with visual evaluation. Moreover, the concept evaluation also puts these three items into the same category, which however make up factor 3.
- 2) The composition of factor 2 under concept and sense of vision is similar to that of factor 1 under sense of touch, which mainly describes the tactile experience and the corresponding mental image. However,

regarding the difference, the factor under concept adds more mental images, such as 『**Lively-Rigid** and **Natural-Artificial**』, while sense of vision and sense of touch don't have this part. This factor under sense of vision doesn't include more image perception. When it comes to the sense of touch, it reflects more mental associations, such as 『**Assured-Risky, Conflicting-Harmonious** and **Geometric (Regular)-Flexible (Changing)**』, which are consistent with the concept. It seems to indicate the mental association under sense of touch is stronger and clearer than that of sense of vision, and is closely linked with the concept.

- 3) As for the composition of other factors, factor 3 under sense of vision and sense of touch reflects the same mental perceptions, which are distributed in factor 1 and factor 2 under the concept. Factor 3 under the concept is about the features of vision-touch sense. Besides, factor 3 adds 『**Geometric (Regular)-Flexible (Changing), Assured-Risky**』 under sense of vision, and adds 『**Decorative-Plain**』 under sense of touch. Finally, in terms of the composition of factor 4, it reflects the corresponding sensory feature. For example, 『**Bright-Dark**』 is the main image under sense of vision, which could be only acquired by sense of vision; it is mainly 『**Natural-Artificial**』 under sense of touch, which reflects whether material itself is natural on touch or not.
- 4) From the correlation with images in the factor composition tables of the three experiments, we could find the elements influencing and arousing the adjectives of preference image, namely, 『**Like-Dislike, Pretty-Ugly** and **Comfortable-Uncomfortable**』. In the concept evaluation, the adjectives related to preference image include 『**Pure-Mixed, Fabulous-Humble, Decorative-Plain, Bond-Conservative, Conflicting-Harmonious, Assured-Risky** and **Simple-Complex**』. It indicates the shape and positive mental perception show great influence on the preference, in other words, the visual experience shows higher influence on the concept. In the evaluation in the sense of vision, the adjectives related to preference include 『**Rough-Fine, Pure-Mixed, Unsmooth-Smooth, Simple-Complex, Decorative-Plain** and **Conflicting-Harmonious**』. It indicates the tactile perception also shows influence on the preference in addition to the shape, which is absent in the concept evaluation. Finally in the evaluation in the sense of touch, the adjectives related to preference include 『**Unsmooth-Smooth, Rough-Fine, Pure-Mixed, Simple-Complex** and **Bright-Dark**』. From the image composition, the keys are the surface roughness and texture composition of the material. The association from the material is no longer the shape, but the composition of material surface. The hard and cold touch is not the critical factor as well.
- 5) In the factor composition of the three experiments, we could also find some correlation with the perception and image. For example, perceptions and images of 『**Cold-Warm, Hard-Soft, Chill-Passionate, Intimate-Distant** and **Low tactile-Touch-oriented**』, perceptions and images of 『**Bond-Conservative** and **Fabulous-Humble**』, perceptions and images of 『**Simple-Complex** and **Pure-Mixed**』, perceptions and images of 『**Rough-Fine** and **Unsmooth-Smooth**』, they have clear correlation, so they may be classified into the same category regardless of the perception evaluation means in the experiment. Among these perceptions and images, the items of 『**Cold-Warm, Hard-Soft, Chill-Passionate, Intimate-Distant** and **Low tactile-Touch-oriented**』 are the image adjectives consisting of tactile perception and mental perception.

It indicates the close correlation between the tactile and mental perceptions and images. Again it tells the perceptions and images under sense of touch are more consistent and uniform with the mental associations.

3.3 Overall factor analysis

In the study, the evaluation of the three evaluations all adopt the same perception and image evaluation scale. Therefore, it integrates the image adjectives in the 79 stimuli in total in the three experiments, and conducts factor analysis on the mean matrix of the image adjective evaluation towards the stimuli collected from the respondents, so as to obtain the image elements consisting of the product design style and tactile style. It further reviews the composition of each factor, to learn the major items consisting of the factor and the corresponding image features. Moreover, it could obtain the scores of the 79 stimuli in the four factors from the results of overall factor analysis, which is helpful to the subsequent clustering analysis and to construct the tactile style types.

The overall factor analysis results are shown in Table 6. Four principal factors are extracted, with the explained variance of 29.11%, 28.16%, 20.15% and 10.5% respectively, as well as the total accumulated explained variance of 87.92%. Each factor is explained as below:

- 1) Factor 1: It includes 7 adjective pairs, namely, Hard-Soft, Cold-Warm, Intimate-Distant, Chill-Passionate, Assured-Risky, Geometric(Regular)-Flexible(Changing) and Conflicting-Harmonious. These adjectives mainly consist of tactile perception description and mental images. Higher score of this factor may bring the cold and hard images, and further arouse the emotions of distant, risky and chill; and vice versa.
- 2) Factor 2: It includes 8 adjective pairs, namely, Rough-Fine, Unsmooth-Smooth, Pure-Mixed, Pretty-Ugly, Pure-Complex, Like-Dislike, Comfortable-Uncomfortable and Bright-Dark. The adjectives under this factor reflect the tactile, visual and mentally preferred perceptions. Higher score of this factor may bring smooth, fine and pure images, leave the simple and bright impression, and arouse the feelings of pretty, comfortable, and like; and vice versa.
- 3) Factor 3: It includes 4 adjective pairs, namely, Bold-Conservative, Fabulous-Humble, Lively-Rigid and Decorative-Plain. The adjectives under this factor are inclined to the mental emotion. Thus, higher score of this factor may bring bold and fabulous images; and vice versa.
- 4) Factor 4: It includes 2 adjective pairs, namely, Natural-Artificial and Low tactile/Touch-oriented. Natural-Artificial image is the major item for this factor. It clearly states the material composition; it is either organic or not, and either strongly processed or not. Although Low tactile/Touch-oriented is classified in this factor, its factor loading is as small as that in factor 1, hence the little influences. Thus, higher score of this factor may bring high image of natural material.

On the whole, the factor composition in Table 6 is extremely like that of Table 5. It could be found from the overall factor analysis that the main vocabulary of sensory image in each factor mainly seems to describe the tactile perception (factor 1 and 2 with the highest explained variance). It is followed by the mental image, and lastly the feature of material. Maybe it indicates the evaluation of tactile image shows significant influence on the product design style.

3.4 Clustering analysis to construct tactile style

The study conducts cluster analysis based on the scores obtained by the 79 stimuli obtained in the four factors during above overall factor analysis, so as to learn the similar summarization features. In this paper, we use the

hierarchical cluster analysis, and perform cluster convergence mainly by Ward's minimum variance. The hierarchical tree is shown in Figure 3. Through the hierarchical clustering tree, it could clearly obtain the types of tactile product design style. As shown in Figure 3, the 79 stimulus samples are appropriately divided into five clusters. The features of each cluster are further detailed as below:

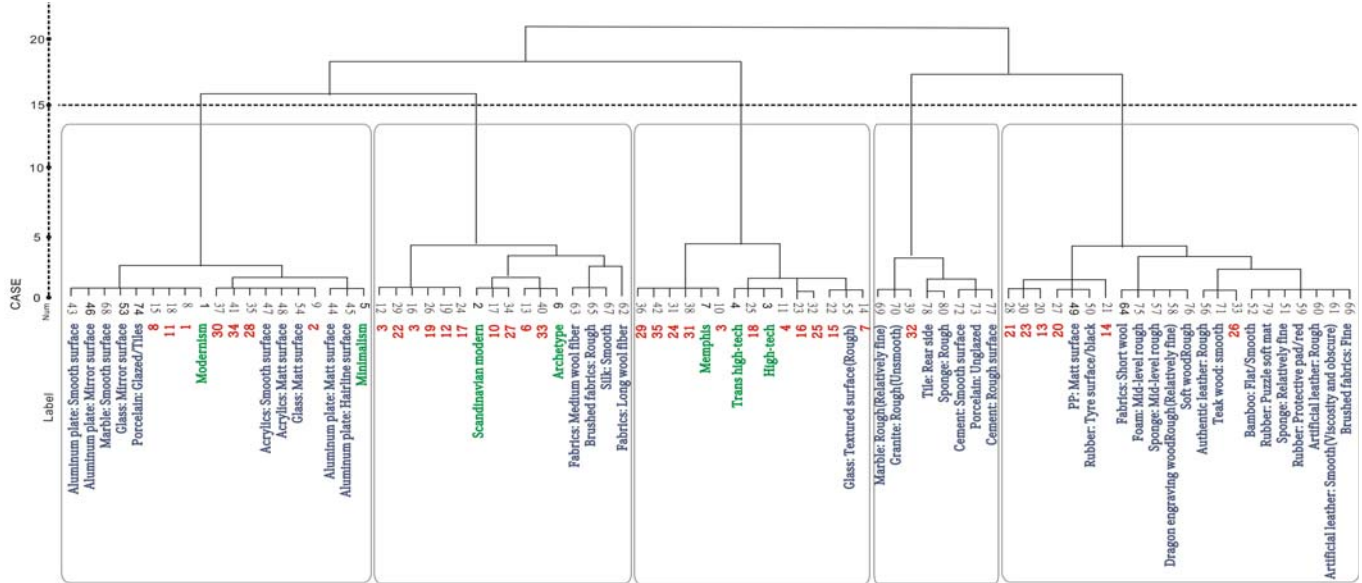


Figure 3 Hierarchical clustering tree of (Blue stands for material, red for number of product picture, while green for style name)

- 1) The composition elements of cluster 1 mainly include the styles of Modernism and Minimalism; product picture samples of 1, 2, 8, 11, 28, 30 and 34; material samples of Aluminum plate-Smooth surface, Aluminum plate-Mirror surface, Aluminum plate-Matt surface, Aluminum plate-Hairline surface, Marble-Smooth surface, Glass- Smooth surface, Glass-Matt surface, Porcelain-Glazed, Acrylics-Smooth surface and Acrylics-Matt surface, among which product 1 and 34 under the archetype style and product 8 and 28 under the high-tech style are classified into this cluster. Summarize the product stimulus of this cluster. It is with simple shape, fine and smooth surface. The material samples reflect obvious hard, cold, bright and smooth features on touch. The image evaluation scores of stimulus show the images of this cluster are mainly hard, cold, smooth, pure, simple and chill. Therefore, this cluster could be named 『**simple and fine style**』.
- 2) The composition elements of cluster 2 mainly include the styles of Scandinavian modern and Archetype; product picture samples of 5, 6, 9, 10, 12, 17, 19, 22, 27 and 33; material samples of Fabrics-Medium wool fiber, Fabrics-Long wool fiber, Brushed fabrics-Rough and Silk-Smooth, among which the product 5 under high-tech style, product 6 under modernism style, and product 27 under minimalism style are classified into this cluster. The product stimuli under this cluster are mainly with flexible (curved) surface, mellow and simple shape with few furnishings. Its surface may not have bright gloss, but looks soft, plain and intimate. The material samples under this cluster are mainly fabrics, which present soft and warm features. It's found from the image evaluation scores of the stimuli that the images of this cluster are mainly flexible (changing), harmonious, fine, warm, soft, plain, assured and intimate. Therefore, this cluster could be named 『**plain and elegant style**』.
- 3) The composition elements of cluster 3 mainly include the styles of Memphis, High-tech, Trans high-tech; product picture samples of 3, 4, 7, 15, 16, 18, 24, 25, 29, 31 and 35; material samples of Glass-Textured

surface(Rough). It classifies the high-tech and trans high-tech under the same category, which are two opposite design styles in the design history. The possible reason is that half of the respondents in this experiment don't have design background, so they show deviation on the interpretation and understanding to the connotation of these two design styles. Product 15 under the archetype style and product 31 under the minimalism style are classified into this cluster. Further reviewing this cluster, we could find the product stimuli are with unique and irregular shape, rich and bold colors, as well as extraordinary appearance. The material of this cluster uses the glass with textured surface, which has ups and downs on the surface. It indicates this cluster has various shapes and unique features. It's found from the image evaluation scores of the stimuli that the images of this cluster are mainly fabulous and bold. Therefore, this cluster could be named 『**complex and decorative style**』.

- 4) The composition elements of cluster 4 don't involve any style concept; but include the product picture sample of 32; material samples of Marble: Rough (Relatively fine), Granite: Rough(Unsmooth), Sponge: Rough(Emery cloth), Cement-Smooth surface, Cement-Rough surface, Porcelain-Unglazed. This cluster doesn't involve any product design style listed in the study, but include the products under trans high-tech, which have the images of cold, hard, risky and mixed. The material stimulus under this cluster is unsmooth, with obvious ups and downs, mixed surface and rough appearance. It's found from the image evaluation scores of the stimuli that the images of this cluster are mainly hard, rough and risky. Therefore, this cluster could be named 『**rough and mixed style**』.
- 5) The composition elements of cluster 5 don't involve any style concept; but include the product picture sample of 13, 14, 20, 21, 23 and 26; material samples of PP-Matt surface, Rubber-Tyre surface/black, Rubber-Protective pad/red, Rubber(Puzzle mat)- Rough and mid-level elasticity, Sponge-Mid-level rough, Foam-Mid-level rough, Artificial leather-rough, Artificial leather-Smooth, Artificial leather-Smooth(Viscosity and obscure), Authentic leather-Rough, Fabrics-Short wool, Brushed fabrics-Fine, Teak wood-smooth, Dragon engraving wood-Rough(Relatively fine), Soft wood-Rough, Bamboo-Flat/Smooth. The products in this cluster include the product 20, 23 and 26 under modernism style, product 14 and 21 under high-tech style, and product 13 under minimalism style, which have the images of cold, hard, simple, fine, pure and chill. What is interesting, the shape composition of this cluster may not be too complex or simple. Instead, it has obvious structure and multiple materials (using two kinds of material). There are diverse materials under this cluster, including plastics, silicone rubber, leather, fabrics and wood, which are elastic and soft. Their surface could be smooth or rough with some particles. It doesn't feel too rough, but warm. Although it contains wood and bamboo, it feels soft and elastic on the whole. This cluster covers the wood, fabrics and leathers which have the most significant natural image. Therefore, this cluster could be named 『**facile and natural style**』.

Finally, through above hierarchical classification, it could be found that the tactile product styles could be converged into five categories. The following seven product design styles are classified into three categories, namely, Modernism and Minimalism in the same category; Scandinavian modern and Archetype in the same category; Memphis, Trans high-tech and High-tech in the same category. It indicates the 7 design styles obtained from the interview seem not to cover all types of product and material. Similarly, there may be some lags between the styles and the corresponding representative products.

4. Conclusions

Through a series of interview, this study firstly sorts out 7 most common and typical design styles, which could be taken as the reference for tactile product design style. Moreover, it works out 21 adjective pairs of perception and image for these 7 styles, and the stimulus samples for SD evaluation (35 representative samples for each style and 37 pieces of tactile evaluation material). Next it conducts SD evaluation experiment through concepts, product pictures and touch samples. After data evaluation, factor analysis and result comparison, it's found that these three stimuli are different in terms of the number of factors and composition of factors. Moreover, the connotation of the perception and image adjectives varies in different sensory experiences. Therefore, it must be careful and cautious in selecting the image vocabularies for the image evaluation of product design style in the future. For the overall factor analysis, the images of product design style could be divided into four factors. Their compositions are similar to that of the factors under sense of touch, indicating the tactile perception has great influence on the style summarization. Based on the scores of the four factors, it sorts 5 tactile product design styles by using hierarchical clustering analysis, including simple and fine style, plain and elegant style, complex and decorative style, rough and mixed style, and facile and natural style. However, the product design styles are not enough to cover all stimulus samples, and membership of the representative products and the corresponding styles may have some lags. Based on the results sorted in this study, it could further analyze the correlation between the style and stimulus in the future, so as to learn the correlation between the physical feature of the material and the perception. Moreover, it could construct the complete structure of tactile style by means of Kansei engineering. The results of this study could serve as the reference for the researchers in the academic survey and study related to tactile styles. For the design application, it could provide reference for the designers in selecting material to create styles for the product design.

5. References and Citations

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