Style Recognition And Description

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(Date Received : September 20,1997 ; Date Accepted : November 18,1997)

Abstract

This paper covers two parts. The first part speculates some supporting theories for formal style recognition by reviewing some well-established form recognition theories. The second part describes in detail a framework for both analyzing existing formal styles and prescribing expected formal styles for target markets.

The framework, also named "Style Profile", consists of a set of polar adjectives associated with three corresponding sets of estimated values. Within the profile, the stylistic attributes defined by the set of polar adjectives comprise six categories: form elements, joining relationships, detail treatments, materials, color treatments and textures. The first set of estimated values describes a given formal style while the rest serving as weighting mechanisms, an importance index and a confidence factor, fine-tuning the description. The "Style Profile" can be used not only to communicate formal styles between designers and computers but also to accumulate formal style knowledge.

Keywords: Formal Style Recognition, Form Language, Formal Style, Computer- Supported Form Design

I. Introduction

Times are changing. The concept of "mass production" is being replaced by "custom design". The introduction of new product development technologies such as concurrent engineering, fast prototyping and flexible manufacturing not only can shorten time to market dramatically, but also make "custom design" more feasible. Nevertheless, the creation of form – a key aspect of "custom design" – is still a manual art and, now, a bottleneck in the product development process. To bring "custom design" to its full potential, a computer understandable language for describing formal styles is just as necessary as other CAD tools now used routinely in the product development process.

In an article entitled: "The Key is Concept", Owen [1] predicts that rule systems for the creation of individualized products from generalized models will be the focus of attention for many products. The "individualized" design Owen seeks is not only at the functional level but also at the level of style. In the same way that a wide variety of expert systems, or rule systems, have been developed and utilized quite successfully in many other fields, [2] research into systems capable of communicating style knowledge ought to be encouraged.

This paper first discusses some form recognition theories that may also support formal style recognition, and then proposes a "Formal Style Description Framework" (FSDF) for describing formal styles. The framework is devised to equip designers with both the ability to analyze existing formal styles and the ability to describe expected formal styles for target markets.

II. Formal Styles Recognition

Formal style is a key factor differentiating consumer markets. According to Jay Doblin, [3] some high level discriminators (such as: Gropius, Moholy-Nagy, Mies van der Rohe, Eames, Vignelli, Chermayeff, Rand, Nizzoli, Bill, Rames, etc.) have the ability to both recognize styles and think in systems. But, how exactly people (including the above figures) perceive a so-called "X style" was not much explained. However, some theories established in other fields, such as: Gestalt Psychology and cognitive psychology, in explaining the way people recognize shapes may have pointed to a relatively promising direction for this purpose. [4]

Being able to recognize shapes or patterns is one of human's most basic instincts. Through recognition, man can differentiate things and/or objects and make further categorization and remembrance possible. Such kind of recognition ability is believed to be both sophisticated and constant; which means that things and/or objects can still be recognized without problem even when their physical appearances vary dramatically. Hence, it is believed that all formal styles consisted of particular set of stylistic characteristics can still be recognized under different physical structures. Some of the related theories are reviewed and analogized in parallel as below.

2.1 Gestalt gesetz

Early Gestalt Psychologists have summarized several human perceptional phenomena according to the way people recognize shapes. These are: Proximity, Similarity, Continuation, Closure, Simplicity, Symmetry, and Common Fate. [5] Since formal styles cannot be perceived without visible images, and shapes are the very basic elements of all sorts of images; therefore, some discoveries made in Gestalt Psychology might have a meaningful parallel association in explaining the way people recognize formal styles.

2.2 Template-matching theory

People learn and experience formal styles in all sorts. Following the lines of the template-matching theory of cognitive psychology, we may as well consider that each time a new style comes to a person's mind forms a template; therefore, we have a lots of such templates in our memory. The whole process can be comprehended as follows: a formal style is identified first; and then, it is recognized as a new kind and stored as a template in a person's memory if it doesn't match with any of the templates saved already in his memory; otherwise, it'll be recognized as the style of the template it matches and associated to it. Although, it may seem not so practical for people to remember all the formal styles template-by-template, but, obviously it does offer a schematic framework -- templates -- for people to save information about formal styles with a unique set of stylistic characteristics.

2.3 Prototype theory

Our visual experiences also indicate that some forms do share same set of visual characteristics among each other. People tend to recognize them as a unique style according to the common visual characteristics they share. Such a set of common visual characteristics, which specifies a particular style, is deemed as the norm or the prototype of a given style. Two models can be identified: central tendency model, which considers the prototype as the average representation of many samples; and attribute-frequency model, which considers the prototype as the sum of attributes that most frequently sensed. And the recognition processes, which use the norm as matching-aid, are, hence, grouped into the class of prototype theory.

2.4 Feature analysis theory

Feature analysis is a very important process within that of information analysis. Features are considered as the basic distinct attributes, which can be applied to tell one shape from the other. Formal style regarded as the qualitative information a product carries can only be perceived and categorized properly through comprehensive analysis of its complicated structure. Therefore, the features or attributes a certain style has can be identified and, then, used for differentiating products with different visual characteristics.

2.5 Summary

Through the review and parallel analogy of the related theories established in the fields of Gestalt Psychology and cognitive psychology, some theories such as: Gestalt gesetz, template-matching, prototype, and feature analysis are found useful for understanding the processes of formal styles recognition. In his dissertation entitled: "Form Generation And

Style Association", Chen [6] summarized that formal styles depend basically upon physical form-properties and psychological imagery-effects. This particular remark is coincident with the theory of feature analysis reviewed above, and will underpin the Formal Style Description Framework proposed in this paper.

III. A Formal Style Description Framework (FSDF)

Building on the concepts of formal elements and stylistic features, [6] a framework for style description can be created. The model uses polar adjective pairs, augmented by two appropriate weighting mechanisms, as means for the stylistic assessment of qualities exhibited by the elements of a product's form. This framework enable a designer both to analyze and understand existing styles and to develop new styles especially suited to specific markets. An overall description of the structure of the framework is presented, then, a detailed elucidation of the framework (a style profile) follows. Following this, two examples are given to demonstrate the framework's practicality.

3.1 Structure of the FSDF

Concept. Style descriptions gain little from attempts to quantify characteristics. At most, some very remote notions such as "larger radii make a form 'round' in style" or "too many facets make a form 'fragmentary'" come to mind while analyzing a style. But the words "larger" and "too many" used in such a context are both fuzzy and qualitative rather than clear quantitative concepts. In order to analyze and describe styles objectively, underlying visual elements, rather than general associations, should be examined. To do this, a set of descriptive polar adjective pairs are employed in the FSDF.

Although the underlying visual elements used to convey visual styles are relatively few in number, the combinations of possible variations could be astronomically large. A design for an exhaustive framework that would cover all possible style combinations is neither advisable nor practical. In contrast, a design that is adaptable is proposed. In this model an FSDF records salient attributes for a style of interest. For each salient attribute, there is one estimated centric value converted from the scale used for the polar adjective pair, one confidence factor adjusting the range of the centric value, and one importance index regulating the weight of the attribute for the style of interest. Both the techniques for converting qualitative descriptions to quantitative values proposed in Chien's [7] thesis and the linguistic evaluation method using fuzzy set theory in Lee's [8] can be employed to calculate the position of a style or the distance between any two styles in the style space.

Hierarchy. An object-oriented concept is adopted to construct a style hierarchy and make the instantiation of a new style easier. A style class with fewer salient attributes (meaning more importance indices having low values) and/or looser boundaries (meaning more confidence factors having low values) is likely to be at a higher level in the style hierarchy. A style subclass, on the other hand, will either have more salient attributes, thus becoming more specific in the entire style space, or will have stricter boundaries, meaning it is more specific regarding certain attributes than its parent class. Creating a new style class at any level can be easily achieved by instantiating from a parent class and then making the necessary adjustments to the estimated values and/or importance indices' values to give the new class its own character.

Realization. The proposed framework regards the entire style space ST as n-dimensional in which each dimension is represented by three attribute-value tuples [a, ev], [a, cf], and [a, ii], denoting <attribute, estimated_value>, <attribute, confidence_factor> and <attribute, importance_index> respectively. Thus, any specific style of interest s, it can always be represented as S(s) with n pairs of attribute-estimated_value, attribute-confidence_factor, and attribute-importance_index tuples:

S(s) =
{s, {ev, [a(1),ev(1)], [a(2),ev(2)],... [a(n),ev(n)]},
{cf, [a(1),cf(1)], [a(2),cf(2)],... [a(n),cf(n)]},
{ii, [a(1),ii(1)], [a(2),ii(2)],... [a(n),ii(n)]}};

in which s is the style's name; and ev, cf, and ii are the identifiers for estimated value, confidence factor, and importance index respectively. This information is stored and accessed as an object. Since each estimated value, confidence factor, and importance index is always associated with its corresponding attribute, the order in which they are saved in memory is of no significance as long as they follow the right identifier. The same holds for the three sets of data ev, cf and ii, for each of them is always associated with its corresponding identifier.

The class and subclass relationship between any two styles x and y can be described as follows:

let

S(x) =
{x, {ev,[a(1),evx(1)],[a(2),evx(2)],...[a(n),evx(n)]},
{cf,[a(1),cfx(1)],[a(2),cfx(2)],...[a(n),cfx(n)]},
{ii,[a(1),iix(1)],[a(2),iix(2)],...[a(n),iix(n)]}};

S(y) =
{y, {ev,[a(1),evy(1)],[a(2),evy(2)],...[a(n),evy(n)]},
{cf,[a(1),cfy(1)],[a(2),cfy(2)],...[a(n),cfy(n)]},
{ii,[a(1),iiy(1)],[a(2),iiy(2)],...[a(n),iiy(n)]}};

We say x is a subclass of y, if and only if

a. $|iix(j) - iiy(j)| \leqq Dy$, for j = 1, n; and

b. $\{U(j)|(evx(j)*cfx(j)) \leqq U(j) \leqq (evx(j)*(2-cfx(j)))\}$

$\subseteq$

$\{V(j)|(evy(j)*cfy(j)) \leqq V(j) \leqq (evy(j)*(2-cfy(j)))\}$, for j = 1, n;

where

1. Dy is the maximum deviation allowed for importance indices of y;
2. {U(j)} and {V(j)} are value intervals including end points for each j.

For better understanding, a simplified example with real values will illustrate this relationship. Let us say there are only four attributes (dimensions) in the style space, and they are: Geometric - Biomorphic (for form elements), Monolithic - Fragmentary (for joining relationships), Functional - Decorative (for detail treatments) and Single - Multiple (for materials). The estimated values of these four attributes for style y are: 0.2, 0.3, 0.1 and 0.3 respectively on a 0.0 to 1.0 scale, and are: 0.21, 0.32, 0.11 and 0.28 on the same scale for style x. The confidence factors are: 0.7, 0.6, 0.6 and 0.6, and 0.9, 0.8, 0.8 and 0.7 for style y and x respectively. The importance indices are: 0.5, 0.6, 0.7 and 0.3, and 0.6, 0.7, 0.6 and 0.4 for style y and x respectively; and their maximum deviation allowed for style y, Dy, is 0.15. Then, the test for class/subclass proceeds:

$|iix(1)-iiy(1)| = |0.6 - 0.5| = 0.1 \leqq 0.15;$

$|iix(2)-iiy(2)| = |0.7 - 0.6| = 0.1 \leqq 0.15;$

$|iix(3)-iiy(3)| = |0.6 - 0.7| = 0.1 \leqq 0.15;$

$|iix(4)-iiy(4)| = |0.4 - 0.3| = 0.1 \leqq 0.15;$

and

$\{U(1)|(evx(1)*cfx(1)) \leqq U(1) \leqq (evx(1)*(2-cfx(1)))\}$
$= \{U(1)|(0.21*0.9) \leqq U(1) \leqq (0.21*(2-0.9))\}$
$= \{U(1)|0.189 \leqq U(1) \leqq 0.231\}$

$\{V(1)|(evy(1)*cfy(1)) \leqq V(1) \leqq (evy(1)*(2-cfy(1)))\}$
$= \{V(1)|(0.2*0.7) \leqq V(1) \leqq (0.2*(2-0.7))\}$
$= \{V(1)|0.14 \leqq V(1) \leqq 0.26\};$

$\{U(2)|(evx(2)*cfx(2)) \leqq U(2) \leqq (evx(2)*(2-cfx(2)))\}$
$= \{U(2)|(0.32*0.8) \leqq U(2) \leqq (0.32*(2-0.8))\}$
$= \{U(2)|0.256 \leqq U(2) \leqq 0.384\}$

$\{V(2)|(evy(2)*cfy(2)) \leqq V(2) \leqq (evy(2)*(2-cfy(2)))\}$
$= \{V(2)|(0.3*0.6) \leqq V(2) \leqq (0.3*(2-0.6))\}$
$= \{V(2)|0.18 \leqq V(2) \leqq 0.42\};$

$\{U(3)|(evx(3)*cfx(3)) \leqq U(3) \leqq (evx(3)*(2-cfx(3)))\}$

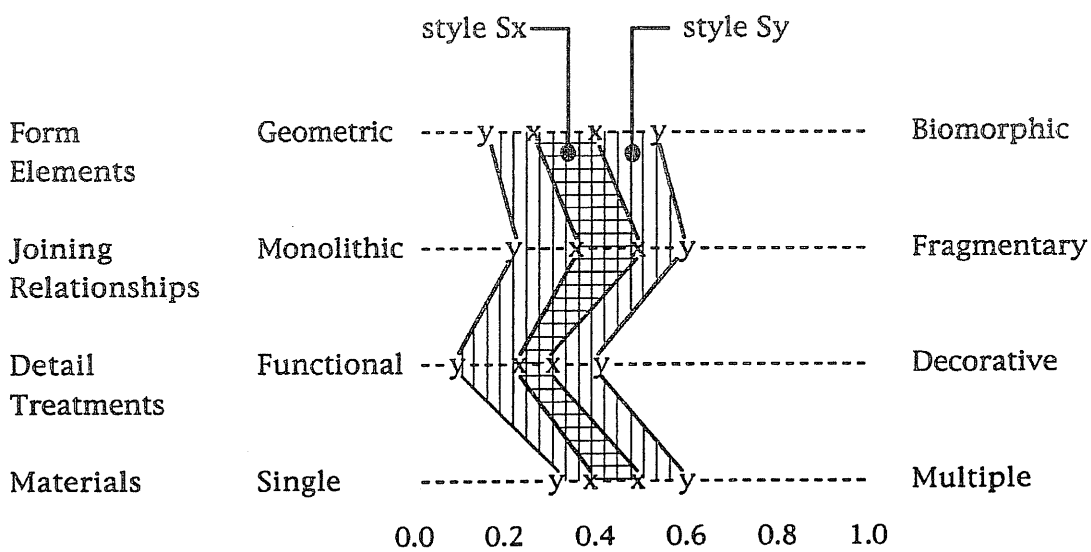
$$= \{U(3) | (0.11*0.8) \leqq U(3) \leqq (0.11*(2-0.8))\}$$
$$= \{U(3) | 0.088 \leqq U(3) \leqq 0.132\}$$

$$\{V(3) | (evy(3)*cfy(3)) \leqq V(3) \leqq (evy(3)*(2-cfy(3)))\}$$
$$= \{V(3) | (0.1*0.6) \leqq V(3) \leqq (0.1*(2-0.6))\}$$
$$= \{V(3) | 0.06 \leqq V(3) \leqq 0.14\};$$

$$\{U(4) | (evx(4)*cfx(4)) \leqq U(4) \leqq (evx(4)*(2-cfx(4)))\}$$
$$= \{U(4) | (0.28*0.7) \leqq U(4) \leqq (0.28*(2-0.7))\}$$
$$= \{U(4) | 0.256 \leqq U(4) \leqq 0.384\}$$

$$\{V(4) | (evy(4)*cfy(4)) \leqq V(4) \leqq (evy(4)*(2-cfy(4)))\}$$
$$= \{V(4) | (0.3*0.6) \leqq V(4) \leqq (0.3*(2-0.6))\}$$
$$= \{V(4) | 0.18 \leqq V(4) \leqq 0.42\}.$$

From the calculation, style x is a subclass of style y according to the definition of class-subclass relationship. Figure 1 shows the class-subclass relationship between subclass x and its parent class y using their profiles.



<u>Adaptation</u>. The proposed framework is based on an open structure and is, therefore, highly adaptive. Because the structure is flexible, a new style can easily be configured by assigning a new set of evs, cfs, and iis to a set of existing attributes. Moreover, new attributes can be added to the attribute list whenever necessary.

3.2 The Style Profile

The Style Profile collects detailed attribute information in a format that allows comparison visually. Figure 2 shows an example of a Style Profile.

		Estimated Value	Confidence Factor	Importance Index
Form Elements	Harmonious - Contrasting	-------------	-------------	-------------
	Homogeneous - Heterogeneous	-------------	-------------	-------------
	Geometric - Biomorphic	-------------	-------------	-------------
	Pure - Impure	-------------	-------------	-------------
	Simple - Complex	-------------	-------------	-------------
	Balanced - Unstable	-------------	-------------	-------------
	Low - High Cultural Reference	-------------	-------------	-------------
Joining Relationships	Monolithic - Fragmentary	-------------	-------------	-------------
	Self Evident - Hidden	-------------	-------------	-------------
	Static - Dynamic	-------------	-------------	-------------
Detail Treatments	Uniform - Multiform	-------------	-------------	-------------
	Angular - Rounded	-------------	-------------	-------------
	Functional - Decorative	-------------	-------------	-------------
	Subtle - Bold	-------------	-------------	-------------
Materials	Harmonious - Contrasting	-------------	-------------	-------------
	Single - Multiple	-------------	-------------	-------------
	Hard - Soft	-------------	-------------	-------------
	Mat - Glossy	-------------	-------------	-------------
Color Treatments	Harmonious - Contrasting	-------------	-------------	-------------
	Single - Multiple	-------------	-------------	-------------
	Cool - Warm	-------------	-------------	-------------
	Hard - Soft	-------------	-------------	-------------
Textures	Harmonious - Contrasting	-------------	-------------	-------------
	Single - Multiple	-------------	-------------	-------------
	Subtle - Bold	-------------	-------------	-------------
	Regular - Irregular	-------------	-------------	-------------
	Tactile (3D) - Visual (2D)	-------------	-------------	-------------

The Major Groupings. The major factors contributing to the formation of visual styles can be summarized as: form elements, joining relationships, detail treatments, materials, color treatments and textures -- six categories. Correspondingly, the attributes adopted for describing styles can be assigned to these six categories. They are:

1. form elements -- including the number of different form elements used, the shape(s) of the form elements used, and the symbolic associations;

2. joining relationships -- including the number of different spatial relationships used, spatial relationship(s), number of different joining types used, and joining type(s);

3. detail treatments -- including the number of different treatments used on faces, edges, and corners, and the treatments used on faces, edges, and corners;

4. materials -- including the number of different materials used, type(s) of materials used, and the finishing of the materials;

5. color treatments -- including the number of different colors used, colors used, and tone groups (color images); and

6. textures -- including the number of textures used, type(s) of textural patterns, characteristics of textures, and tactility of textures.

The first three groups decide the geometric modeling of the object; the second three groups control the surface mapping.

The Polar Adjective Pairs. Polar adjective pairs are the core constituents of the Style Profile. To obtain descriptive values, each attribute is associated with one pair of polar adjectives. These polar adjective pairs are organized according to the six major groupings:

Form Elements. Seven polar adjective pairs are included to describe the form elements representing distinguishable parts of an object.

Harmonious - Contrasting: Do the form elements match well or contrast with each other?

Homogeneous - Heterogeneous: Are the form elements of one kind or of several different types? If more than one kind of form elements exists, there will be more than one estimated value for each of the following attributes to accommodate the coexistence of multiple characteristics.

Geometric - Biomorphic: Are the form elements geometric, biomorphic or partially biomorphic?

Pure - Impure: Are the form elements pure in appearance or impure?

Simple - Complex: Do the form elements demonstrate the quality of simplicity or not?

Balanced - Unstable: Are the form elements in a balanced state or an unstable one?

Low Cultural Reference - High Cultural Reference: Do the form elements refer to any cultural association?

Joining Relationships. Polar adjective pairs here are used to picture the joining relationships among parts in three dimensions.

Monolithic - Fragmentary: Do the joinings make the object look like a single piece or one that is fragmentary?

Self Evident - Hidden: Are the joinings clearly visible or very subtle?

Static - Dynamic: Does the construction of form elements result in a structure that seems static or one that seems dynamic?

Detail Treatments. Four adjective pairs label the detail treatments given on an object. Uniform - Multiform: Do the detail treatments on the object demonstrate the quality of homogeneity or heterogeneity? If more than one type of detail treatments exists, there will be more than one estimated value for each of the following attribute to accommodate the multi-characteristics.

Angular - Rounded: How are the details of the object perceived? Sharp-cornered? or soft and rounded?

Functional - Decorative: Do the details look practical or merely ornamental?

Subtle - Bold: Are the details very refined or very striking?

Materials. Four polar adjective pairs characterize the materials used in an object.

Harmonious - Contrasting: Do the materials used match each other well? or do they create a strong contrast?

Single - Multiple: How many different types of materials are used in the object? just one? or quite a few? If more than one type of material exists, there will be more than one estimated value for the hard-soft and mat-glossy attributes to express their multi-characteristics.

Hard - Soft: Do the materials used contribute to a feeling of hardness? or softness?

Mat - Glossy: Do the materials used create a dimmed finish? or a shiny one?

Color Treatments. Four pairs of polar adjective similar to those for materials are employed to portray color treatments.

Harmonious - Contrasting: Do the colors used match each other well? or do they create a strong contrast?

Single - Multiple: How many different hues appear in an object? just one? or quite a few? If more than one color appears, there will be more than one estimated value for cool-warm and hard-soft attributes to express the multiple color images.

Cool - Warm: Do the colors used display a cool image or a warm one?

Hard - Soft: Do the colors used create a hard image or a soft one?

Textures. Five adjective pairs are used to differentiate the textural patterns exhibited in an object.

Harmonious - Contrasting: Do the textural patterns used match each other well? or create a strong contrast?

Single - Multiple: How many different textural patterns appear on the object? just one? or many? If more than one textural pattern appear, there will be more than one estimated value for each of the following attributes to express the multiple characteristics.

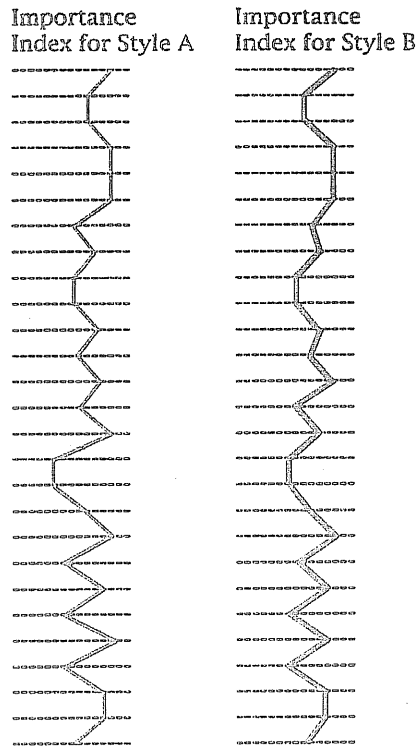
Subtle - Bold: Are the textural patterns very fine-grained or very coarse?

Regular - Irregular: Are the textural patterns well-regulated and predictable? or asymmetric and erratic?

Tactile (3D) - Visual (2D): Are the textural patterns three dimensional or two dimensional?

The Refinement Mechanisms. Two weighting factors are used to refine the Style Profile for each style: an importance index and a confidence factor. Two polar adjective pairs, namely: insignificant - significant, and uncertain - certain, are designated to importance indices and confidence factors respectively. The former indicates how significant an attribute is to a specific style -- similar styles should have similar importance index measures on corresponding attributes (in other words, the importance index profiles of two similar styles should resemble each other). Figure 3 shows two profiles of importance indices from two similar styles. The latter denotes how certain the estimated value is, or how much a product can deviate from the estimated value and still be considered as "of this style". The higher this measure is the higher is the certainty and the lower the deviation.

Form Elements	Harmonious - Contrasting
	Homogeneous - Heterogeneous
	Geometric - Biomorphic
	Pure - Impure
	Simple - Complex
	Balanced - Unstable
	Low - High Cultural Reference
Joining Relationships	Monolithic - Fragmentary
	Self Evident - Hidden
	Static - Dynamic
Detail Treatments	Uniform - Multiform
	Angular - Rounded
	Functional - Decorative
	Subtle - Bold
Materials	Harmonious - Contrasting
	Single - Multiple
	Hard - Soft
	Mat - Glossy
Color Treatments	Harmonious - Contrasting
	Single - Multiple
	Cool - Warm
	Hard - Soft
Textures	Harmonious - Contrasting
	Single - Multiple
	Subtle - Bold
	Regular - Irregular
	Tactile (3D) - Visual (2D)



The Scoring Systems. Along with an adjective pair, a five-rank descriptive scale is used for describing each attribute. Taking the cool - warm pair as example, these five ranks are: very cool, cool, neutral (hard to tell), warm, and very warm. These five fuzzy descriptors then are mapped to a normalized scaling system, from 0.0 to 1.0, with the first descriptor close to value 0.0 and the last near the value of 1.0. For example, in the case of cool - warm, very cool produces a value close to 0.0 while very warm is near 1.0. A more detailed discussion of fuzzy theory and linguistic variables can be found in Lee's [8] thesis.

As described earlier, style class s is represented as:

S(s) =

{s, {ev,[a(1),ev(1)],[a(2),ev(2)],...[a(n),ev(n)]},
{cf,[a(1),cf(1)],[a(2),cf(2)],...[a(n),cf(n)]},
{ii,[a(1),ii(1)],[a(2),ii(2)],...[a(n),ii(n)]}};

while a product p can be described as:

S(p) =

{p, {ev,[a(1),ev(1)],[a(2),ev(2)],...[a(n),ev(n)]},
{cf,[a(1),cf(1)],[a(2),cf(2)],...[a(n),cf(n)]}}.

Because a product can only be evaluated with estimated values and confidence factors for each attribute before being given any particular style label, importance indices are left out in the above description. The location of any given style or product p in a style space of n dimensions can then be represented by L(p) as:

$$
\begin{aligned}
L(p) = \{p, & [a(1), ev(1)], \\
& [a(2), ev(2)], \\
& \quad \ldots \\
& [a(n), ev(n)]\}
\end{aligned}
$$

where p is the name identifier of the product or style.

The image distance between two products or styles x and y, called the absolute distance D(x,y), can be calculated as:

$$D(x,y) = \sqrt{\sum_{i=1}^{n} (evy(j)-evx(j))^2} \;;$$

and the image distance from a product or a style p to a specific style x, called referential distance Dr(x,p), can be calculated as:

$$Dr(x,p)= \sqrt{\frac{\sum_{i=1}^{n} iix(j)*(evp(j)-evx(j))^2}{\sum_{i=1}^{n} iix(j)}}$$

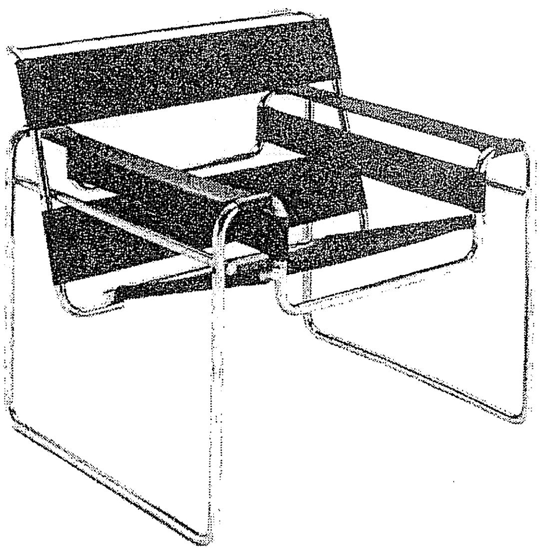
In the referential distance, the importance index of each attribute of the referential style x is used to weight each corresponding estimated value, while in calculating absolute distances no importance indices are necessary.

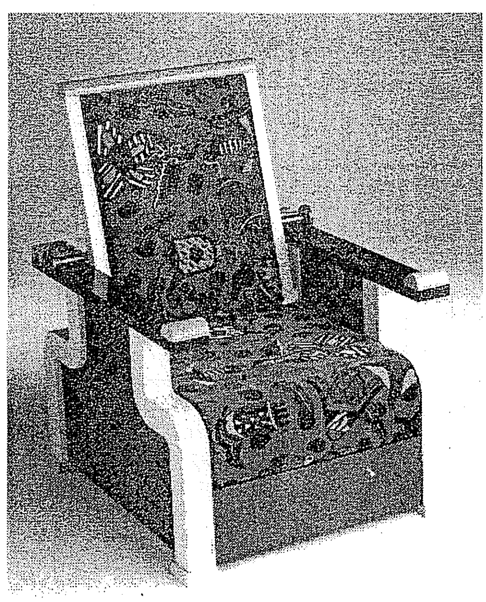
A few issues need to be addressed before closing this section on relations among the notions of class-subclass, absolute and referential distances. As the definition has been given, two styles with class-subclass relationship will not necessarily have smaller absolute or referential distances between them than exist between others without such a relationship. This is possible because the class-subclass relationship takes into account the confidence factors, while the absolute and referential distances do not. The situation might occur, for example, that two styles, such as German style and Braun style, with a distant class-subclass relationship might end up having greater image distance between them than two styles, such as Braun style and Krups style, that do not have a class-subclass relationship. The referential distance from a product or a style to any particular style may also be less (or more) than that to another style even though the two styles referenced may have exactly the same estimated values on all the attributes -- because the importance indices for the attributes of the referenced styles may not be the same.

The fact that two styles have a small absolute distance between them does not mean that they will have a small referential distance, either. This seeming discrepancy is possible because the referential distance differentiates the importance indices of the attributes of the referential styles, while the absolute distance takes no consideration of the importance indices. This situation resembles that where two styles with a small absolute distance between them might end up having much larger referential distance between them than two others with a greater absolute distance. An illustration is the case where Braun products are closer to Functionalist style than Minimalist style in absolute distance (without the weighting of importance indices), but better qualified as Minimalist style than Functionalist style in referential distance (with the weighting of importance indices). In general, however, the smaller the absolute distance is between two styles, the closer will be their image.

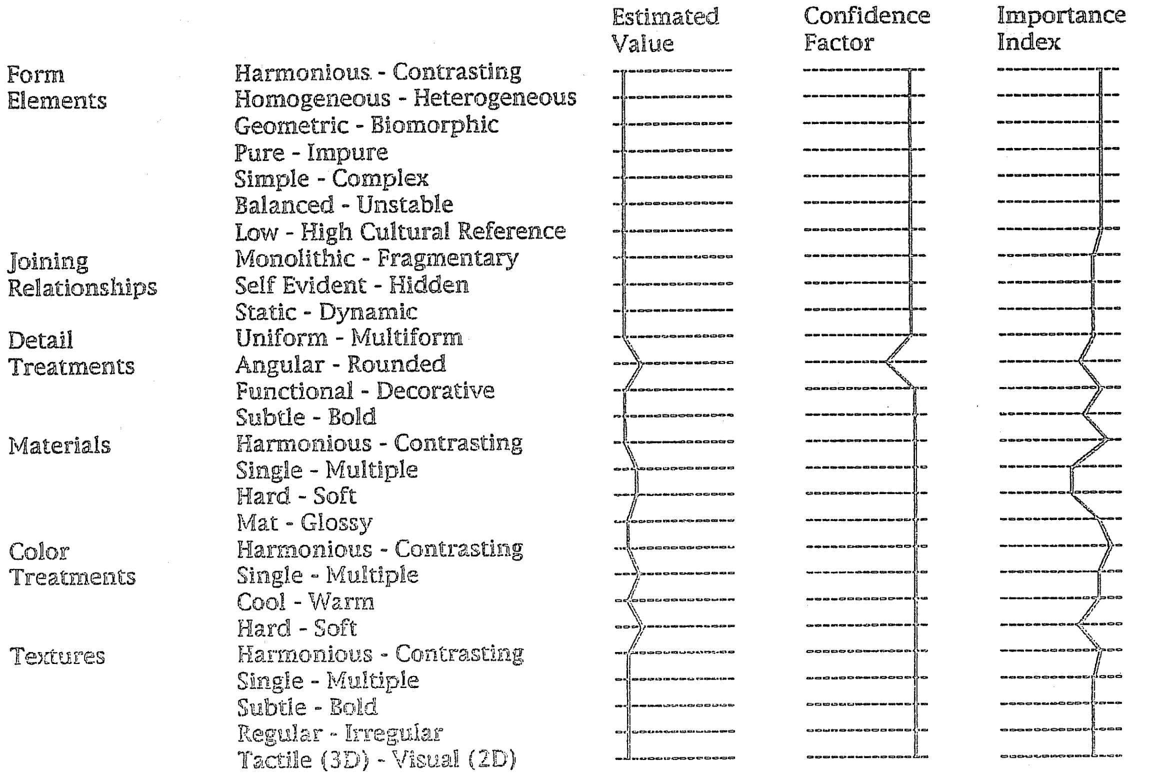
3.3 Some Testing Examples

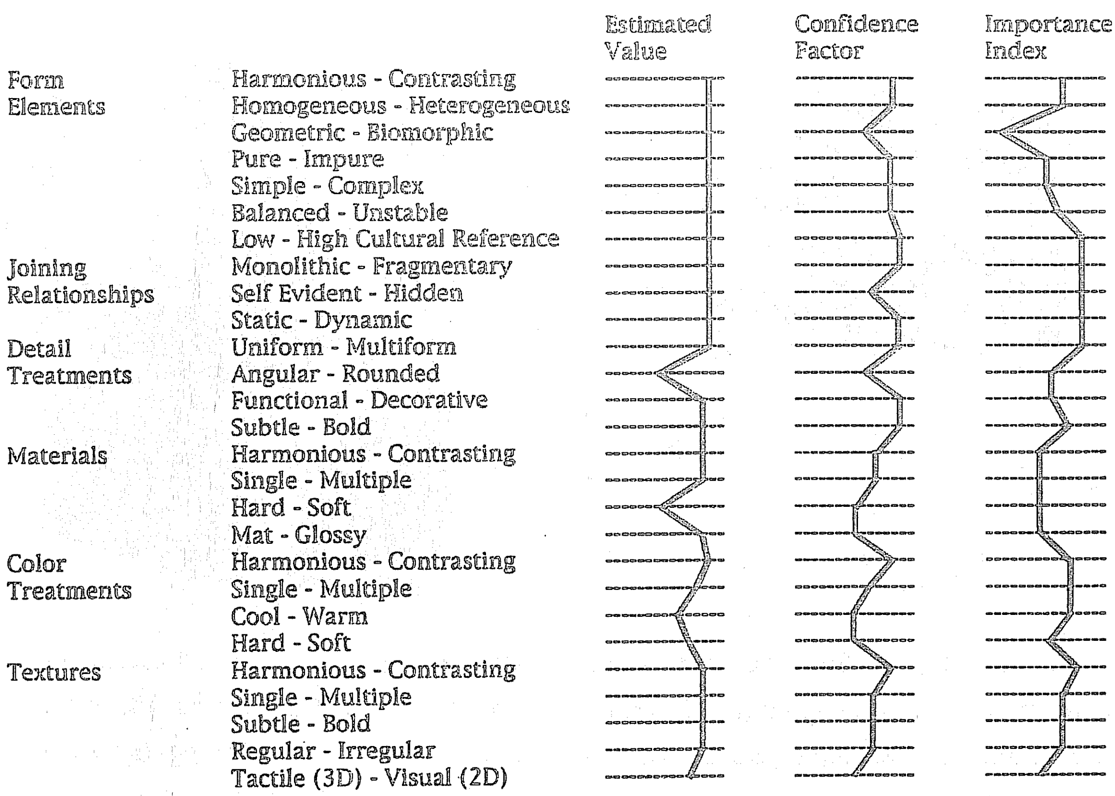
Figure 4 shows products of Bauhaus style and Memphis style. "Bauhaus style" is also frequently used as the representative of Modernism, or German style, while the "Memphis style" epitomizes Post-Modernism, or Italian style. Figures 5 and 6 are the two Style Profiles for the products shown in Figure 4 representing Bauhaus style and Memphis style respectively. Figure 7 is a superimposition graph showing the differences between the two styles in all aspects. Generally speaking, these two styles are in opposition on almost every salient attribute. For example, while Bauhaus is harmonious, homogeneous, ordered, geometric, pure, simple, modest, logical, functional, practical, austere, mechanistic, white/gray/black, timeless, minimalist, and abstract in form, Memphis is contrasting, heterogeneous, disturbing, organic, impure, complex, radical, illogical, decorative, mischievous, strangely decorative, playful, brightly colored, faddish, fantastic, and referential to POP art and popular culture.





The measures in the other two columns essentially echo each other except on a few attributes in the column of importance indices. This reveals that both styles place relatively equal emphasis on the salient attributes; while the relatively obvious discrepancies shown in the column of confidence factors are a reminder that Bauhaus style has a stricter and narrower range than that of Memphis style. Beyond their previously defined functions, the confidence


Estimated Value
Confidence Factor
Importance Index
Form Elements
Harmonious - Contrasting
Homogeneous - Heterogeneous
Geometric - Biomorphic
Pure - Impure
Simple - Complex
Balanced - Unstable
Low - High Cultural Reference
Joining Relationships
Monolithic - Fragmentary
Self Evident - Hidden
Static - Dynamic
Detail Treatments
Uniform - Multiform
Angular - Rounded
Functional - Decorative
Subtle - Bold
Materials
Harmonious - Contrasting
Single - Multiple
Hard - Soft
Mat - Glossy
Color Treatments
Harmonious - Contrasting
Single - Multiple
Cool - Warm
Hard - Soft
Textures
Harmonious - Contrasting
Single - Multiple
Subtle - Bold
Regular - Irregular
Tactile (3D) - Visual (2D)


Estimated Value
Confidence Factor
Importance Index
Form Elements
Harmonious - Contrasting
Homogeneous - Heterogeneous
Geometric - Biomorphic
Pure - Impure
Simple - Complex
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Harmonious - Contrasting
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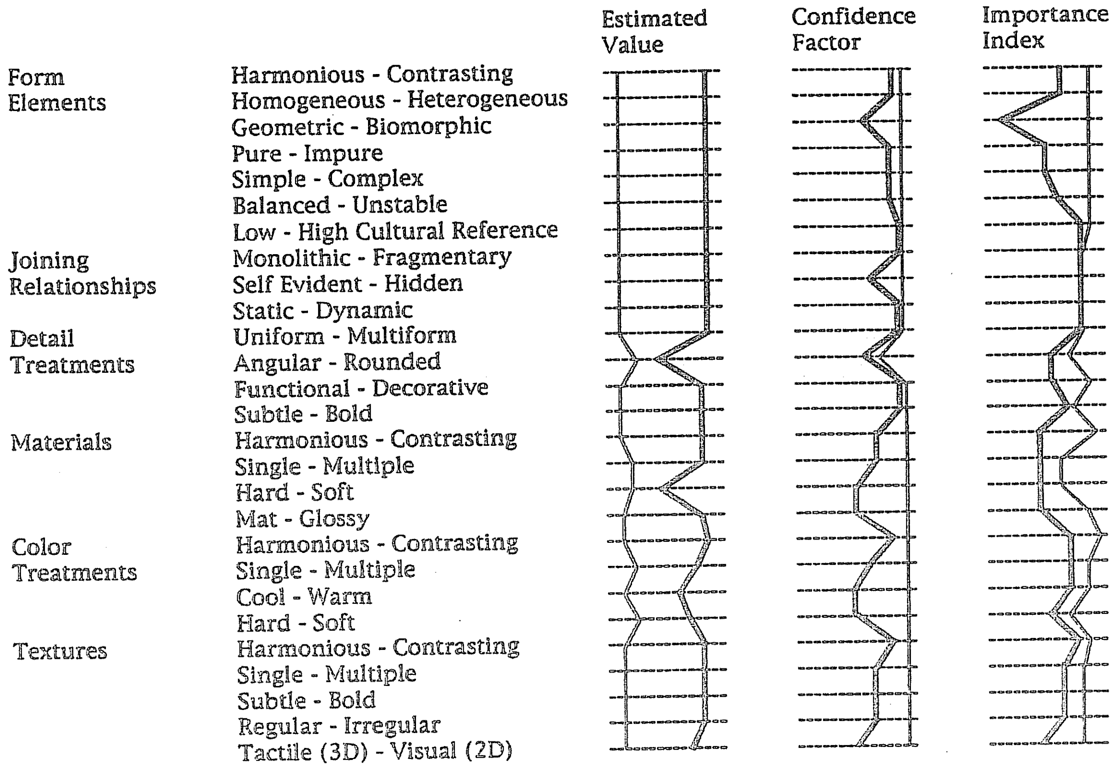
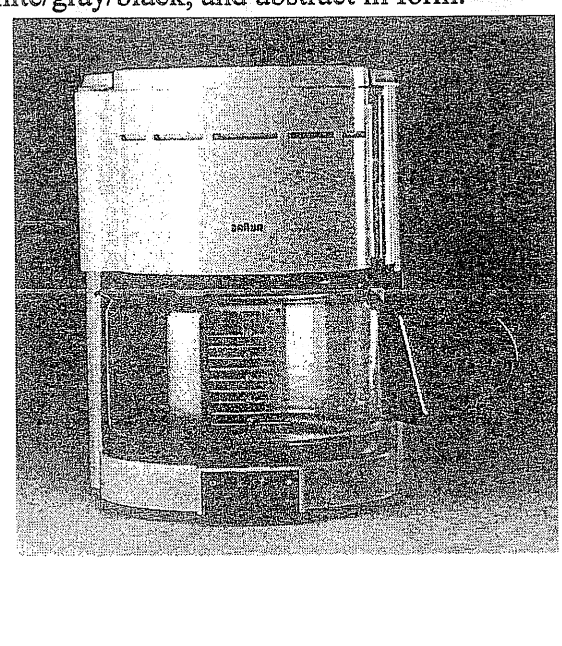
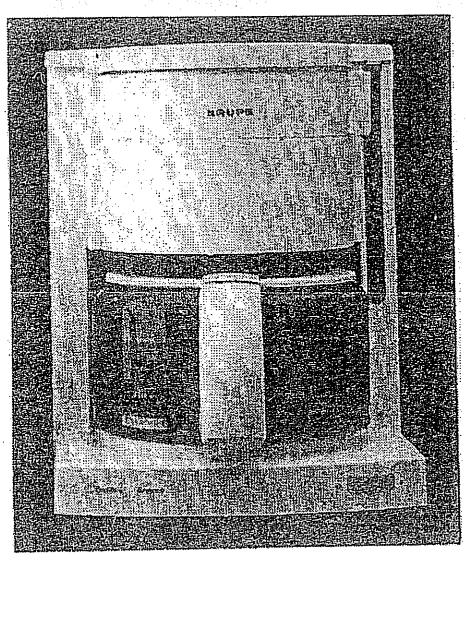
Hard - Soft
Textures
Harmonious - Contrasting
Single - Multiple
Subtle - Bold
Regular - Irregular
Tactile (3D) - Visual (2D)

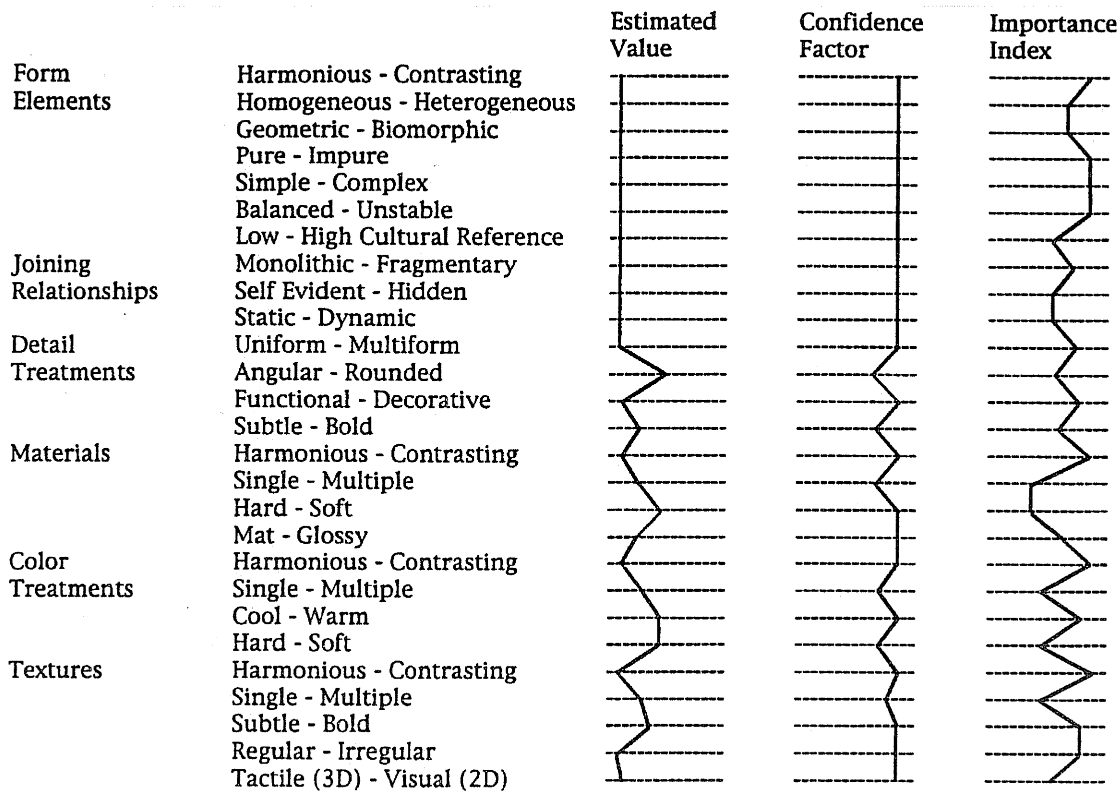


factors and importance indices can also be regarded as indicators of the evaluator's personal biases or intentions regarding the description or generation of a specific style.

Figure 8 shows products from Braun and Krups. They look much alike, and all belong to the so-called Bauhaus style or German style. Figures 9 and 10 are the Style Profiles for the products shown in Figure 8 -- Braun and Krups, respectively -- and Figure 11 shows the superimposition of the two. Generally speaking, these two styles hold similar positions on almost every salient attribute. For example, they both are considered harmonious, homogeneous, geometric, pure, simple, functional, austere, mechanistic, white/gray/black, and abstract in form.






Estimated Value
Confidence Factor
Importance Index
Form Elements
Harmonious - Contrasting
Homogeneous - Heterogeneous
Geometric - Biomorphic
Pure - Impure
Simple - Complex
Balanced - Unstable
Low - High Cultural Reference
Joining Relationships
Monolithic - Fragmentary
Self Evident - Hidden
Static - Dynamic
Detail Treatments
Uniform - Multiform
Angular - Rounded
Functional - Decorative
Subtle - Bold
Materials
Harmonious - Contrasting
Single - Multiple
Hard - Soft
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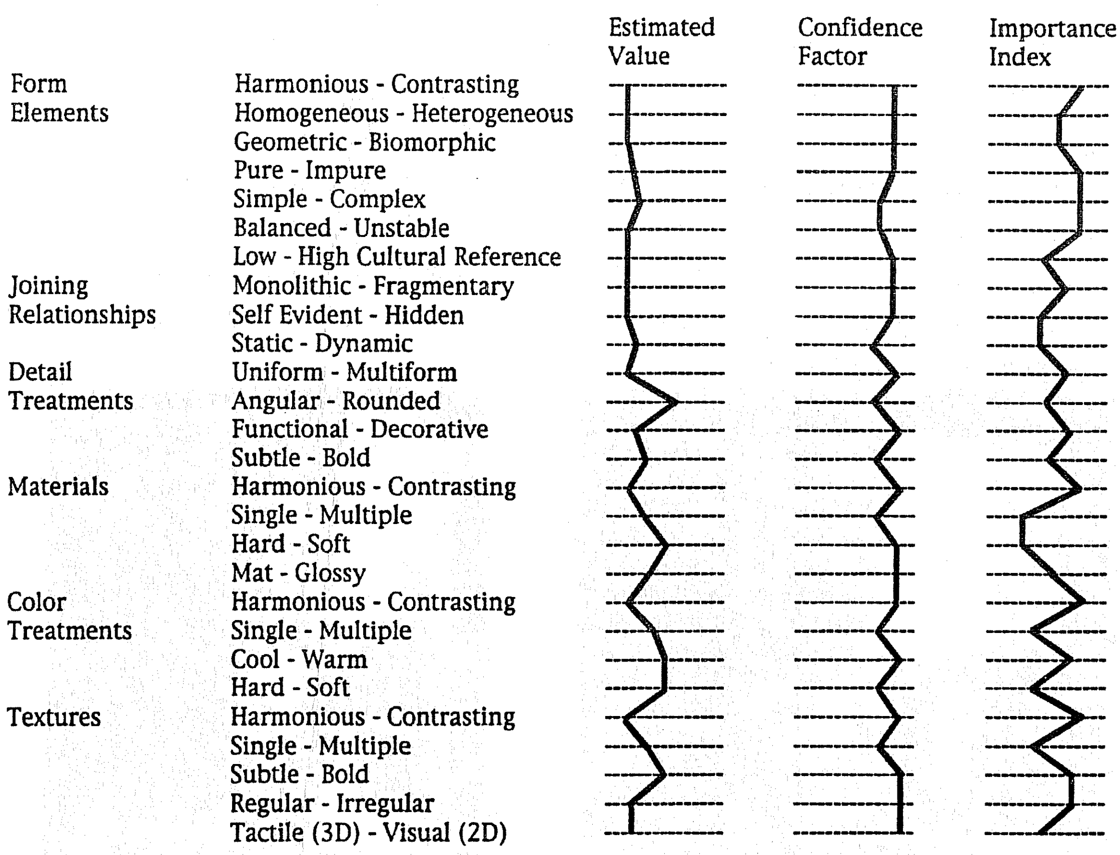
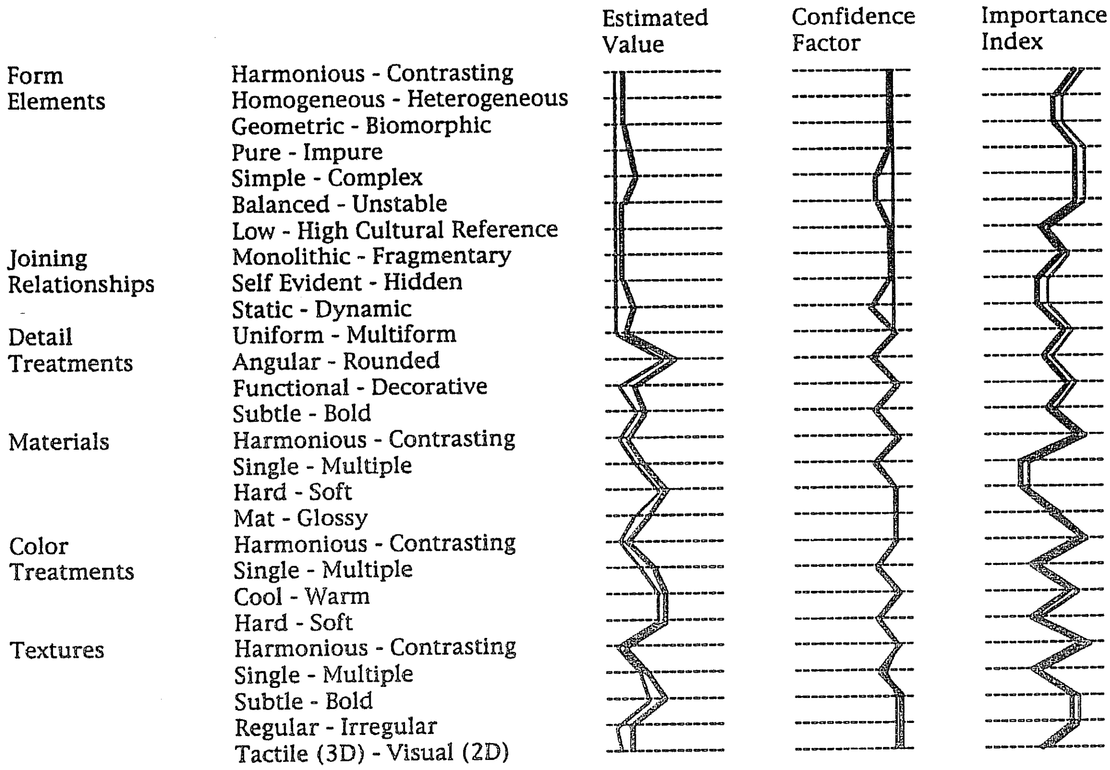
Color Treatments
Harmonious - Contrasting
Single - Multiple
Cool - Warm
Hard - Soft
Textures
Harmonious - Contrasting
Single - Multiple
Subtle - Bold
Regular - Irregular
Tactile (3D) - Visual (2D)


Estimated Value
Confidence Factor
Importance Index
Form Elements
Harmonious - Contrasting
Homogeneous - Heterogeneous
Geometric - Biomorphic
Pure - Impure
Simple - Complex
Balanced - Unstable
Low - High Cultural Reference
Joining Relationships
Monolithic - Fragmentary
Self Evident - Hidden
Static - Dynamic
Detail Treatments
Uniform - Multiform
Angular - Rounded
Functional - Decorative
Subtle - Bold
Materials
Harmonious - Contrasting
Single - Multiple
Hard - Soft
Mat - Glossy
Color Treatments
Harmonious - Contrasting
Single - Multiple
Cool - Warm
Hard - Soft
Textures
Harmonious - Contrasting
Single - Multiple
Subtle - Bold
Regular - Irregular
Tactile (3D) - Visual (2D)



The measures in the columns of importance index of the two are also very much the same. Under close examination, minute variations between the two can only be found in the confidence factor columns on a few attributes: simple - complex, balanced - unstable, and static - dynamic. In these, Braun always has the simplest and the most balanced form elements and the most static structure while Krups may relax a little bit.

3.4 Summary

What has been presented in this section is an approach to the description of styles utilizing the concepts of semantic differential and class-subclass relationships. Within the framework proposed existing styles are analyzed and new styles are planned by using polar adjective pairs to describe attributes associated with each style, confidence factors to refine the style scope, and importance indices to differentiate attributes' weights. All the styles described with the Style Profile framework are organized as objects that can be retrieved, modified and instantiated with ease by computer. Within a separate article, a form modeling infrastructure will be proposed to explore the possibilities of associating the style information recorded within the Style Profile to a form under construction.

IV. Conclusions

Designers create styles to satisfy consumers' tastes by bestowing specific visual forms on the artifacts they design. In this concluding section, both achievements and the directions for future research will be summarized and discussed.

4.1 Summary of Achievements

The objectives of this research are: to supply designers with a language that can communicate style with computers; to assist designers in analyzing stylistic attributes of objects (products); and to help designers to accumulate style related knowledge. In fulfilling these objectives, this research accomplished the following:

Formal Style Analysis Mechanism. The Style Profile, with its bi-polar adjective pairs covering the essential stylistic attributes of form elements, joining relationships, detail treatments, materials, color treatments, and textures (six major categories) can also serve as a mechanism for comprehensive formal analysis. By plotting Style Profiles on a chart, designers can compare stylistic attributes among objects (products).

Formal Style Knowledge Accumulation Framework. By recording the essential properties of specific styles, the Style Profile serves as a framework for formal style knowledge accumulation. By accumulating Style Profiles that record market preferences, cultural preferences, corporate identities, or individual designer's characteristics, designers can build knowledge bases for styles that can be reused almost effortlessly whenever they are applicable.

Computer-Comprehensible Style Description Language. The Style Profile is a frame-like data storing structure as well as a data communicating language in which attribute-value pairs are recorded. Values recorded within a normalized scale ranging from 0.0 to 1.0 are converted from bi-polar adjective pairs, the component vocabulary of the style description language. Through the Style Profile, designers (users) will be able to describe to a computer a particular style and command the computer to generate forms with the specified style eventually.

4.2 Directions for Future Research

In order to bring the proposed Style Description Framework to its full potential -- integration with CAD systems -- the following topics might be considered as subjects for further research:

Design Oriented Form Modeling Infrastructure. A form modeling infrastructure, better suiting the designer's intuitive manipulation of forms than currently existing modeling methods, is needed. Such an infrastructure should be capable of converting the stylistic information stored in the Style Profile into geometrically represented forms while purposely relieving designer of the problems of mathematical representation and manipulation for detail treatments, joining relationships and spatial allocations.

Further Integration of CAD Systems. That the Style Profile is capable of communicating styles between designers and computers is a major step toward the development of completely integrated CAD systems. However, such integrated CAD systems should be able to free designers of the needs to repeatedly construct geometric models with the same type of detail treatments again and again. Designers, then, can use more of their time to investigate style diversities and taste divergence among different cultures, corporations, distinctive designers, market segments, and even individual consumers.

V. Acknowledgments

The author would like to thank the National Science Council of R.O.C. for her financial supports under contract number NSC85-2213-E-006-031.

References

1.Owen, Charles (1988) The Key is Concept. *Design Processes Newsletter,* Vol. 2, No. 5, pp. 5-6. Institute of Design, Illinois Institute of Technology, Chicago, IL, U.S.A.

2.Hunt, V. Daniel (1986) *Artificial Intelligence and Expert Systems Sourcebook.* Chapman & Hall, New York, NY, U.S.A.

3.Doblin, Jay (1987) Discrimination: The Special Skills Required for Seeing, and the Curious Structure of Judgment. *Design Processes Newsletter,* Vol. 2, No. 4, pp. 1-6. Institute of Design, Illinois Institute of Technology, Chicago, IL, U.S.A.

4.Chen, Kuohsiang (1996) *The Research and Development for the Design of a Computer Supported Form Generation System (I).* Project report, 120 pages. Supported by National Science Council. Printed in Tainan, Taiwan, R.O.C.

5.Anderson, J. R. (1990) *Cognitive Psychology And Its Implications* 3rd ed. W. H. Freeman and company, New York, NY, U.S.A.

6.Chen, Kuohsiang (1995) *Form Generation And Style Association.* Doctor of Philosophy in Design dissertation, pp. 26-27. Institute of Design, Illinois Institute of Technology, Chicago, IL, U.S.A.

7.Chien, Greg T. H. (1989) *Dynamic Modeling and Simulation in Product Design.* Master of Science in Design Thesis. Illinois Institute of Technology, Chicago, IL, U.S.A.

8.Lee, Soon-Jong (1984) *The Linguistic Evaluation Method Using Fuzzy Set Theory.* Master of Science in Design Thesis, pp. 69-76. Illinois Institute of Technology, Chicago, IL, U.S.A.

造形風格之辨識與描述

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（收件日期:86年9月20日；接受日期:86年11月18日）

摘要

本論文包含兩個部份。第一部份乃藉形態辨識理論推測造形風格辨識的理論依據。第二部份乃描述一個設計師可藉以分析現有造形風格並可界定及描述目標市場所期望的造形風格之架構。

此架構，又名爲『風格側面像』，乃由一組相反形容詞對及與其相對應之三組評量值所組成。其中，該組相反形容詞對所界定之造形風格特徵包含了六個向度：形態元件、接合關係、細部處理、材質、色彩與紋理。第一組評量值用以描述一造形風格之特徵；後兩組評量值則爲加權機制：一爲重要性指標另一爲自信度指標，乃用以微調對該造形風格之描述。此『風格側面像』不但可用以溝通設計者與電腦之間之造形風格概念並可作爲累積造形風格知識之用。

關鍵字：造形風格辨識、造形語言、造形風格、電腦輔助造形設計