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THE MECHANISMS OF PRODUCT FORM CLASSIFICATION

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ABSTRACT

The purpose of this study is to explore the users' process mental models of classification task. Hierarchical grouping and image tests are conducted to analyze the way they classify the real product samples of mobile phones. From the database of similarity and image tests, cluster analyses were used to analyze the distribution of total images and form features (the form treatments) in the tree diagram of product form classification. The result indicated that local features are the dominant mechanism. Moreover, the verbal descriptions of hierarchical grouping task demonstrated that in the process of product form classification, subjects first employ local features and later total images step by step in the classification procedure. The mental models the users employ in processing product form classification confirm the cognitive models preliminarily proposed by other scholars. At the early stages, product form classification is mainly dominated by the bottom up process (local features), and at later stages, the top-down process (total image) will gradually take over the dominance position. These two processing models interact with each other during the whole classification procedure.

Keywords: product form classification, similarity, top-down processing, bottom-up processing

1. INTRODUCTION

The ability to recognize and distinguish objects is important to human beings and allsorts of creatures. In a complicated information environment, we should be able to deal with all kinds of information. In such an information processing route, particularly in encountering a mixture of complex messages, people tend to categorize the messages and group the highly similar ones into the same group. In the competitive market, there are all kinds of similar products. It is a big challenge for designers to work out a prominent product that has outstanding styles to catch the consumer's eyes. Therefore, it is necessary that designers have an in-depth understanding about the visual interaction between consumers and product form so as to work out successful products that can catch consumer's eyes.

In terms of product image perception, the design elements of product form play a key role in the user's perceptions. Because the product image is composed of all design elements, different product images may indicate different forms and furthermore correspond to different patterns of design elements. Whether designers can endow specific form treatments in the product form so as to evoke the intended emotional responses in consumers, i.e., to transmit specific meanings, is an important issue in product aesthetics in recent years. In this study, emphasis is placed upon the underlying factors that dominate the classification of product form. Real mobile phone samples are used in the experiment for hierarchical grouping and image perception evaluation. Distribution patterns of images and form treatments are analyzed to explore the mechanisms subjects use in looking at product form and further categorize them into subgroups. The exploration of the mental model users apply in product from classification can help clarify the roles total image and local features play in human being's visual perception, which can further offer a hint to designers in new product design and development. The creative manipulation of specific image and form features will add emergent attraction to new product form. This not only reduces the risk in new product design and development but also helps guarantee that the new product draws user's attention in the market.

2. LITERATURE REVIEW

Human being's classification procedure of product form is closely related to object recognition, belonging to the recollection of sensational experience in psychological process. Particularly, it is directly related to the image association generated in visual processing. Recognizing the outer form of various objects in the world is an important innate ability of human beings. Through recognition procedure, people can categorize objects according to their similarity. There are many models for object recognition, including gestalt, template matching, feature analysis, and prototype recognition (Anderson, 1990).

From the analysis of object recognition theories, two modes dominate the object recognition procedure. One is mainly influenced by the Gestalt psychology: people recognize objects by the total images. Such a recognition manner is mainly affected by the overall features, i.e., whether objects are consistent in global attributes. In the other way, the recognition of the total image is created by the analysis of the local features. When people perceive images of objects, they will manipulate a sort of visual search, trying to match them with the existing schemas and interpreting the underlying meaning. For object recognition, Biederman (1987) proposed a recognition by components (RBC) theory. In this theory, the image of an object is decomposed to the arrangement of fundamental geometric geons, units defined by five properties of objects: curvature, linearity, symmetry, parallelism, and high point. Furthermore, he pinpointed that if the observer can identify two or three geometric geons in an object, he or she can still rapidly recognize the object even if it is rotated or displayed in different perspective views.

Similar to the global and local feature recognition, Wickens (1992) points out two procedures in terms of information processing: (1) Top-down or conceptually-driven processing where the preliminarily set expectations or labeling will help people interpret the incomplete sensational input. For product form, such a visual cognition starts from the recognition of global images. (2) Bottom-up or data-driven processing in which the information manipulation starts from the lower to higher layers progressively. Differently put, it starts from the recognition of local features of product form.

As far as the classification or grouping of product form is concerned, Espe (1992) performed an image classification study on the symbolic quality of 50 representative watches. Frequencies of two samples assigned to the same group were collected for the index of similarity. Through MDS, three judgment dimensions; namely, material and social representation, functional and logical representation, and aesthetic representation were identified for the image perception. Moreover, Maurer et al. (1992) conducted a study on the form of street furniture and explored the dimensions upon which the subject's judgment was based. Hsu, Hsia, and Wu (1997, 1998) made studies on categorization of 36 work pieces by group technology and demonstrated that conceptual designers conduct their thinking from total views to local features and that work pieces whose local features are similar may not similar to each other in global features. Hsu et. al., (2005) asked 30 subjects to classify 32 3-dimensional prismatic images. Through MDS and cluster analyses, they found that such a classification process was strongly related to the prism's compound features and that each feature had a different effect on the categorization process.

These results provide the analytic support for designers and product managers. Literature mentioned above indicates that most studies of classification or grouping focus on fundamental work pieces, texture, and abstract composition, little literature has been found on the mechanisms of real product form classification. Therefore, in this study, real mobile phone samples are used as the experimental materials for hierarchical

grouping task and image perceptual evaluation experiment to explore the underlying factors of the implicit cognitive behavior.

3. METHOD

In this study, the author adopted a hierarchical grouping task in which subjects were asked to divide a group of samples into two subgroups at one time and speak out how they categorize the samples in a group. Such a think aloud classification task provided the real world data and a similarity matrix for further analyses. Moreover, to understand how the subjects perceive the total image styles of mobile phones, a semantic differential experiment was undertaken to compare and contrast the effects local and total features have on the product form classification task.

3.1 THINK ALOUD CLASSIFICATION TASK

Subjects: 30 college and graduate students with design backgrounds.
Materials: 32 real mobile phone samples (Figure 1) chosen from a collection of 120 samples. All of them were straight type so that the subjects did not need to fold or open the cover.

Figure 1: 32 mobile phone samples used in SD experiment

Questionnaire survey: A tree-diagram-shaped table is used to take down the sample numbers and criteria for classification for each subject.
Procedures:
(1) Each subject had a short glance of the mobile phone samples.
(2) The subjects were asked to separate 32 samples into two groups step by step, corresponding respectively to their first impressions. Meanwhile, they were asked to speak out the criteria for the grouping task.
(3) In a later step, they were asked to split each group into two more subdivisions, and then split each of the four groups into two groups, leading to a total up to 16 groups.

(4) When there is only one sample left in a subdivision, the grouping procedure stops for the subdivision. During the grouping process, all verbal descriptions of the criterion were recorded. The verbal descriptions and group members for each subject were gathered, from which factors frequently used for product form classification and the similarity matrix for the 32 mobile phone samples were further synthesized and calculated.

3.2 THE SEMANTIC DIFFERENTIAL EXPERIMENT

Subjects: The same as those of think aloud hierarchical grouping task.
Materials: 32 real mobile phone samples (Figure 1).
Image words: Twelve pairs of representative image words (in Chinese, the same as those in Chuang et. al. (2001)) each of which is defined by a bipolar pair of descriptive adjectives (Table 1).

Table 1: 12 image word pairs used in semantic differential experiment

traditional – modern	heavy – handy	hard – soft	nostalgic – avant-garde
large – compact	masculine – feminine	obedient – rebellious	hand-made – hi-tech
rough – delicate	plagiaristic– creative	rational – emotional	idle - vigorous

Semantic scale: A 7-pointed Likert's scale along which a score of 7 means that the subject has a very strong image impression of the mobile phone sample, while 1 for the least image impression.
Procedure: The 32 real mobile phone samples are put along two piles of drawing tables in a big conference room. After a short glance of the real mobile phone samples, each subject is asked to evaluate 32 mobile phones according to the image word pair. The evaluation is conducted individually or in a small group and each subject is allowed to proceed at his or her own pace.

4. RESULTS AND ANALYSIS

Cluster analysis was used to extract the subject's mental structure of real mobile phone samples to explore the relationships between classification results and the distributional structure of product form feature space. Data obtained from the hierarchical grouping and semantic differential experiments were analyzed.

4.1 CLASSIFICATION MODELS FROM THINKING ALOUD

Criteria subjects used to classify 32 mobile phone samples were taken down to clarify the subject's mental model in product form classification and the roles different mechanisms play in the classification procedure. After integrating similar verbal descriptions, it was found that subjects varied in such a mental task. Some

subjects adopted a bottom-up approach, namely, classification by local features while others adopted a top-down approach, the total image styles for product form classification. Still others might adopt both approaches for the product form classification task. The frequency of these features was counted and expressed in brackets.

According to the frequency of criteria for product form classification, mechanisms local features are the dominant factors (79%) at first stage; total images only occupy 21% at this stage. The local features that dominate the first stage classification task include sharp or rounded edges, rectangular or curvatured contours, types of screen size, colors, digital buttons, layout and grouping of digital buttons, antenna, etc. In terms of prevailing total images at first stage, soft or hard, feminine or masculine, curvatured or not, simple or complex are the major categories (Table 2).

Table 2: Criteria for product form classification at first stage

Bottom-up approach (local features) (79%)	Top-down approach (total images) (21%)
1. sharp or rounded edges (5)	1. soft or hard (3)
2. rectangular or curvatured contours (4)	2. feminine or masculine (2)
3. streamlined or straight lines (3)	3. curvatured or not (1)
4. types of vertical sidelines (2)	4. simple or complex (1)
5. screen size (2)	
6. silver, white, mixed, or other colors (2)	
7. color or black-and-white displays (2)	
8. with or without antenna (2)	
9. types of digital buttons (2)	
10. layout of digital buttons (1)	
11. grouping of digital buttons (1)	

The subject's classification approaches and percentage of global and local features at second stage are similar to those at first stage with only 20％ for total images and 80% for local features. For total images, subjects tend to use masculine or feminine, soft or hard, traditional or modern, compact or heavy, harmonic and unity for classification of mobile phone product form at this stage. Dorminant local features contain shape of function keys, sharp or rounded edges, shapes and density of the arrangement of digital buttons, screen size, and display colors. At this stage, local features, special form treatments of product design elements such as function keys and digital buttons control the classification procedure (Table3).

At third stage, the percentage of total images is on the rise (29％) even though local features are still the dominant factors for product form classification (71％). At this stage, total images diversify, most of which cover traditional or modern, ordinary or special, soft or hard, and harmonic images. More images can be found to classify mobile phone samples at this stage, some of which are quality and high class, interesting or boring, fashionable or old, plain or luxurious, sporty and entertaining, slender or chubby, and robust images. In addition to various local features used as criteria for product form classification at earlier stages,

more details of design elements such as the receiver, texture, and finish design are added at third stage (Table 4).

Table 3: Criteria for product form classification at second stage

Bottom-up approach (local features) (80%)	Top-down approach (total images) (20%)
1. shape of function keys (10)	1. soft or hard (4)
2. sharp or rounded edges (9)	2. masculine or feminine (3)
3. shape of digital buttons (7)	3. traditional or modern (2)
4. screen size (4)	4. compact or heavy (1)
5. separated or integrated function keys (4)	5. harmonic or not harmonic (1)
6. color or black-and-white displays (4)	6. unity of the digital button and overall product form (1)
7. organic or geometric digital buttons (3)	
8. shape of display (2)	
9. sparse or dense digital buttons (2)	
10. grouping of digital buttons (2)	
11. regular or irregular digital buttons (1)	

Table 4: Criteria for product form classification at third stage

Bottom-up approach (local features) (71%)	Top-down approach (total images) (29%)
1. types of digital buttons (12)	1. traditional or modern (4)
2. separated or integrated function keys (12)	2. looks cool or ordinary (4)
3. types of function keys (8)	3. simple or complicated (4)
4. rectangular or curvatured contours (6)	4. with or without design quality (3)
5. texture variety (6)	5. interesting or boring (3)
6. screen size(5)	6. masculine or feminine (2)
7. screen shape (4)	7. looks high class or not (2)
8. quality of texture (4)	8. fashionable or old style (2)
9. arrangement of digital buttons (4)	9. plain or luxurious (2)
10. body colors (3)	10. looks cute or not (2)
11. shape of receiver (3)	11. sporty or entertaining (2)
12. curvature of the upper edge (3)	12. slender or chubby (2)
13. with or without antenna (2)	13. individual or general (1)
14. color or black-and-white displays (2)	14. thick and robust (1)
15. similarity of the interface (2)	15. harmonic or not (1)
16. rectangular or rounded display (2)	
17. regular or irregular digital buttons (2)	
18. traditional or rebellious digital buttons (2)	
19. size of digital buttons (2)	
20. simple or complex digital button layout (1)	

A dramatic change occurs at fourth stage in terms of proportions of two classification approaches. Different from earlier stages, mechanisms of total images increase to 44%, while those of local features decrease to 56%. An evident relative dominance of the local features is not so obvious. Instead, total images play an increasingly important role that influences the subject's classification task. Minor details of local features such as layout lines, mark position, transparency of materials, and interface layout will be added at this stage. The variety of total images at fourth stage is larger than that of local features. More functional images such as handy or heavy, enduring or robust, and idle or vigorous as well as more symbolic images such as

fitting a gentleman or hippie, organic or geometric, man-made or hi-tech can be seen at the final stage of product form classification procedure (Table 5).

Table 5: Criteria for product form classification at fourth stage

Bottom-up approach (local features) (56%)	Top-down approach (total images) (44%)
1. types of digital buttons (14)	1. total images (9)
2. types of display (14)	2. simple or complex (8)
3. types of function keys (11)	3. soft or hard (8)
4. shape of the receiver (10)	4. conservative or modern (7)
5. with or without antenna (9)	5. feminine or masculine (7)
6. separated or integrated function keys (8)	6. ordinary or attractive (6)
7. colors (6)	7. looks cute or not (5)
8. texture design (6)	8. fitting a gentleman or hippie (4)
9. product finish (5)	9. individual or general (4)
10. sharp or curvatured edges (5)	10. handy or heavy (4)
11. types of local lines (4)	11. common or specific (4)
12. positions of the mark (4)	12. organic or geometric (3)
13. ratio of length to width of the display screen (4)	13. enduring and robust (3)
14. size of screen (4)	14. man-made or hi-tech (3)
15. layout of digital buttons (3)	15. looks idle or vigorous (3)
16. transparency of the upper body (2)	16. unity of the total form and receiver (2)
17. layout of the interface (1)	17. unity of the total form and digital buttons (2)
	18. orderly or complicated (2)
	19. slender or chubby (2)
	20. layout of the total form (1)

Generally speaking, it is evident that both local and global features will affect the product form classification task. Particularly, local features such as the form treatments of some important design elements play a more important role than the total images. However, the obvious relative difference between these two approaches will decrease at later stages.

4.2 CLASSIFICATION BY SIMILARITY FROM HIERARCHICAL GROUPING EXPERIMENT

To further analyze how subjects classify mobile phone samples, a 32 by 32 matrix was used to record the similarity between members of every possible pair of mobile phone samples as sorted in the hierarchical grouping task. The similarity between any two samples was specified at the range of [0, 1], generating a similarity symmetrical data matrix of the 32 mobile phone samples. With the 32 samples as evaluation targets, the similarity matrix was analyzed by cluster analysis in SPSS. The final dendrogram for clustering the 32 mobile phone samples are shown in Figure 2, in which six groups are generated.

In a reverse order of the hierarchical grouping task, the dendrogram obtained from cluster analysis starts from two samples that are most similar to each other and step by step, form a larger cluster when new members are added. Table 6 shows the agglomeration schedule for Group A. In this group, mobile phone Samples M2 and M8 are very close to each other, so they are combined to form a cluster at Stage 1. Later in

Stage 3, Sample M14 joins the cluster to create another cluster because it is similar to Sample M2. Then, at Stage 4, a new member, Sample M21 joins the cluster to make a larger cluster. In a similar way, Samples M22, M27, and M24 are combined to create a cluster from Stages 2 and 5. At last, these two clusters are merged to form Group A. The way how these samples are classified depends on the similarity, or the heterogeneousness among members in the group.

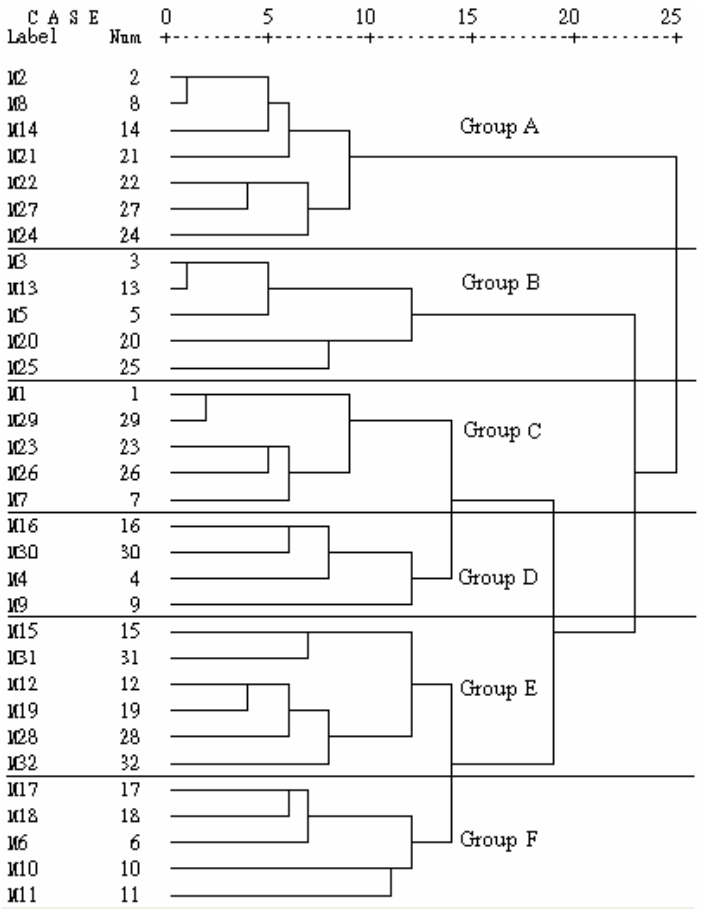

Figure 2: The dendrogram for clustering the 32 mobile phone samples

Table 6: The agglomeration schedule for members in Group A

	Cluster combined		Coefficients	Stage cluster first appears		Next stage
Stage	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	M2	M8	0.143	0	0	3
2	M22	M27	0.553	0	0	5
3	M2	M14	0.726	1	0	4
4	M2	M21	0.831	3	0	6
5	M22	M24	0.941	2	0	6
6	M2	M22	1.184	4	5	0

4.3 CLASSIFICATION BY LOCAL FEATURES

In this study, morphological analysis was used to decode the form treatment of mobile phone samples with an aim at extracting local features for cluster analysis. Based upon the morphological analysis of mobile phone proposed by Chuang et. al., (2001) and the design elements mentioned in the hierarchical grouping task, seven design elements were identified: body, receiver, digital button, display, function key, color, and power switch location, each of which was then divided into three to six levels, i.e., three to six different form treatments, as shown in Table 7.

Table 7: Design elements and morphological patterns of mobile phone samples

A: Body	a1: Sharp a2: Geometric a3: Streamlined a4: Big curvatured
B: Receiver	b1:Hole series b2: Grid-shaped b3: Solid area
C: Digital button	c1: Rectangular c2: Elliptical c3: Capsular c4: Organic
D: Display	d1: Separated d2: Integrated with function keys d3: With frame d4:Mixed
E: Function key	e1: Joy stick e2: Slide button e3: Button type
F: Color	f 1: Light gray f2: Dark gray f3:Black f4:White f5:Blue f6:Red
G: Power switch location	g1:Stand along to the left g2:Stand alone to the right g3:Integral to the left g4:Integral to the right g5: Other types

From the tree diagram of cluster analysis, each cluster of mobile phones has its common form features. Take Group A for instance, samples in this group are of the same form features in terms of function key (e3), which is the dominant factor for the sample grouping of Group A (see Figure 3). In the first agglomeration, Samples M2 and M8 are extremely close to each other, streamlined body (a3), hole series receiver (b1), organic digital buttons (c4), button type function key (e3), except for display, color and power switch location patterns. At second agglomeration stage, Samples M22 and M28 have five common features, streamlined body (a3), hole series receiver (b1), organic digital buttons (c4), button type function key (e3), and stand alone to the right power switch (g2). At third agglomeration stage, Samples M2, M8, M14 have two common features, streamlined body (a3) and button type function key (e3). Then, M21 joins M2, M8, M14 to form a bigger cluster. They are in common in button type function key (e3). Next, M24 joins M22 and M27 to form a cluster with streamlined body (a3), organic digital button (c4), button type function key (e3), and stand along to the right power switch (g2) as their common features. Finally, these samples are combined to form Group A. It is clear that common features vary with different agglomeration stages. It is the button type function key (e3) that controls the grouping of these seven mobile phone samples, indicating that this form feature plays the most important role in Group A. The compound form feature streamlined body and button type function key (a3e3) also affects the grouping task and so does the compound form feature streamlined body, hole series receiver, organic digital buttons, and button type function key (a3e3b1c4e3).

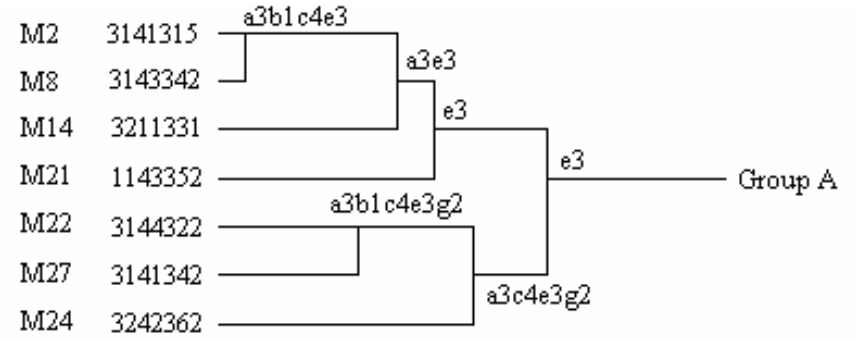

Figure 3: The local form features that dominate the classification of Group A

In the classification procedure of Group B, framed display (d3) is the most important dominant features. The feature grid-shaped receiver (b2) controls the classification task of Group C; organic digital buttons with button type function keys (c4e3) dominate the grouping of Group D; big curvatured body (a4), and capsular digital buttons and separated display (c3d1) dictate the clustering of Group E. No evident form features are found to control the categorization of Group F.

Generally speaking, subjects first classify mobile phone samples according to the most salient form features, or the combination of form features, and then make a more detailed classification according to the second salient form feature. The consistency of the combination of form features in the subjects' classification process is evident. The analysis of the distributions of the features on different stages of six groups reflects the effects of compound form features. This means that in making their decision on classification task, subjects will attend to features as compounded rather than attending to them individually (Hsu et. al., 2005).

4.4 CLASSIFICATION BY TOTAL IMAGES

To explore whether total images affect the product form classification, an ANOVA with Duncan MRT Post hoc is performed to examine whether there exists significant differences among samples in the same group. The number of image words where no significant difference is found among the samples is used as index for the mechanism of total images in product form classification process.

The distribution pattern of common images of mobile phone samples in Group A is shown in Table 8. The clustering of seven samples in Group A is composed of six agglomeration steps. At agglomeration stage 1, Samples M2 and M8 are assigned to the same cluster because of the extremely high homogeneity. They are similar, not significantly different to each other, along all twelve images of mobile phone design. At stage 2, M22 and M27 are combined to form a cluster with soft, compact, delicate, and emotional their common images. Later at stage 3, M2, M8, and M14 are assigned to the same cluster because of there are common in eight total images: handy, futuristic, compact, rebellious, hi-tech, delicate, creative, and vigorous, indicating that they are of high homogeneity. Added with M21, these three samples form a cluster at stage 4. Now

they are common only in two images: futuristic and hi-tech. Then at stage 5, M24 is added to M22 and M27 to form another cluster. They are of low homogeneity, and are common in compact, delicate, emotional images only. At the final stage, seven mobile phone samples are arranged to form Group A.

Table 8: The distribution of common images of mobile phone samples in Group A.

Stage 6	 M2 M8 M14 M21 M22 M27 M24 No common images	
Stage 4	 M2 M8 M14 M21 futuristic, hi-tech	Stage 5  M22 M27 M24 compact, delicate, emotional
Stage 3	 M2 M8 M14 M21 handy, futuristic, compact, rebellious, hi-tech, delicate, creative, vigorous;	Stage 2  M22 M27 M24 soft, compact, delicate, emotional
Stage 1	 M2 M8 M14 modern, handy, soft, futuristic, compact, feminine, rebellious, hi-tech, delicate, creative, emotional, vigorous	 M22 M27

From the agglomeration schedule, it is clear that, on one hand, the clustering of Samples M22, M27 and M24 are mainly dominated by compact, delicate, and emotional images. Furthermore, the soft image plays a key role in dividing these three samples into two clusters, M22 and M27 a cluster and M24 another. On the other, Samples M2, M8, M14, and M21 are mainly affected by futuristic and hi-tech images. Then six total images, including handy, futuristic, compact, rebellious, hi-tech, delicate, creative, and vigorous, cause M21 to be separated from M2, M8, and M14. At last, because of modern, soft, feminine, and emotional images, M14 is separated from M2 and M8.

Similar patterns of common images can be found in the other groups of mobile phone samples. Dominant images for Group B are futuristic, compact, and vigorous. For Group C, the images of compact, hi-tech, and delicate control the classification procedure. Groups D and E are very similar to each other; soft and feminine images are common in Group D while soft, feminine, emotional images are widespread in the members of Group E. At last, the mobile phone samples in Group F are generally of emotional and vigorous images. There exist clear rules among the total image distribution and product form classification in mobile phone groups.

4.5 GENERAL DISCUSSIONS

Overall, mechanisms from global and local features do influence the subjects' product form classification in different ways. At earlier stages, local features such as the edges and corners, receiver, digital buttons, display, and color dominate the classification process. Meanwhile, the total images influence subjects' classification task in a less remarkable manner. However, after third stage, the proportion of influence on classification processing of global features increases though local features are still the dominant factors. At fourth stage, because there are not so many samples in the same group and because samples in the same group are close to each other in terms of detailed features, total images play a more important role in product form classification. In some cases, two approaches will be adopted simultaneously.

When there are many products to be classified, local features will have a higher priority than global images for the subjects' mental manipulation. With the processing keeping going on, the impact coming from total images become more evident. Figure 4 illustrates the distribution patterns of local features and total images at different stages of product form classification.

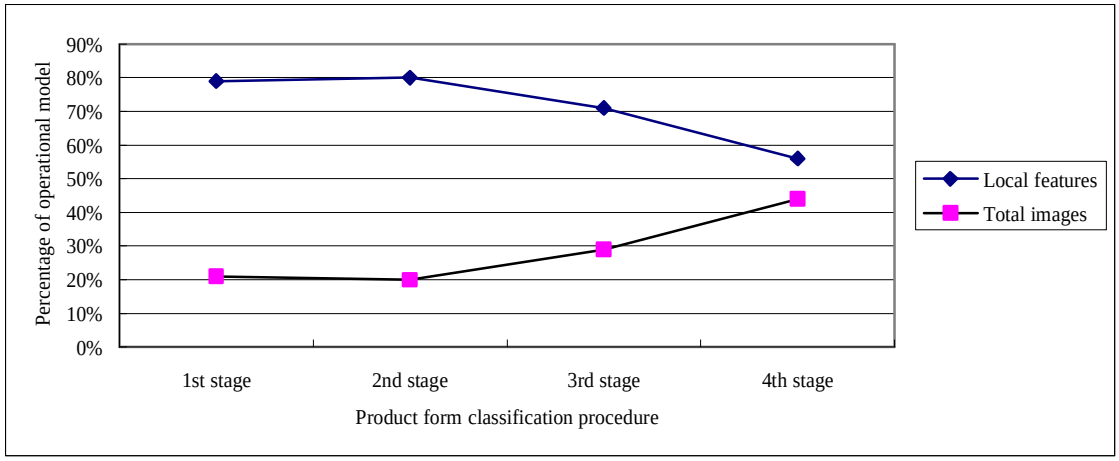

Figure 4: Distribution patterns of percentage of local features and total images at different stages

Furthermore, some form features or images more frequently adopted by subjects play more important roles in product form classification. For example, at the earlier two stages, the local features of the edge and corner play the most important role while the type of digital buttons are more dominant at the two latter stages of product form classification.

5. CONCLUSIONS

The results indicated that both bottom-up and top-down approaches will be used by subjects in the classification of a series of same products. Particularly, the local features play a relatively more important role than the total images. Moreover, the think aloud experiment demonstrated that in the process of product form classification, subjects would first employ local features and later total images step by step in the hierarchical grouping task. The overlapping phenomena happen in the classification based on image perceptions and similarity data. The mental models the users employ in processing product form classification confirm the cognitive models preliminarily proposed by other scholars. At the early stages of product form classification, it is mainly dominated by the bottom up process (local features), and at latter stages, the top-down process (total image) will gradually take over the dominance position. These two processing models interact with each other during the whole classification procedure.

The classification based upon the real product samples in clustering schedule and distribution can help us explore the effects of varying form features. Such a similarity-based product form database will benefit designers in their product form analysis task. Though real mobile phone samples are used in this study, it is hard to bring total images and loca features under control. Therefore, a careful manipulation of these two kinds of mechanisms for product form classification, particularly the dominant features and image styles, should be further investigated.

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REFERENCES

Anderson, J.R., (1990). Cognitive Psychology and Its Implications, 3rd Edition, W.H. Freeman and Company, New York, NY

Biederman, I. (1987). Recognition-by-Components: A Theory of Human Image Understanding, Psychological Review, Vol. 94, No. 2, 115-147

Chuang, Ming C., Chang, Chien C., and Hsu, Shang H. (2001). Perceptual factors underlying user's preferences toward product form of mobile phones, International Journal of Industrial Ergonomics, 27, 247-258

Espe H., (1991). "Symbolic Qualities of Watches," Object ad Images-Studies in design and advertising, 124-131

Hsu, Shang H., Chang, Wuefay, and Chuang, Ming-Chuen, 2005, Effects of geometric form features on three-dimensional object categorization, Perceptual and Motor Skills, 100, 899-912

Hsu, S.H., Hsia, T.C. and Wu, M.C. (1997). A flexible classification method for evaluating the utility of automated workpiece classification system, International Journal of Advanced Manufacturing Technology, Vol. 13, pp. 637-648

Hsu, S.H., Hsia, T.C. and Wu, M.C. (1998). An efficient method for creating benchmark classification for automatic workpiece classification systems, International Journal of Advanced Manufacturing Technology, Vol. 14, pp. 481-494

Maurer, C., Overbeke C.J., & Smets, G., (1991). "The Semantics of Street Furniture," Object and Images-Studies in design and advertising, 86-93

Wickens, C.D., (1992). Engineering Psychology and Human Performance, Second Edition, Harper Collins Publishers, 179-180