

# Can style be measured?

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*Historically, style is studied by features which reflect certain types of characteristics used to illustrate cultural circumstances and social aspects. Thus, style can be identified. If there are some attributes that have magnitude which can serve as common denominators to theoretically represent a style, then a style can be detected as an entity that possesses some basic properties. Furthermore, these attributes can be used as the stages in a scale for measuring how strong a style is, and the degree of similarity between two styles. The fundamental unit of style measurement is a set of common features appearing in objects, which is used for categorising a style. There are two properties of style derived from perceiving the common-feature sets: similarity and degree of style. Therefore, the set of common features is the fundamental unit of measurement and the signature of a style. © 2000 Elsevier Science Ltd. All rights reserved*

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**1 Jencks, C** *The language of post-modern architecture* Rizzoli, New York (1977) p 80

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**4 Kroeber, A L** *Style and civilization* Cornell University Press, Ithaca NY (1957)

**5 Schapiro, M** Style. In Philipson (ed) *Aesthetics today* World Publishing, Cleveland OH (1961) pp 81–113

**6 Smithies, K W** *Principles of design in architecture* Van Nostrand Reinhold, New York (1981)

In the fine and performing arts, any artistic object or performance has its process of creation which follows certain unique ways and methods of generation. If such methods are repeated over time to reproduce similar forms or actions, a pattern of characteristics emerges and a style is formed. Historically, a style is identified by recognisable features (forms) that appear in certain products created by one person (individual style—e.g. van Gogh style) (see note 1), by a group of persons (group style—e.g. Prairie style) (see note 2), across some geographical areas (regional style), or through a period of time (period style—e.g. Renaissance style) (see note 3). Scholars have used the relationships (syntax) between recognisable forms to establish an orderly hierarchy among persons, groups, regions, or periods to build up structures for the history of any arts<sup>1</sup>. Thus, most studies on style have focused on either identifying significant forms that manifest a style<sup>2</sup> or reviewing their developing background<sup>3</sup>, and further tracing their context and associations as they interacted with other forms<sup>4–6</sup>.



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- 20 Ackerman, J S** *A theory of style*. In **Beardsley and Schueller** (eds) *Aesthetic inquiry: essays on art criticism and the philosophy of art* Dickenson, Delmont CA (1967) pp 54–66
- 21 Rapoport, A** *A House form and culture* Prentice-Hall, Englewood Cliffs NJ (1969)

Other notions, that differ from identifying forms and syntax, have concentrated on the study of the ways of doing things<sup>7</sup>. A pattern of the same ways of doing things defines a style. For instance, jazz music has a strong but flexible rhythmic understructure with solo and ensemble improvisations on basic tunes and chord patterns which characterise it as jazz. Gombrich<sup>8</sup> not only mentioned that style is any distinguishable way in which an act is performed or an artifact is made, but also centered more on choices from alternatives. To him, the history of taste and fashion is the history of preferences, of various acts of choice between given alternatives<sup>9</sup>. The factors influencing the choices made from alternatives in design and fine arts have multiple dimensions. Analyzed from a cognitive psychological point of view, possible factors could include personal knowledge<sup>10</sup>, mental image<sup>11,12</sup>, rules and procedures of handling domain-specific tasks<sup>13–17</sup>, and individual preferences<sup>18,19</sup>. Individual preference, viewed from the perspective of social science, could be affected by cultural forces in society<sup>20,21</sup>. The cultural forces, e.g. fashion, value, and custom, symbolize conventions which could affect the characteristics of art forms, and artists ought to select among given conventions while they are designing<sup>3,22,23</sup>. Thus, the decisions made among choices determine a style, and the relationships among the choices indicate the history, evolution, and changes of style.

Other than examining the choices that influence style, few studies have investigated the driving forces that cause a style<sup>14</sup>—especially, the individual style in architectural design<sup>24,25</sup>. These studies initiate an interesting question about how to recognise an individual style from different design products. Particularly, can a style be recognised and measured? The answer to this question is based on the premise that a style can be treated as an entity. This concept is similar to how a color can be operationally defined in information science. In fact, color exists everywhere in the real world. It is difficult, in the old manner, to measure two colors exactly by words to get identical hue, saturation, and brightness. In the field of information technology, however, there is a hexadecimal number which causes a color to be displayed on Internet Web pages, and there are several common color models (see note 4) (HSB, RGB, CMYK, L\*a\*b) available for printing and rendering. The properties of color can be mathematically defined using one of the color models. Although all models yield different numeric numbers for one color, as demonstrated in PhotoShop, they represent the same color for monitor display and printing. For instance, light grey has RGB values of 155, 155, 155; HSB of 0°, 0%, 61%; CMYK of 42%, 29%, 29%, 7%; L\*a\*b of 72, 0, 0; and a hexadecimal value of 9b9b9b. This manner of representing colors by numbers develops a new convention. Similarly, a style can be identified by repetitious forms, features, and syntax (see note 5) appearing in objects. As long as these elements are recognised, a style

is identified. Thus, styles can be treated as special entities that can be measured.

Unlike the notions of styling applied in industrial design to explore the design language for generating stylistic forms<sup>26</sup>, or of developing a formal model to communicate stylistic concepts to the computer for form generation<sup>27</sup>, this paper intends to develop a descriptive model for scientifically analysing style. The purpose is to establish some algorithm which can be used to understand how style can be measured and identified. This will provide a tool to comprehend a particular style in design, painting, and sculpture.

### *1 Identifying features*

A style is recognised by means of perception across products. Perception is to recognize, be aware of, or understand the message revealed in a product. If a set of features (forms) occurs repetitiously in a number of products, a style emerges. The artistic products can be actions in dancing and drama, patterns in music, or physical design objects of sculpture, painting, furniture, and building in fine arts. Thus, objects are parts of products which are represented as collections of features. The term 'feature' covers many meanings of patterns (detail treatments), physical forms (materials and treatments), or characteristics (textures and colors). Other than the meaning used in structural linguistics<sup>28</sup>, it is applied in this article to cover the forms of design products. Furthermore, the meaning of feature can also cover the functional and geometrical relationships between forms. If a feature in an object is originally created by a designer, it is one of the signatures of the designer's style.

Any legitimate features to be regarded as stylistic should have the following properties:

- (1) it has a form or composition distinguished by some particular configuration, and a contextual relationship with other features;
- (2) it is generated originally by a designer through creative processes, or is adapted or copied by a designer from other sources with certain functionality achieved;
- (3) it is a member of a set of prominent forms repeatedly used by the designer.

For instance, common features appearing in the Prairie House Style included a low hip roof, a band of casement windows, continuous bands of sill, extended terraces with low parapet and coping, watertable, corner blocks, planting urns, massive brick chimney, continuous wall between sill

**22** Kroeber, A L *An anthropologist looks at history* University of California Press, Berkeley CA (1963)

**23** Schwarting, JM 'Teaching style: the first term at Columbia' *The Journal of the Graduate School of Architecture and Planning* Vol 5 (1984) pp 7-24

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**26** Tovey, M 'Styling and design: intuition and analysis in industrial design' *Design Studies* Vol 18 (1997) pp 5-31

**27** Chen, K and Owen, C 'Form language and style description' *Design Studies* Vol 18 (1997) pp 249-274

**28** Hampton, J and Dubois, D Psychological models of concepts: introduction. In Mechelen, Hampton, Michalski and Theuns (eds) *Categories and concepts: theoretical views and inductive data analysis* Academic Press, London (1993) pp 11-33

and watertable, overhanging eaves, and symmetric side facade<sup>29,30</sup>. Some features can be founded by other sources, but most were created and put together uniquely by Frank Lloyd Wright to fit special functions. In this case, this set of common features signifies one of Wright's individual styles.

Studied from a broader point of view, these same features can be seen as an ensemble in the Prairie Style houses designed not only by Wright from 1901 to 1910 but also by his followers. Thus, this set of common features also signifies a group style. In any case, such features found in a group of houses are called the 'critical common features' which define a stylistic set for determining a style.

## 2 Identifying a style

After a set of common features is identified, all objects that possess the same feature set should have the same style (see Figure 1). In some cases, some objects have more members of the set than others. For instance, 10 features appearing in one design will more strongly suggest a style than having five features present. Thus, the number of features appearing in an object affects how easily a style can be recognised, which suggests the notion of perceptibility. In other words, greater or fewer numbers of features existing in an object will alter the perception of a particular style, which signifies the degree of style within a style class.

In the same way, 10 common features appearing in 20 design objects will more strongly suggest the style than five features. The number of the set of common features indicates the notion of expressiveness. Greater or fewer members in the set appearing in a group of objects will affect the expression of styles, which denotes the degree of style between style classes.

The results of psychological experiments<sup>30</sup> exploring the definition of style suggest that if a feature appears in three products, it can be registered as

29 Chan, CS 'Exploring individual style through Wright's design' *Journal of Architectural and Planning Research* Vol 9 No 3 (1992) pp 207-238

30 Chan, CS 'Operational definition of style' *Environment and Planning B.: Planning and Design* Vol 21 (1994) pp 223-246

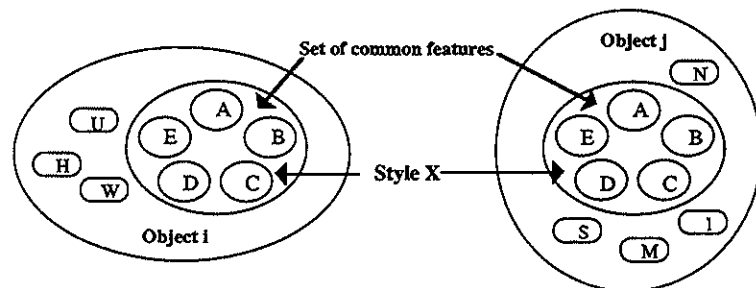


Figure 1 Objects i and j of style X share the same set of features

a common feature. If it appears in four products created by the same designer, it is a critical common feature. The set of common features is used as a measurement unit with a number assigned to represent its magnitude. For instance, the number of the common set given in Figure 1 for objects *i* and *j* is five of five features representing style X. Other features of {U, H, W} in *i* and {I, M, N, S} in *j* are distinctive feature sets. The magnitude of the number and its significance of representation set up certain restraints and expediencies to the sets. The restraint of the magnitude is the concept of measurement of styles.

If the set of common features appears in many objects designed by the same person, it signifies an individual style. If the set appears in objects designed by a group of designers, it signifies a group style. By the same token, a collection of the sets can symbolize a regional style and a period style. In the process of identifying features, there are two key issues: first, at what point are two features claimed similar enough to be the same feature, and second, will the syntax among features affect the recognition of a style?

A psychological experiment in applying geometrical and topological distortions to change the feature's shape for studying recognisability of stylistic features has yielded some interesting findings<sup>30</sup>. The experiment applied computer images of the Little House designed by Wright (1903) as stimuli. On each image, dimensions of a particular feature were either elongated or reduced by 10% at a time along the X or Y axis. The distorted features included horizontality, verticality, corner block, watertable, roof and coping (see Figure 2). The geometrical distortions, ranging from 10 to 50%, were presented on 33 cards shown to an expert on Wright's style to identify whether the modified images can represent Wright's style. The expert is a faculty member who had studied Wright's style in his Ph.D. dissertation and was teaching architectural history at the time the experiments were conducted. Results showed that if a feature was geometrically distorted up to 40%, it was still recognisable by the subject as a representative feature. Distorted beyond this level, it failed. Therefore, it may be assumed that if a feature has been distorted within the tolerable range, it still shares the same identity as its original shape. This addressed the first key issue mentioned above.

In the same experiment conducted in the same study, images with topological changes were used as stimuli (see Figure 3). Results showed that the subject did not recognize any of these distorted forms as Wright's style. This suggested that topological distortions change the syntax among features, which changes the characteristics of the product and, consequently,

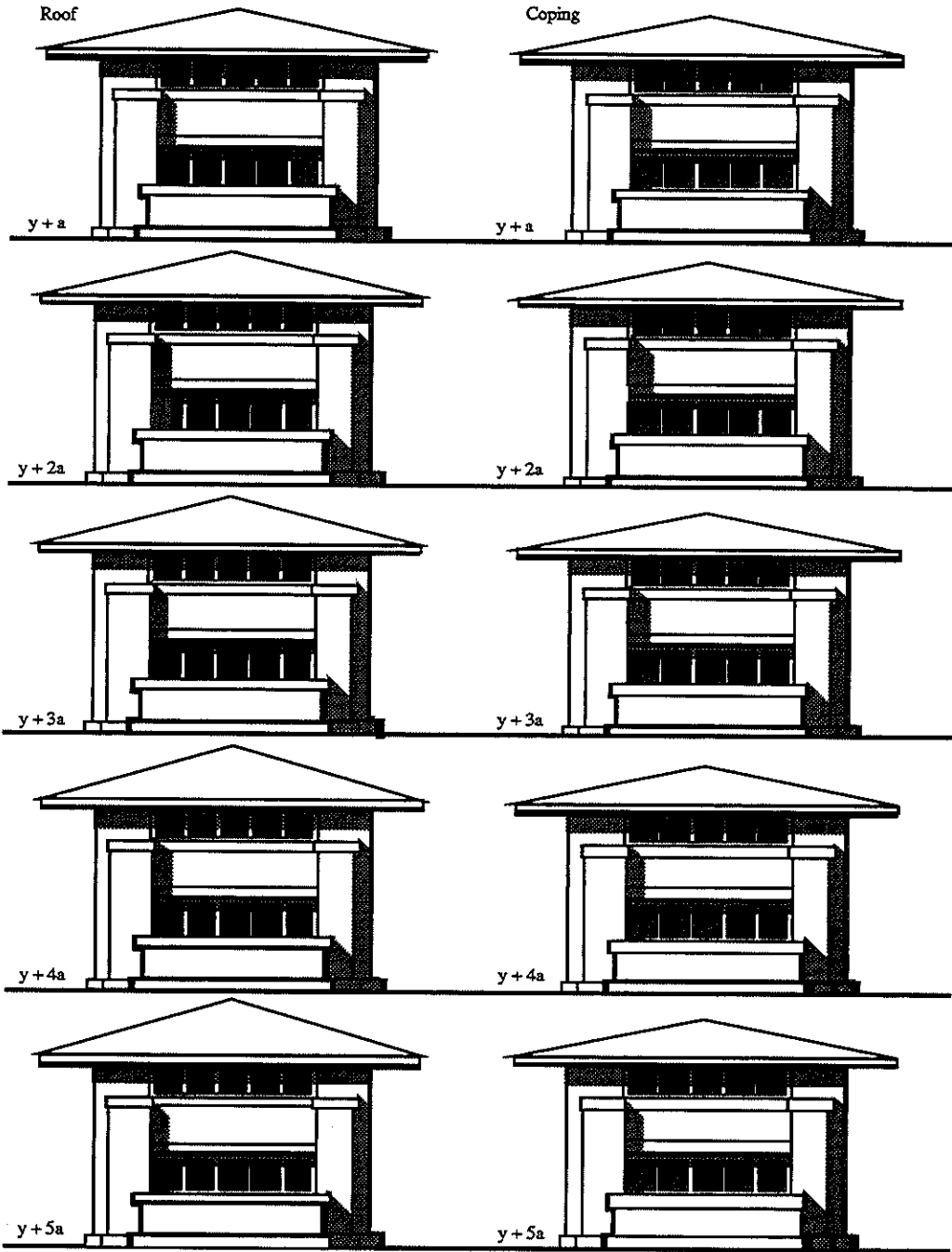


Figure 2 Distorted features of roof and coping in the Little House

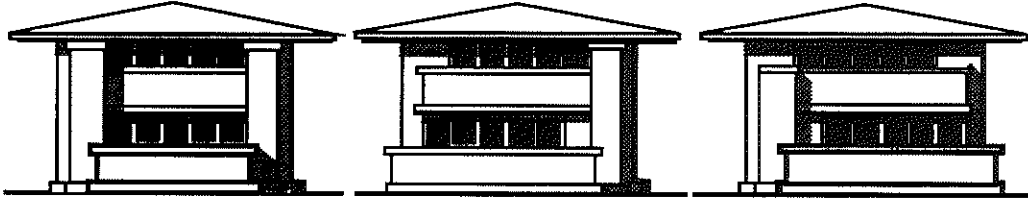


Figure 3 Topologically distorted images of the Little House

alters the style. Syntax or topological relationship among features is a crucial factor for sustaining a style. This provided a better understanding of the second issue, indicating that any changes of syntax would influence style recognition.

### 3 Measurement of the common-features set

As long as the common-features set is established for the group of objects, its number affects the recognition of its style representation. The key issue relates to how many common features are enough to represent a style. An experiment conducted in the same study by Chan<sup>30</sup> suggested that three is the minimum critical number of common features for defining a style. In that experiment, Wright's side elevation of Little House (1903) with six recognisable features was used for the stimulus. These six features were taken away one at a time until all were gone. Results indicated that if the number of common features appearing in a product is less than three, its style is barely perceptible. Thus, the set of critical common features appears to be the key for identifying a style. This suggests that any three features could constitute the basic ingredient of an image to be recognised as a member of the same style group, which signifies the perceptibility of a style (see note 6).

Often, art critics will compare many works to study a particular style. A new question arises: how to measure the magnitude (the number) of their common sets to determine whether they do share the same style? Typically, viewers use sets of features to categorise objects into styles. To categorise is to group objects and events into classes and to respond to them by their class membership rather than their uniqueness<sup>31</sup>. 'Category' means a set of entities or objects that are considered equivalent and are grouped together based on some criterion or rule. A way to compare the classes is to compare the similarities between objects<sup>32,33</sup>.

#### 3.1 Similarity between objects

Similarity is a fundamental principle by which individuals create concepts, form generalisations, and classify entities. Similarity can be explored using

31 Bruner, J S, Goodnow J J and Austin G A *A study of thinking* John Wiley, New York (1956)

32 Smith, E E Concepts and induction. In Posner (ed) *Foundations of cognitive science* MIT Press, Cambridge MA (1989) pp 501–526

33 Tversky, A 'Features of similarity' *Psychological Review* Vol 84 (1977) pp 327–352

a similarity model<sup>30</sup> based on the theory of feature matching<sup>32,33</sup>. In feature matching, similarity is a combination of the measures of common and distinctive features existing in objects. Thus, the similarity between objects *i* and *j* is monotonically related to:

$$S(i,j) = \theta f(I \cap J) - \alpha f(I - J) - \beta f(J - I), \theta, \alpha, \beta \geq 0.$$

In this model, *i* and *j* are two objects. *I* and *J* are the sets of features in both.  $S(i,j)$  is the similarity between the objects *i* and *j*.  $(I \cap J)$  is the common set of features in both objects.  $(I - J)$  is the set of features in *i* but not in *j*. If  $(\theta = 1, \alpha = \beta = 0)$  is true, similarity between objects is determined only by their common features. On the other hand, if  $(\theta = 0, \alpha = \beta = 1)$  is true, it is determined by their distinctive features only. This provides weighted difference of the measures of their common and distinctive features. The scale *f*, determined by the intensity of the geometric form, frequency of appearance, viewers' familiarity with the form, and the amount of informational content it consists of, can be used as an index to reflect the salience or prominence of the various features.

For instance, if *i* is the object selected to compare the similarity with *j*, then features on *i* should be weighted ( $\alpha$ ) more heavily than the features in *j* ( $\beta$ ). If the common features are larger in proportion than the distinct features, then  $\theta$  should be weighted more than  $\alpha$  and  $\beta$ . However, studies<sup>33,34</sup> have shown that the relative weight assigned to the common and the distinctive features may differ in various tasks. If subjects are asked to compare differences, they would give more attention to the distinctive features other than common features. In perceiving architectural images for style recognition, all features hypothetically are treated as equally important and salient to balance out the visual bias and different focuses of attention; therefore, to simplify this formula,  $\theta = \alpha = \beta = 1$  and the model can be rewritten as:

$$S(A,B) = f(a \cap b) - f(a - b) - f(b - a).$$

Where  $S(A,B)$  is the similarity between objects *A* and *B* and  $f(a \cap b)$  is the function of the quantity which is a positive integer denoting the number of common features in *A* and *B*.  $f(a - b)$  is the number of distinctive features in *A* but not in *B*. Applied to the field of architecture, the value of the similarity between two buildings,  $S(A,B)$ , is dominated by the quantity of common features and distinctive features in the buildings *A* and *B*. This value could range from positive (highly similar) to negative (highly dissimilar). An increase in the common features increases similarity and decreases difference, whereas an increase in the distinctive features

**34 Rosch, E and Mervis, CB**  
 'Family resemblances: studies in the internal structure of categories' *Cognitive Psychology* Vol 7 (1975) pp 573-603



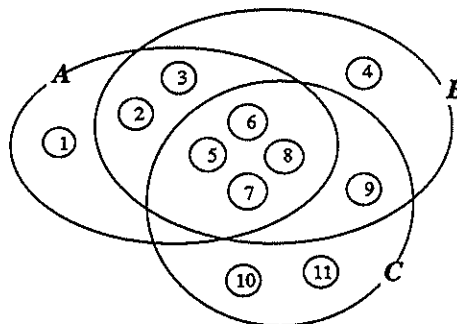
decreases similarity and increases difference. For example, three buildings—A, B and C—can be symbolized by having three sets of features, and these sets of features can be Venn diagrammed as in Figure 4. Numbers on the lists of sets represent features. The similarity scores between AB, BC, and AC are 3, 0, and - 2, respectively. If 0 stands for the breaking point, then positive 3 of  $S(A,B)$  is greater than  $S(A,C)$  of - 2, and A looks more similar to B than to C. Charles Moore's design, in general, represents vernacular style. Using photographs of his works published in various architectural periodicals<sup>35-37</sup>, 10 buildings can be used as examples for explanatory purposes (see Figure 5). As detected from the photographs, features that identify Charles Moore's style are double-pitch roof, single-pitch roof, vertical redwood siding, protruding small units with single-pitch roof, shingle roofing, left and right declining composition, white stucco surfacing, and full openings. In these examples, Charles Moore's style is characterised by this set of distinct features, but not all the features appear in each building (see note 7). This is easily explained by Moore's collaboration with other designers whose own styles affected the final product (see note 8). Sets of features can vary, permitting the definition of subsets nested in styles. Thus, features appearing in the buildings also constitute subsets. The list of common features consists of four subsets symbolised by letters from A to D that were identified from these 10 buildings (see Figure 6). The Venn diagram explains their relations (see Figure 7). The similarity between the Santa Barbara Faculty Club (1968) and Ranch (1966) is:  $S(\text{Club,Ranch}) = 2 - 3 - 1 = - 2$ ; whereas  $S(\text{Club,Burns}) = 5 - 0 - 0 = 5$ . This indicates that there are variations of magnitudes of objects within a style. Some objects look more similar together than others; thus, they more strongly represent the style than others.

**35** Bloomer, K C and Moore, C W *Body, memory, and architecture* Yale University Press, New Haven (1977)

**36** Allen, G *Charles Moore: monographs on contemporary architecture* Whitney Library of Design, New York (1980)

**37** Johnson, E *Charles Moore: buildings and projects 1949-1986* Rizzoli, New York (1986)

The key unit for determining a style has been demonstrated as the set of common features. These features provide visual clues for perception and pattern recognition. More common features yield more signs for perception



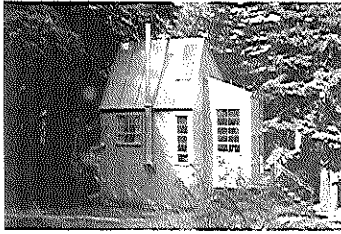
**Contents of features:**

- A: {1, 2, 3, 5, 6, 7, 8}
- B: {2, 3, 4, 5, 6, 7, 8, 9}
- C: {5, 6, 7, 8, 9, 10, 11}

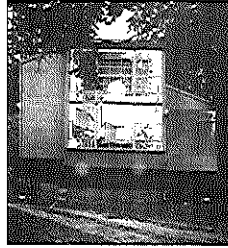
**Similarity between objects**

$S(A,B) = 6 - 1 - 2 = 3$   
 $S(B,C) = 5 - 3 - 2 = 0$   
 $S(A,C) = 4 - 3 - 3 = -2$

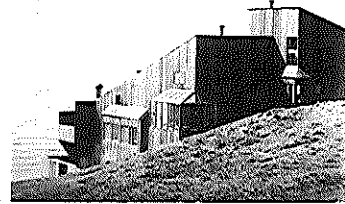
Figure 4 Venn diagram of three objects with various features



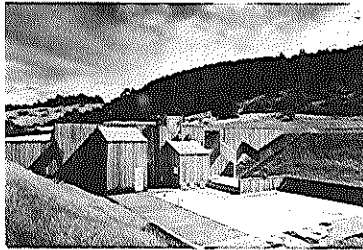
Bonham House, 1962



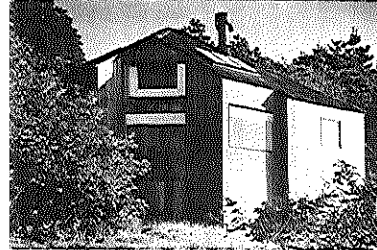
Bonham House, 1962



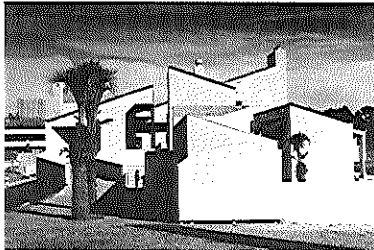
Sea Ranch Condominium I, 1965



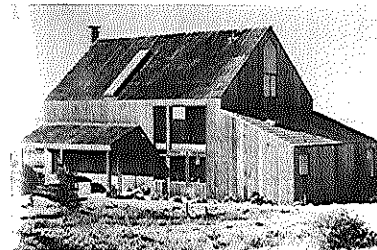
Sea Ranch Swim Club I, 1966



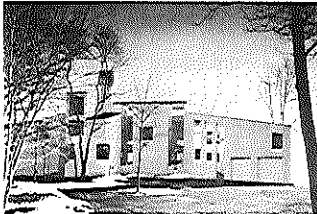
Johnson House, 1966



Santa Barbara Faculty Club, 1968



Sea Ranch "Spec House II," 1967-1969



Koizin House, 1971



Burns House, 1972



Swan House, 1976

Figure 5 Images of the buildings designed by Charles Moore

than fewer features. Therefore, the more common features that appear, the stronger the style is manifested, which is the notion of the degree of style within a style class. In other words, the set of common features that appear repetitiously in objects is a glue that binds features together into one style.

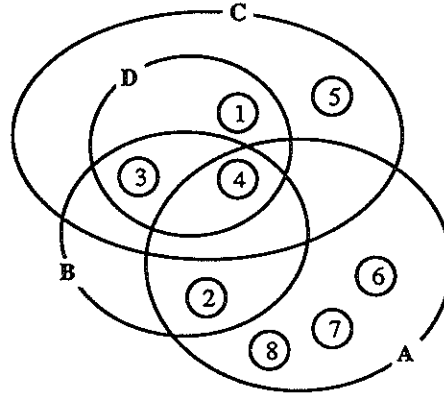
Figure 6 Features apparent in Charles Moore's 10 designs

The common set of features:

1. Double pitch roof.
2. Single pitch roof.
3. Vertical redwood siding.
4. Protruded small units with single pitch roof.
5. Shingle roofing.
6. Left and right declining composition.
7. White stucco surfacing.
8. Full opening.

Building name	Feature ID number	Subset
1. S. B. Club, 1968	2,4,6,7,8	A
2. Koizim, 1971	2,4,6,7,8	A
3. Burns, 1972	2,4,6,7,8	A
4. Bonham, 1962	2,3,4	B
5. Ranch I, 1965	2,3,4	B
6. Ranch, 1966	2,3,4	B
7. Johnson, 1966	1,3,4,5	C
8. Ranch, II, 1969	1,3,4,5	C
9. Swan, 1976	1,3,4,5	C
10. Bonham, 1962	1,3,4	D

Figure 7 Venn diagram representing subsets of features in Charles Moore's 10 buildings



More members will power the coherence of the style. This phenomenon is true both within and between styles.

### 3.2 The degree of style

The present theory indicates the set of common features in objects represents a style. A large number of common features appearing in an object would more strongly represent its style than the object having fewer common features. This is the factor of the quantity of representation determining image recognition of a style. If the set of common features exists in many objects in large quantity, then these objects will more easily be recognised as having the same style, and the style is strongly manifested by them. This factor of the quantity of representation determines the pattern recognition among styles. It also means that objects equipped with a large number of common features not only are more easily determined to have the same style but also are strongly recognised. For instance, the study<sup>30</sup> comparing the styles of Wright, Meier, and Moore from three sets of 10 buildings showed that Wright's Prairie Style, with 8–11 common features, is stronger than Meier's style with 5–6 features and surpasses Moore's style with 3–5 common features. Results of the experiments demonstrated

that the styles of Wright and Meier were identified without any mistakes, whereas Moore's style elicited some confusion. Metaphorically, the number of common features represents the strength of a glue that holds a style together. A larger set of features will more strongly hold the style together. Thus, the styles of Wright, Meier, and Moore have different strength, signifying the phenomenon of the degree of style.

The degree of style is not only influenced by the quantity of the critical common features, but also by their quality. A style is judged by the features perceived, and two factors determine how the critical common features can be perceived: (1) the size of the features in an object, and (2) the significance of perceptibility. The size of a feature correlates to its dimensions in proportion to the entire object. Large-sized features will attract more attention than small-sized features.

The visual significance of perceptibility relates to the complexity and the visual impact of the feature's shape. Some features are more appealing and attractive than others. Interesting features are more easily visualised, and a style that has such features is easier to recognise. For instance, Picasso's cubic styles and the Rococo building style with strong, bold, curvilinear shapes and heavy color are easier to identify than Pierre-Auguste Renoir's style of Impressionism (1841–1919) and the Modern International building style. Therefore, critical common features should have evaluation weight and can be used to rank how critical they are for recognising a style.

The more perceptible a feature is, the easier it is to be located and the more easily a style can be identified. This suggests variations in perceiving and expressing styles. Such variations may occur because the critical common features of a style appear in objects in different quantities and combinations: one object consists of certain features drawn from the set, while different objects of the same style have different combinations of features from the same set. For example, incorporating four features from Wright's common set into a residence design would characterise the Prairie Style. However an observer's ability to perceive the style depends upon the specific features applied. Based on the notion of strength or degree of style, the combination of a low-hip roof, a band of casement windows, a continuous band of sill, and an extended terrace with low parapet would be more perceptible as Prairie Style than the combination of planting urn, massive brick chimney, corner blocks, and watertable. In sum, different combinations of features yield different expressions and perceptibility: if the stylistic features in A are stronger than the same number of features in B, its style is stronger than its counterpart. The same is true for objects in the same style as well as the objects across styles. For instance, four strong

features from Wright's set could be more easily identified than four weak features from Meier's set. In this case, perceptibility is in proportion to the frequency with which a style can be recognized.

Taking the number of times a style can be recognised to represent perceptibility, the degree of style in a style and between styles can be diagrammed in Figures 8 and 9. Figure 8 is set up under the hypothesis that while objects A and B both represent the same style, but A with  $n$  number of strong features would be recognised more frequently than B with the same number of weak features. For example, three features having strong texture, color, and curvilinear shape will be more easily identified than three flat and monotonous features.

Figure 9 shows the degree of style between styles. If the object A representing style A' has less significant critical common features than the object B of style B', A might be less perceptible and A' is a weaker style. On the other hand, if object C of style C' has a greater number of features than the object D of style D', but they are weaker features, object C may be less perceptible and its style C' is probably weaker than style D'. There-

Figure 8 The degree of style between objects with strong and weak features

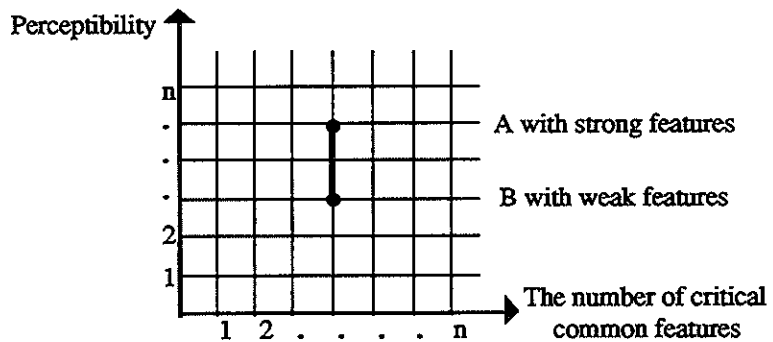
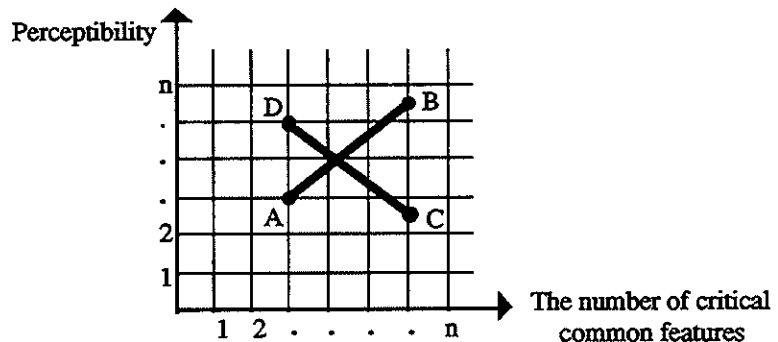


Figure 9 The degree of style between styles



fore, the degree of style is determined not only by the quantity but also by the quality of features.

## 4 Conclusions

Concepts developed in this article focus on the basic notions of style in fine arts, with the exception of discussing style in performing arts, which relates to the issues of patterns of behavior. Similar methods of identifying common features to label a style can be used to study painting, sculpture, furniture, interior design, and architectural design styles. The way to identify a style is to identify the common features that appear repeatedly in objects. In painting, for example, Johannes Vermeer (1632–1675), a famous Dutch painter, applied figures in 17th-century rooms with combinations of light, color, and proportion of objects in the room. Features appearing repeatedly in his 35 certified paintings include: light sources come from the upper left corner; black-and-white chessboard patterned marble floor tile, figures have their own visual focus point in the painting, windows in the painting are located on the left side of the wall (see note 9). These features can be used to define the set of critical common features signifying Vermeer's style (see note 10). Similar methods of identifying constant features in objects have been used to study the product style in industrial designs<sup>38</sup>.

Of course, features can change over time due to changes in social context, convention, custom, knowledge, mental image, and personal preferences. For instance, Wright's style changed from his earliest residential design (Bootlegged Houses<sup>39</sup>), which he developed while employed by Louis Sullivan from 1889 to 1894, to the Prairie houses, to the Usonian houses<sup>40</sup> throughout his career. Each stylistic period shared some different sets of features. Changes do occur with special intentions. Thus, the change of the set of common features over time marks the change of an artist's individual style. The more new features that can be created by a designer who puts them into different organisational syntax will signify more styles generated by the same designer over time. These changes of style and emergence of new common features can be used as an index to mark creativity and as a scale to measure the degree of creativity of an individual designer.

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**38** Chuang, M C and Chen, C C Exploring the perception and recognition of the eastern and western style: using chairs as examples. In *Proceedings of the 1994 Conference on Technology and Teaching—Industrial Design Section* Taiwan (in Chinese) (1994)

**39** Manson, G C *Frank Lloyd Wright to 1910* Van Nostrand Reinhold, New York (1958)

**40** Storrer, W A *The architecture of Frank Lloyd Wright* MIT Press, Cambridge MA (1974)

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Notes

- 1 The world in van Gogh's paintings was represented as a vortex of lines [see p 241 Ref. 2].
- 2 Prairie Style was originated by Frank Lloyd Wright from 1901–1910. His Prairie House Style had stimulated a number of followers.
- 3 Renaissance style was born in Italy and was primarily royal and mercantile—especially north of the Alps. The basic classical elements appear over and over again and are easy to recognize, e.g. the combination of large Doric and Ionic columns—Doric below, Ionic above, each with its correct base, capital and entablature—with piers carrying arches [see p 167 Ref. 4].
- 4 In color rendering and printing, a few color models are developed. The four common ones applied in most computer software are (1) hue, saturation, and brightness (HSB); (2) red, green, and blue (RGB); (3) cyan, magenta, yellow, and black (CMYK); and (4) CIE L\*a\*b\*.
- 5 The geometric relationships between the repeated forms define syntax, which has not been focused on in this article but will be a future topic.
- 6 Additional experiments using other buildings and styles with similar results would solidify the assertion about the set of common features being key for style identification.
- 7 The frequency of appearance varies among individual styles. In Wright's Prairie Style, for instance, a large set of common features was constantly apparent in most of his designs. Thus, Wright's style was more constant than Charles Moore's style.
- 8 Two personal interviews with Professor Charles Moore were conducted in Austin, Texas on 15 and 16 of November, 1991. This piece of information was obtained from these personal conversations.
- 9 Of course, there certainly are other features existing in the pictures relating to the use of color and techniques of stroke.
- 10 The 35 certified paintings of Johannes Vermeer have been displayed on the Web at <http://www.ccsf.caitech.edu/~roy/vermeer/thumb.html>

41 Jordan, R F A *concise history of western architecture* Harcourt Brace Jovanovich Inc, London (1969)