

An examination of the forces that generate a style

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The concept of style has long been central to both historical analysis and pedagogical discourse in architecture. Most often these discussions focus on the nature of 'signature' physical features, but notions expressed in this article would contend that several aspects of the design process are just as significant in defining a style as the replication of features. Aspects emerging in the personal design process include operations of cognitive mechanisms, utilization of repeated procedures, personal preference for certain images, and manipulation of certain seasoned design knowledge. Employment of these factors and procedures in a design process is actually the driving force that generates recognizable features to be manifest in a style. © 2001 Published by Elsevier Science Ltd on behalf of .

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1 Introduction

The major purpose of this research is to explore mechanisms involved in design thinking for teaching design studios. In general, students may have learned about many different ways of designing and, thus, started to develop their own ways. But students may not be aware of or be able to distinguish their own styles. Occasionally, similar design behaviors are repeated with the consequence that students fall cyclically into using fixed design patterns. The concept supported by this research not only provides students with a means to understand their potential personal styles, but also provides an impetus to explore other ways of designing and ultimately to diversify their design abilities.

The classical theory of style was not traditionally thought of as a theory. It was taught and learned in most disciplines not as an empirical hypothesis but as an unquestionable, definitional truth. Therefore, studies of style by historians, critics, and theorists have paid attention to design products. For



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1

- 1 Greene, T M** *The Arts and the Art of Criticism*, Princeton University Press, Princeton (1940) pp 5–12
- 2 Ackerman, J S** 'Style', in **Ackerman and Carpenter** (eds) *Art and Archaeology*, Prentice, Englewood Cliffs, NJ (1963) pp 174–186
- 3 LaRue, J** Guidelines for Style Analysis, W. W. Norton, New York (1970) p ix
- 4 Blumenson, J J G** Identifying American Architecture: A Pictorial Guide to Styles and Terms, 1600–1945 American Association for State and Local History, Nashville, TN (1977)
- 5 Banham, R** Theory and Design in the First Machine Age, MIT Press, Cambridge, MA (1980) pp 44–67
- 6 Howe, B J, Fleming, D A, Kemp, E L and Overbeck, R A** Houses and Homes: Exploring Their History American Association for State and Local History, Nashville, TN (1987) pp 97–108
- 7 Poppeliers, J C** What Style Is It?: A Guide to American Architecture Preservation Press, Washington, DC (1983) pp 10–11
- 8 Hauser, A** The Philosophy of Art History, Alfred A. Knopf, New York (1959) pp 3–17, 21–40, 43–116
- 9 Watkin, D** The Rise of Architectural History, Architectural Press, London (1980) pp vii–xi, 183–190
- 10 Kleinbauer, E W** Modern Perspectives in Western Art History: An Anthology of 20th-Century Writings on the Visual Arts Holt, Rinehart and Winston, New York (1971) pp 13–36
- 11 Finch, M** Style in Art History, Scarecrow Press, Metuchen, NJ (1974) pp 1–6
- 12 Gombrich, E H** Meditations on a Hobby Horse: and other Essays on the Theory of Art, Phaidon, London (1971) pp 86–94
- 13 Chan, C S** 'Operational definitions of style' *Environment and Planning B: Planning and Design* 21 (1994) pp 223–246
- 14 Chan, C S** 'Exploring individual style through Wright's designs' *Journal of Architectural and Planning Research* 9 (1992) pp 207–238
- 15 Schapiro, M** Style, in: Philipson, M P (ed) *Aesthetics Today*, World Publishing, Cleveland, OH (1961) pp 81–113

them, style is a mode of expression in a work of art, and they use style to characterize relationships among different persons, periods, or regions^{1–3}. Because these scholars use style as a tool to differentiate works of art, they focus primarily on interpreting features in products to discover the period⁴, group⁵, regional⁶, or vernacular⁷ styles and how they develop and what their developments mean in a social⁸, cultural⁹, political¹⁰, and psychological⁸ context. In addition, many studies have previously focused on the relationship between style and meaning^{2,11}, style and social development¹², style and political significance^{9,10} and ideology⁸. As a result, they defined styles and interpreted what styles look like periodically, regionally, collectively, and vernacularly. Rare attention has been paid to style on the individual designer's level, especially to explore the mechanisms¹ that generate a personal style.

2 How style emerges from design processes

This article focuses on how an individual style emerges from design processes, especially on the schematic design stage, which is critical to design education. The study is based on the supposition that an individual style is a function of both a set of common features¹³ and design processes¹⁴. The concept that a style is a function of common features can be explained by the magnitude of the set of common features exhibited across products of design. According to Schapiro¹⁵, style means the constant form—and sometimes the constant elements, qualities, and expressions—in the art of an individual or a group. The concept that constant forms appearing in works of art define a style also has been explained by Ackerman² in art history, Kroeber^{16,17} in anthropology, and by Smithies¹⁸ and Pothorn¹⁹ in architectural history. Following this line of thought, one may assume that the constant forms occurring in a number of designs can be used to identify an individual style in design. A study¹³ found that common features in designs actually are used by viewers as perceptual indices for classifying styles. If products share many common features, a style will be strongly expressed and recognized. Thus, the number of common features in products determines the degree of style, and a style is the function of common features.

For instance, Frank Lloyd Wright's Prairie House Style in Chicago at the turn of the century (1901–1910) can be represented by sets of common features appearing in elevations², floor plans,³ and the use of materials.⁴ A building exhibiting many of these features can be seen as representative of his Prairie House Style. Thus, the Willitts House (1902) and Little House (1903) more typically represent Wright's Prairie Style than does the Gale House (1909). Conversely, the Davenport House (1901) and the Henderson House (1901) have fewer common features than the others, so they are

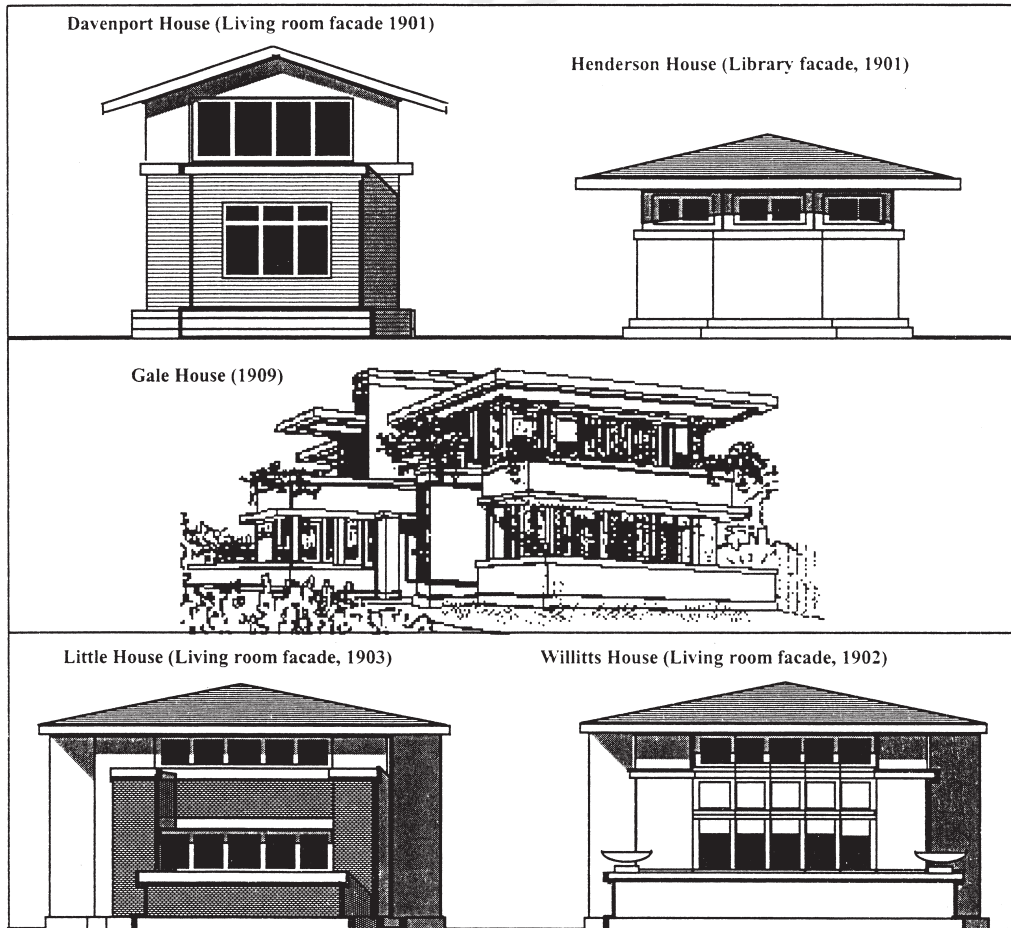


Figure 1 Wright's Prairie Style. (Drawings are generated as computer images. Elevation drawings are published in the *Journal of Architectural and Planning Research*, 1992, 9, pp. 207–238, figure 1, Locke Science Publishing, Chicago)

16 Kroeber, A L *Style and Civilizations*, Cornell University Press, Ithaca, NY (1957) pp 24–26

17 Kroeber, A L *An Anthropologist Looks at History*, University of California Press, Berkeley, CA (1963) p 66

18 Smithies, K W *Principles of Design in Architecture*, Van Nostrand Reinhold, New York (1981) p 25

19 Pothorn, H *Architectural Styles: An Historical Guide to World Design, Facts On File*, New York (1982) pp 7–12

20 Gombrich, E H *Art and Illusion*, Pantheon Books, New York (1960) pp 21–25

less like the Prairie House Style (see Figure 1). This phenomenon, that the repetition of common features reveals an individual style, also can be found in upper-level architectural design studios. For example, some students like to use circular staircases and repeat them in their designs, whereas other students prefer angular configurations. It is because of the repetition of particular features in a student's designs that an individual style is recognizable.

Another function of style is the design process, which is the focus of this article. The basic assumption is that a style is a designer's distinctive personal and professional way of doing things resulting from a series of decisions made in the process to deliberate the pattern of expression^{20–23}.

An examination of the forces that generate a style

3

In architectural design, the way of doing things refers to certain procedures of designing. Theoretically speaking, a design consists of a series of design processes, each of which can be seen as an episode that is intended to achieve a design goal by utilizing design methods. These design methods may include manipulating mental images for form generation^{24,25}, applying design rules to generate solutions, or utilizing design constraints to limit the memory search load. These fundamental components—mental images, design rules, design constraints, and design goals—are the basic factors capable of generating a tangible product, which is a form presented in certain degrees of abstraction. The presented level of abstraction in a form depends upon how far the design has been pursued and the level of details achieved. The less abstract a design product is, the more details will appear. Consequently, more features will appear in that product and a stronger style will be manifested.

Designers must go through a number of processes to achieve design goals by utilizing various methods for different projects. Repeating the design methods, certain factors may appear and reappear despite their different design natures. The repetition of these factors in different design processes would generate similar features by which a style arises. A large number of similar features generated by similar processes will express the style more strongly. This defines the proposition that a style is a function of both common features and design processes. If the repetitive factors that correlate with the repetitious generation of features in design processes can be operationally defined and verified by scientific methods, then the driving forces of a style can be explained. This serves as the premise of this research.

In order to justify the concept, empirical studies should be conducted by applying analytical methods which allow investigators to scrutinize a design process step by step. One approach uses techniques to analyze the information gathered from a design process and explores the cognitive mechanisms involved. This will yield insight into the processes by which designers solve design problems. Theories of analyzing information processing have been developed in cognitive science to study the thinking process, and a design process can be seen as a problem-solving process. Several theoretical developments in this area have provided valuable tools, which are mainly the methods of 'protocol analysis' for analyzing design procedures^{26,27}.

3 Protocol analysis

Protocol analysis is a series of procedures of collecting verbal data and systematically analyzing the data to prove hypotheses on thinking patterns

21 Gombrich, E H Style, in: Sills, D L (ed) *International Encyclopedia of the Social Sciences*, Macmillan, New York (1968) pp 352–361

22 Simon, H A Style in Design, in: Archea, J, Eastman, C M (eds) *Proceedings of the 2nd Annual Environmental Design Research Association Conference* Dowden, Hutchinson and Ross, Stroudsburg, PA (1975) pp 1–10

23 Meyer, L B Toward a Theory of Style, in: Lang, B (ed) *The Concept of Style*, University of Pennsylvania Press, Philadelphia, PA (1979) pp 3–44

24 Downing, F 'Conversations in imagery' *Design Studies* 13 (1992) pp 291–319

25 Chan, C S 'Mental image and internal representation' *Journal of Architectural and Planning Research* 14(1) (1997) pp 52–77

26 Newell, A and Simon, H A *Human Problem Solving*, Prentice-Hall, Englewood Cliffs, NJ (1972) pp 787–868

27 Hayes, J R *The Complete Problem Solver*, The Franklin Institute, Philadelphia, PA (1981) pp 51–69

or cognitive mechanisms utilized for generating solutions or decisions. The data are verbal reporting data obtained while an invited subject is working on an experiment and responds orally to an instruction or probe. The method is to instruct subjects to think aloud or talk aloud. To talk aloud is to say out loud everything one normally says to oneself silently. Three techniques have been used since 1890 to obtain verbal data: concurrent, retrospective, and introspective reporting²⁸.

- (1) Concurrent verbalization is the procedure of obtaining data while information is verbalized at the time the subject is attending to it. Ericsson²⁸ demonstrated that the concurrent report reveals the sequence of information heeded by the subject without altering the cognitive process. The method is to probe, concurrently with their performance of a task, for specific information that they presumably need to guide their succeeding behavior. In design, studies were done on running controlled experiments for identifying the mental operators and representations applied in the design processes²⁹⁻³¹, or exploring cognitive behavior through developing cognitive models that best fit the experimental data^{32,33}.
- (2) Retrospective verbalization involves asking a subject about cognitive processes that occurred at an earlier point in time. In retrospective reports of specific processes, subjects generally will actually retrieve the trace of the processes. The method is to ask subjects, to report just after the process has been completed, for information about the completion of the task-induced processes³⁴.
- (3) Introspective verbalization is the response to experimenter probes or retrospective answers to questions about prior behavior. In design, examples of studies included tape recording interviews with designers on exploring the operations applied underlying design processes³⁵, and on exploring the cognitive processes in problem-solving behavior³⁶. In forms of introspective reporting, subjects, instead of recalling related information, may report information that they have inferred or otherwise generated. This is similar to students' behavior in that students can make up whatever justifications are needed to defend their design in the final jury presentation.

While it has been generally agreed that introspection may be useful for the discovery of psychological processes involved in solving problems, it is discredited for its value of verification²⁸. Thus, only the concurrent and retrospective reporting methods are most likely to yield direct and faithful evidence of cognitive aspects in problem-solving processes, and are the most powerful means for obtaining detailed information about thinking. In the field of design, the most popular method applied for protocol analysis is concurrent reporting.

28 Ericsson, K A and Simon, H A Protocol Analysis: Verbal Reports as Data, MIT Press, Cambridge, MA (1996) pp 48-62, 109-168

29 Eastman, C M On the Analysis of Intuitive Design Processes, in: Moore, G T (ed) Emerging Methods in Environmental Design and Planning, MIT Press, Cambridge, MA (1970) pp 21-37

30 Akin, O How Do Architects Design? in: Latombe, J C (ed) Artificial Intelligence and Pattern Recognition in Computer Aided Design, North-Holland, New York (1978) pp 65-104

31 Chan, C S Cognition in Design Process, Proceedings of the 11th Annual Conference of the Cognitive Science Society, Lawrence Erlbaum, Hillsdale, NJ (1989) pp 291-298

32 Akin, O Psychology of Architectural Design, Pion, London (1986) pp 12-22

33 Chan, C S 'Cognitive processes in architectural design problem solving' *Design Studies* 11 (1990) pp 60-80

34 Guindon, R 'Designing the design process: exploiting opportunistic thoughts' *Human Computer Interaction* 5 (1990) pp 305-344

35 Darke, J 'The primary generator and the design process' *Design Studies* 1 (1979) pp 36-44

36 Thomas, J C and Caroli, J M 'The psychological study of design' *Design Studies* 1 (1979) pp 5-11

Applying protocol analysis to study design processes is very relevant. Because design thoughts are conceived and generated gradually and progressively within a process, whenever they are generated, these thoughts remain constant and available to the subject while reporting. Also, the related information is retained in the short-term memory (STM) during the entire process. Thus, reporting information that is saved and activated in STM would give first-hand data about the designer's mind. The study of this information would also provide robust evidence for the causal effect and explanations of the phenomenon of concept formation. On the other hand, data on intermediate processing are costly to gather and analyze. It is critical to consider carefully how such data can be interpreted validly, and what contribution they can make to our understanding of the phenomena under study.

Recently, protocol analysis has been used broadly as a tool to analyze design activity³⁷ and behavior³⁸, (see articles in Cross et al.³⁹). In 1994, a workshop on 'analyzing design activity' was formed in Delft, Netherlands, to study the virtue of the protocol analysis concentrating on the data analysis part. In this workshop, videotapes⁵ and transcribed protocols were sent to a group of researchers to perform the analysis in any form they chose. Even though the algorithms for transcribing protocol coding and the methods of episodizing the codes were not reported clearly,⁶ results generated by the group on analyzing the given set of protocol data have yielded many interesting findings. These findings vary from the study of social activity in a group design process⁴⁰ and episodic knowledge used in the design activity⁴¹ to verbal and visual coding applied in the design process⁴², among others. This shows that verbal data are a rich data mine which has potential for various explorations. In fact, a single set of data generated 20 different papers, which really demonstrated clearly that protocol analysis is a rigorous research tool for empirical study on design activity.

As recognized by the research society, protocol analysis is expensive and requires substantial time and energy to complete. Thus, it is costly to conduct multiple experiments observing common generic patterns of a design. Needless to say, it is luxurious to collect more than one set of data to verify the conclusions generated by those thoughtful papers completed in the Delft Workshop. In statistical analysis, a sample size (data set) of one is not sufficient to draw conclusions nor to yield sound statistical plots. It is fair, however, to treat an initial experiment as a pilot study which can be repeated by other scholars to further test the validity of findings. For this purpose, it is worthwhile to set up a public protocol data bank accessible through the Internet to be shared by the research community.

37 Valkenburg, R and Dorst, K 'The reflective practice of design teams' *Design Studies* 19 (1998) pp 249–271

38 Suwa, M, Purcell, T and Gero, J 'Macroscopic analysis of design processes based on a scheme for coding designers' cognitive actions' *Design Studies* 19 (1998) pp 455–483

39 Cross, N, Christiaans, H and Dorst, K (eds) *Analysing Design Activity*, Wiley, New York (1997)

40 Cross, N and Cross, A C 'Observations of teamwork and social processes in design' *Design Studies* 16 (1995) pp 143–170

41 Visser, W 'Use of episodic knowledge and information in design problem solving' *Design Studies* 16 (1995) pp 171–187

42 Akin, O and Lin, C 'Design protocol data and novel design decisions' *Design Studies* 16 (1995) pp 211–236

4 *Justification of approaching method*

This research explores style by identifying the repeating factors that appear across a number of design processes. Because information processing for solving design problems occurs within the designer's mind, it is necessary to first comprehend the cognitive aspect of the design process. Then the explanations of how a style is generated will be meaningful and justifiable. In this regard, the study of intelligence and intelligent systems, with particular reference to intelligent behavior as computation⁴³, becomes especially useful. The approach applied in this research is to observe a number of a designer's processes as they occur, identify the repetitious features in products, then sort out the repeated factors to explain the underlying mechanisms involved in manufacturing the features that symbolize the style.

The ultimate purpose of this research is to explore the mechanisms that produce a designer's individual style and to find whether these mechanisms have been repeatedly reused as generative forces. According to the information processing theory, cognitive aspects might differ from person to person but not within the same person. In other words, the basic cognitive mechanisms utilized by the person should remain constant to be claimed as the driving forces of a personal style. Thus, if a number of protocol data sets are collected from one person, it is appropriate to observe the generic patterns that manifest the style.

5 *Factors that relate to generating styles*

Based on the hypothesis that a style is manipulated by prominent two- (2D) or three-dimensional (3D) entities (which are termed features) generated by design processes, it is possible to see that a style is a product of certain factors that occurred in a design process. The process of architectural design is a unique thinking process that involves the use of logical reasoning, manipulation of images, 2D or 3D representation to reveal forms generated in the designer's mind, and many other mental activities. In general, there are two ways to elucidate design thinking. Seen from the view of information science, design activity is a series of problem solving, and a design has a logical and explainable sequence of processing information. This perspective has its historical context. In the 1960s, notions of systematic design emerged to provide systematic procedures for managing design processes. This movement, started by Jones⁴⁴ and Alexander⁴⁵, stimulates a completely new way of designing. From the fine arts perspective, design is to develop a piece of art with intuition involved to trigger the creation of beautiful forms and features generated in the designer's mind. Nonetheless, to achieve a persuasive study on design thinking, efforts must be focused on how information is processed in the mind, which is symbolically described as the black box in the brain.

43 Simon, H A and Kaplan, C A Foundations of Cognitive Science, in: Posner, M I (ed) Foundations of Cognitive Science, MIT, Cambridge, MA (1989) pp 1-47

44 Jones, C J 'A Method of Systematic Design' in Jones, J C and Thornley, D (eds) Conference on Design Methods Pergamon Press, Oxford (1963)

45 Alexander, C Notes on the Synthesis of Form Harvard University Press, Cambridge, MA (1964)

The information involved in design thinking has two key components: (1) symbolic representation⁷ of design knowledge and reasoning that moves the design stage forward; and (2) iconic representation that portrays the mental image of the design forms. Within a design course, these components are intentionally manipulated and handled to achieve certain goals until the final product is accepted by both the designer and the client, or by the students and the instructor. Therefore, a design process can be seen as executing a series of design goals sequentially to arrive at an acceptable solution. This is the fundamental characteristic of problem solving. Within the processes, several factors can be seen as operators to move problem-solving stages onward.

5.1 Design goals

A design goal is to accomplish a particular design task. Goals can be used as a means to differentiate stages for describing design activities. Within each goal, designers search for either the knowledge that provides solutions, or the sources of potential solutions existing in memory. That knowledge is the seasoned knowledge obtained from learning, practicing, or from various information resources. The potential solutions existing in memory can be images created in the past or cases generated in previous designs.

In designs, a process is usually based on logical reasoning used to guide the movement, and a designer has a general and common goal sequence to signify the procedures. Such a goal sequence not only defines the design strategy used in a design but also reflects the designer's general design method. Different designers have specific individual ways of approaching a design and different strategies for tackling design problems. If a designer always follows the same sequences of goals or procedures on different projects, then the products will exhibit certain similarities. As long as a pattern of design strategy repeats in designs, a style appears.

5.2 Design constraints

A more experienced designer may have a larger knowledge repertoire.⁸ But only a limited subset is utilized for a particular goal, and it sets up a design constraint. In other words, a particular set of design constraints is selected for a particular goal stage. Design constraints include spatial relationships among building elements, physical laws, structural and material properties of buildings, qualitative requirements of spaces, or energy efficiency. The repertoire of design knowledge stored in memory is in the form of chunks⁴⁶⁻⁴⁸. Each constraint is a chunk with some knowledge embedded. A solution to a design problem is generated by imposing a constraint onto the process and searching for the associated knowledge from memory to meet the problem situation.

46 Miller, G A 'The magical number seven, plus or minus two: some limits on our capacity for processing information' *Psychological Review* 63 (1956) pp 81-97

47 Simon, H A 'How big is a chunk?' *Science* 183 (1974) pp 482-488

48 Larkin, J H, McDermott, J, Simon, D P and Simon, H A 'Expert and novice performance in solving physics problems' *Science* 208 (1980) pp 1335-1342

Described another way, designers must find (or compose) an object (or form) to satisfy a set of constraints. Although some constraints are given in the design problem by clients, the designer also must provide personal constraints to help organize problems and develop solutions. Because a design problem has indefinite solution paths,⁹ each path could lead to a final solution. Therefore, a constraint helps limit the search effort in the problem space and defines the design solution path. If a designer always uses the same set of design constraints associated with a particular goal in designs, then the design solution paths will show some similarities and the products will possess resemblances. Different designers have different seasoned knowledge, which generates different solutions. However, repeatedly using the same constraint may generate similar solutions, and thus a style emerges.

5.3 Mental images

Mental image²⁵ is another design constraint. Designers often mentally manipulate the spatial relations among fundamental geometric shapes and represent the product in graphic or model representations. In other words, sketches are tried out in the mind's eye before they emerge onto the drawing board. Whenever an architect is confronted by a design problem, his or her initial problem-solving process involves a visualization of potential solutions; that is, a mental image of something not real or present. It is a mental reproduction or imitation of the form of a physical object. Gombrich²⁰ explained that one way a painter learns to paint a mountain is to go out to the field to observe a mountain. The process of observation would abstract the form of the mountain; then a pattern or a prototype is developed and stored in memory. Such a pattern not only has the form of a mental image, but also is the painter's concept about the mountain. The term 'schema' is used to describe the pattern stored in memory. The formation of the schema makes a pattern available, and the painter is able to draw his own mountain, which may not be any particular mountain but the painter's concept. In a painter's memory, there are thousands of patterns of objects that form a data bank. Similarly, in the field of architectural design, a designer may have many images of architectonic elements stored in his or her memory to form a part of the image schemata. Repetition of the same image may create similar features in design products, and a style can be easily identified.

5.4 Search pattern and order

The large sets of knowledge chunks and image schemata in memory become, metaphorically, a data ocean full of data items. The processes of searching for an appropriate item of information and applying it shape the search pattern. The search pattern can be a search for mental images, design

49 Simon, H A *The Sciences of the Artificial*, MIT Press, Cambridge, MA (1982) p 138

rules, design constraints, or design goals. Different designers may have different search patterns. For instance, some designers would rely more on the search for mental images and less on design rules or vice versa. Thus, which search pattern is utilized in a design affects the generation of a style.

Search order²² is another factor in the design process that determines a style. Designers have certain sets of procedures to determine which design unit (space requirement), design constraint, or design goal to start with. Because the process of design is considered as the process of satisfying the design constraints⁴⁹, the first object taken into consideration will satisfy a specified set of constraints and yield a first satisfying solution. Any successive object taken into account will be based on the first solution to generate a further solution that also is satisfying. Thus, the order in which possibilities are examined will have a major influence on the solution and will ultimately cast an influence on forms. Therefore, the search order also serves as a driving force of an individual style.

5.5 Personal preferences

Designers may have unique preferences for certain primitive forms or for forms that have developed in their past designs¹⁵. The primitive forms are 2D or 3D geometric shapes and volumes used in compositions. The forms generated in past designs are called presolution models³³.¹⁰ These models may serve as solutions for certain tasks in later designs. For instance, Manson pointed out that the Walser-Barton House (1903) was a schema that Wright often used as the answer to the problem of fitting a Prairie House to a narrow lot and a limited budget⁵⁰. Different individuals may have different tastes and favor certain geometric forms and forms generated in the past. The use of specific forms in designs will mark an architect's idiosyncrasy. Although preferences may change with time, the consistent application of the same form within a specific time span labels the designer's style. If a designer favors a certain presolution model, he or she will copy it to solve similar problems in later designs. Thus, presolution models maintain the same style, but a style comes from the original fabrication of the models.

6 An empirical study on the forces generating a style

The following example is given to verify the proposed concepts of the forces that generate a style. This example is based on the assumption that a design task is a design problem uniquely defined by a design brief.¹¹ For instance, a design brief may consist of a particular owner, a unique site, a certain set of constraints, a particular usage of the building, and a fixed set of space requirements (termed design units). Changing any of the settings creates a new design problem. Regardless of the changes made in

50 Manson, G C Frank Lloyd Wright to 1910, Van Nostrand Reinhold, New York (1958) p 140

51 Newell, A Production Systems: Models of Control Structures, in: Chase, W G (ed) Visual Information Processing, Academic Press, New York (1973) pp 463–526

the design brief, the driving forces remain across designs to generate certain constant aspects and produce constant forms which manifest a style. This study, therefore, purposefully alters the brief for observing the existence of consistent design procedures and to formalize the consistencies of the driving forces in order to explain how an individual style is generated.

6.1 The design tasks

The subject of this study, a professional architect, was invited to do six designs (called sessions). The design problems in the six sessions were systematically changed. Five sets of problem-definition variables were used to set up the basic design problem. The change of any one variable delimits a new design problem, as those shown in sessions 2–5 in Table 1. Session 6 had a totally different set of variables. The concept was to change the problem-definition variables for the purpose of identifying the invariant forces appearing in each process.

The basic design premise was a simplified residential design of a one-bedroom house for a young, single, male professor. The site was located in an urban area in Pittsburgh. The weather in winter was cold, damp, and windy with winds from the northeast, and hot and humid with winds from the southwest in summer. Three design issues were required: cost limitation, view requirement, and noise reduction. Five design units were essential and mandatory: a living room, dining room, kitchen, bedroom, and bathroom. Only one condition changed in each of the sessions (see Table 2). For example, in session 2, the site changed to Seattle (a mild-weather zone), but the lot size remained the same. The owner in session 3 was changed to a retired executive. An extra design unit, a study room, was introduced into session 4, and a different set of design issues was given in session 5. An entirely new set of variables was given in session 6. All these design sessions were restricted to the residential building type to avoid dramatic changes of design approach.

Table 1 The systematic change of design sessions (A, B, and C represent three different values of a variable)

<i>Sessions</i>	<i>Site</i>	<i>Owner</i>	<i>A set of design units</i>	<i>A set of design constraints</i>	<i>Result</i>
#1	A	A	A	A	Solution A
#2	B	A	A	A	Solution B
#3	A	B	A	A	Solution A
#4	A	A	B	A	Solution C
#5	A	A	A	B	Solution D
#6	C	C	C	C	Solution E

Table 2 The design sessions

<i>Session 1</i> Type: Residential Site: A Owner: A single male professor Design issues: Maximum cost x, view, noise Design units: BR, LR, DR, K, bathroom	<i>Session 2</i> Type: Residential Site: B Owner: A single male professor Design issues: Maximum cost x, view, noise Design units: BR, LR, DR, K, bathroom
<i>Session 3</i> Type: Residential Site: A Owner: A retired executive Design issues: Maximum cost x, view, noise Design units: BR, LR, DR, K, bathroom	<i>Session 4</i> Type: Residential Site: A Owner: A single male professor Design issues: Maximum cost x, view, noise Design units: BR, LR, DR, K, bathroom
<i>Session 5</i> Type: Residential Site: A Owner: A single male professor Design issues: Need skylight, maximum privacy Design units: BR, LR, DR, K, bathroom	<i>Session 6</i> Type: Residential Site: C Owner: A middle-aged couple Design issues: Maximum cost y, open and sunny interior space Design units: 2-BR, LR, DR, K, bathrooms, study, workshop, garage

The architect participating in this study was an experienced professional who was in charge of the design activities of his own firm, and had practiced in the field for 25 years at the time this study was conducted. Before the study, he was informed that each session was independent of the others and that he was expected to design in the way he ordinarily does. The six sessions were conducted at different times to diminish the possibility of learning effects. The procedures for each session were similar. First, a design brief was shown to the architect. Then, he was asked to start designing with pencil and paper and to voice his thoughts throughout the study. The processes were recorded on videotape. There was no time limitation, but the architect spent an average of 5 h to finish each design. Data were collected from verbal protocols¹² obtained from each design.

6.2 Observations

The architect created four different design solutions for sessions 1, 2, 5, and 6 within the period of two months (see Figures 2–5). The change of owner in session 3 was not significant enough for the architect to pursue

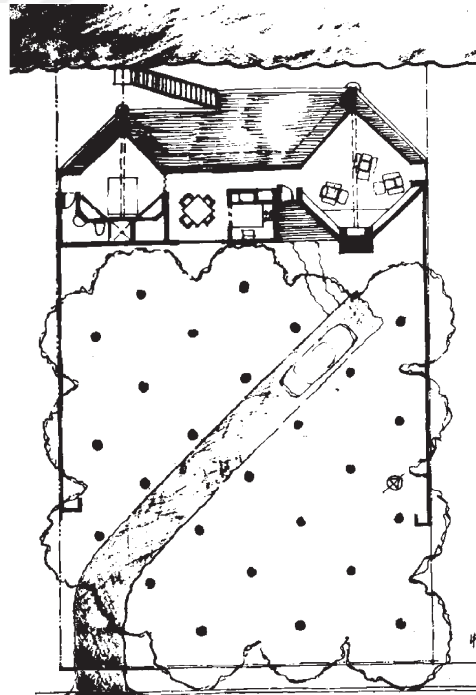


Figure 2 Plan and elevation of session 1

a new design. He indicated that the new owner could have the same design from session 1 and would be happy about the product.

For session 4 (see Figure 6), the addition of the study was accommodated in the basement with a staircase accessible to the upstairs living room. The architect called this solution a remodeling of session 1 without having major changes in plans and elevations. Unfortunately, the valuable verbal data in this session were lost due to an equipment malfunction. Thus, only

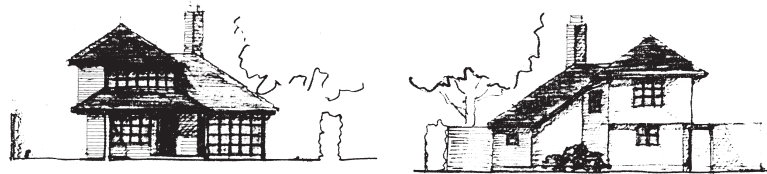
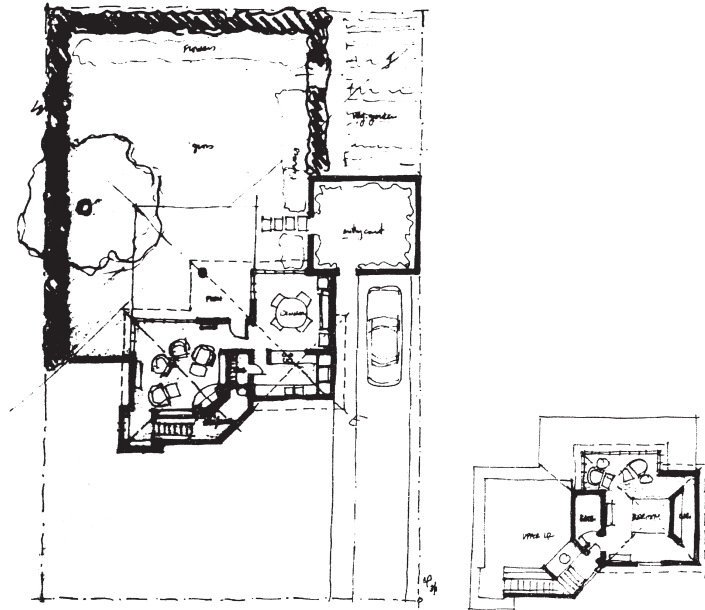


Figure 3 Plans and elevations of session 2

the processes and products from sessions 1, 2, 5, and 6 could be used for analysis.

Methods used for analyzing protocol data involved several steps, which were very time and labor intensive. First, the architect's verbalizations were converted into written forms. Then the transcripts were divided by episodes, which are discernible segments of behavior in attaining a design goal. A design goal is identified by tracing a series of actions attempting to solve one design unit, which is one of the required spaces specified by the design brief, or by identifying a particular recognizable intention under which a group of design units or an intentional design unit is to be resolved. Afterward, the transcripts of some design procedures were coded by a special format of production systems^{37,51} to represent the design knowledge used to solve a design unit. This could: (1) identify the design constraints applied within a particular goal in solving a particular problem; and (2) detect the associated procedural knowledge and declarative knowledge used by the architect.

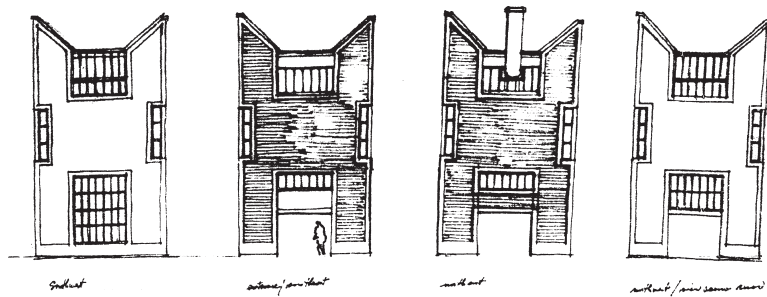
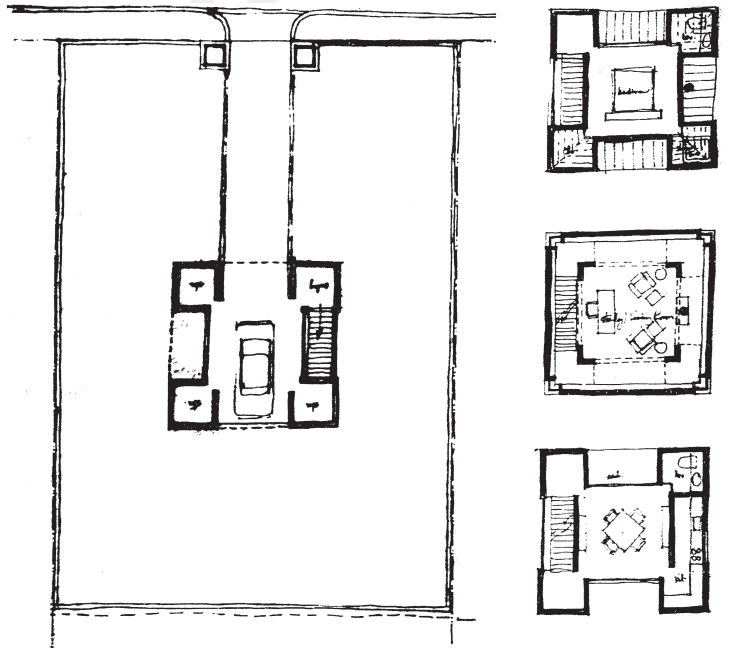


Figure 4 Plans and elevations of session 5

6.2.1 Observation on repetitious constraints used in designs

Results obtained from data analysis showed that there were, indeed, some repetitions occurring throughout the entire design processes. For instance, the set of constraints used in four designs was sunshine/light, view, context, and budget. The sunshine/light constraint was used to determine the orientation of the kitchen, which is located on the southeastern corner of the site. The architect said that "...in the kitchen you could see someone come in, see out into the garden, and you could get some sun in the morning." The same constraint was repeated in the final solution of sessions 2, 5, 6, and in a conceptual scheme of session 1.

It also was found that the architect had precise rules for applying the con-

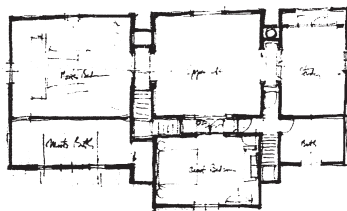
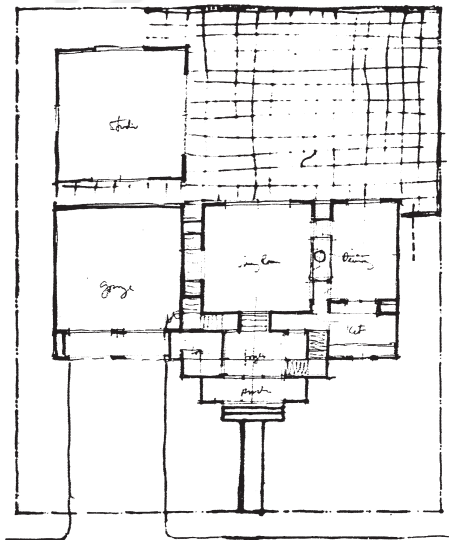


Figure 5 Plans and elevation of session 6

straints. Those rules that explicitly define the contents of a constraint are the main factors creating identical results (solutions). For instance, in session 6, the architect said:

Well, I guess the position of the studio really depends on whether this artist would like the light in the morning. If you put it over here [western site], you can get a morning light [from east], and you can give her morning light, and that can be some late afternoon light [from west]... I am going to assume she doesn't work [elsewhere], that she prefers to be over here [on the site], where she gets eastern light in the morning, and maybe you do some skylights [above] there [in the south of the room], something to give you a little [from south] during the day, and maybe more private in this [north] side. Yeah, I think that is what we are going to do for her.

52 Foz, A Observations on designer behavior in the parti, The Design Activity International Conference, Vol. 1 Printing Unit, University of Strathclyde, Glasgow (1973) pp 19.1–19.4

Described in brief technical terms, parts of the sunshine/light constraint can be represented by schemata representation¹³ as shown in Table 3. The name of the schema is symbolized by <light>, and the following <X> signifies the working design unit. The entire rule is shown by an 'if-then' clause representing a production system. Design actions (procedural

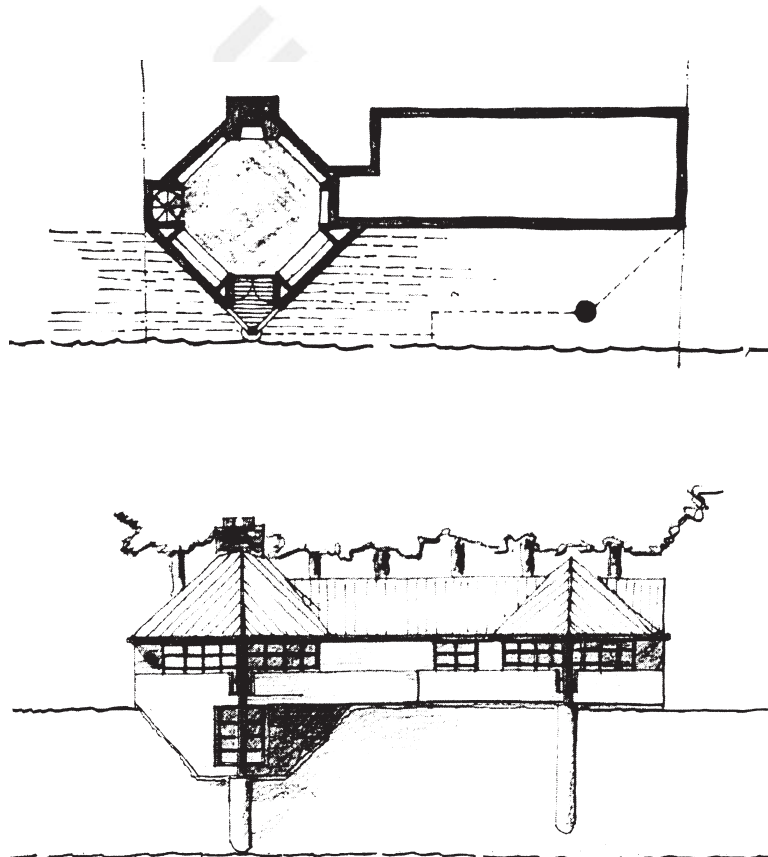


Figure 6 Floor plan and elevation of session 4

Table 3 Inferred rules in the light constraint schema

Light schema:

<Light>(<X>)

Rule 1: If <light-source>=morning light/sun
and <X>=kitchen

Then <X-location>=eastern part of the site
and <opening-location>=eastern surface

Rule 2: If <light-source>=morning light/sun

Then <opening-location>=eastern surface
and the axis from <light-source> to <opening-location> is not intercepted

knowledge) are displayed on the right-hand side of the system, and the left-hand side represents declarative knowledge. Embedded in the sunshine/light constraint is another rule that prohibits any interceptions (rule 2 in Table 3). The same rule also applied in session 1 to test a generated solution. The architect said, “And the bedroom would be in this little spot here. It is not going to get any morning sun. Oh, it is not going to get any morning sun.” Because of the repetitious manipulations, the final

forms of 2, 5, and 6 have the same spatial arrangement for the kitchen floor plan.

The context constraint related to the use of a 25-foot setback from the street side and 5-foot setback from the property line to define the site plan. The budget constraint showed a unique method of applying an average unit-cost-per-square-foot to divide the given budget for determining the room sizes, dimensions of the house, and the materials to be used. Other constraints were associated with each design session: for example, views must be provided by an inner court, a view path must be set from the kitchen through the dining room to the outdoor viewed object, and the living room and dining room must be located at the back of the house.

6.2.2 Observation on repetitious utilization of design goals

Sequences of design goals reveal a designer's strategy of managing a design process to finish a design. Without having a goal sequence, a design would not move on effectively to achieve a promising solution. In a design studio, an instructor could teach the same design method, but students eventually will develop their own methods, which are different from the ones of the instructor and fellow students. Regardless of the variations among individuals, a designer may have different strategies available under different design conditions and situations. After many years of practicing, however, an experienced architect must have developed a general routine for approaching a specific design type, and a fixed routine should exist and be applied on designs of the same type. In this observation, the architect has a routine which represents his general design method appearing in four designs.

The architect's general method was to first understand the design program and the site issues. Then, based on the information, a set of important design constraints was listed and a semantic solution¹⁴ was developed to resolve these global constraints. Afterward, the architect determined the construction budget upon which the total floor area and the room sizes were decided. Then, based on the semantic solution of the constraints, the architect developed a graphic design scenario on the site map to serve as a guide for future design procedures. The design scenario went through a series of refinements to produce a workable scheme, and the floor plans and elevations were developed accordingly. The design goals and their specific order in four designs can be described in diagrams as shown in Figure 7. This sequence signifies the design method utilized by the architect.

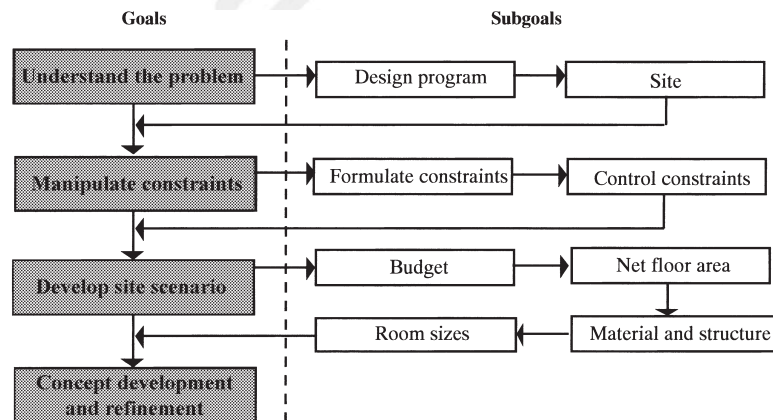


Figure 7 Design goals and their sequences

6.2.3 Observation on repetitious presolutions used in designs

A presolution model is a well-defined, concrete 2D or 3D form representing a design solution generated in previous designs. It can be recalled from memory, modified, reapplied, and saved to memory again for future use. It is analogous to the terms of a case,⁵³ a parti⁵², or a priori concept⁵³. The architect in this study applied several presolution models to generate design scenarios and to resolve design details. The replicated presolution models were kitchen and dining room relationship, walk-around closet, skylight, and window pattern. The kitchen and dining room relationship and the window pattern were solutions obtained from the architect's designs in a different context.¹⁶ The walk-around closet solution was developed in the first design (session 1) and repeated in the other three designs (sessions 2, 5, and 6). A skylight solution was developed in session 5 and repeated in session 6. The architect also used images¹⁷ from his own past designs to work out concepts and details. The applications of the repeated presolution models created similar configurations and forms in the final products.

⁵³ Kant, I Critique of Pure Reason, Cambridge University Press, Cambridge, UK (1998)

⁵⁴ Gardner H Frames of Mind, Basic Books, New York (1983) pp 170–204

6.2.4 Observation on repetitious mental images used in designs

Spatial ability as described by Gardner⁵⁴ is a source of intelligence. An expert designer has more mental images stored in memory than do novice designers²⁵. Parts of the stored body of mental images are previous design solutions, and others are primitive shapes and forms. A designer may prefer certain shapes and primitive forms and apply them as visual vocabulary for a period of time. For instance, Michael Graves used a heavy column and a wedge shape on top or reversed the composition in several projects

during the 1970s (see Figure 8). The feature of this composition is very simple and easy to recognize; it is a strong signature of Graves' style in the 1970s. Similarly, the architect used a U-shape with articulation in the curve on floor plans in this study as shown in Figure 9.

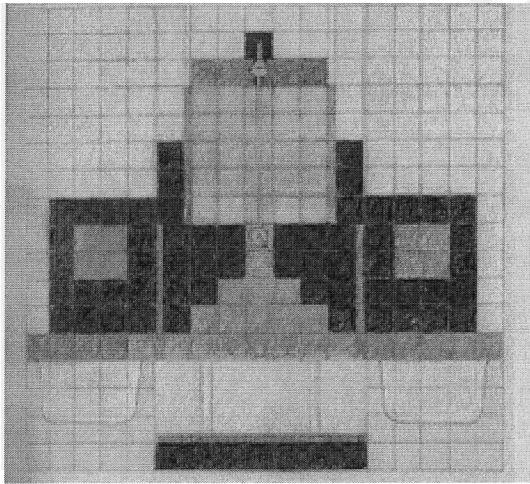
Other repetitious features found on the study subject's floor plans and elevation drawings together with the studied causes that shape these forms are summarized in Table 4. These forms and the primitive geometry were easily recognizable and identifiable in the final products; they had direct influence on the final appearance. Thus, the favored forms served as signatures to mark the architect's personal style and are direct factors on generating a style.

7 Discussions

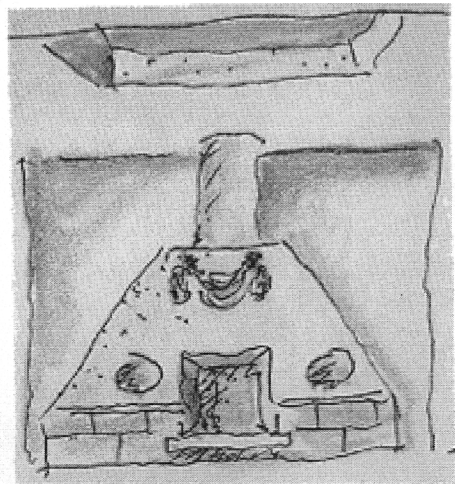
The intentions of this research were to establish and test the operational concepts of style through design studies. The concepts emphasized are that: (1) repeated forms are used to identify a style; and (2) repeated factors in processes creating the repeated forms are the driving forces in generating style. Those forces are assumed to be the designer's seasoned knowledge together with the design constraints applied at each design stage, the fixed order of design goals, presolution models, and the designer's favored forms.

Results obtained from analyzing four design sessions in this study showed that: (1) there were repetitions of forms in plans and elevations; (2) some processes were apparently consistent; and (3) relationships existed between these forms and processes. Interestingly, some relationships between processes and forms could be clearly traced from and supported by protocol data, whereas some could not (see Table 4). For the replicated forms that had no evident generating process, data show that the architect simply drew the forms without verbalizing the causes. This is because the architect retrieved the images of those forms from memory and applied them directly into the design.

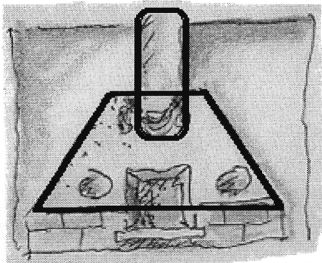
Many examples obtained from the study results indicate that using presolution models, primitive forms, and constraints has a direct impact on forms. Therefore, these variables are regarded as *direct factors* in expressing a style. There also were instances of repeated processes for achieving design goals, but this consistency did not generate any immediate influence on final forms. There were, however, certain constraints constantly bound to certain goals. For instance, the architect mainly applied the budget constraint to achieve the goal of determining the building size, and applied the constraints of context, light, view, and budget to accomplish the goal



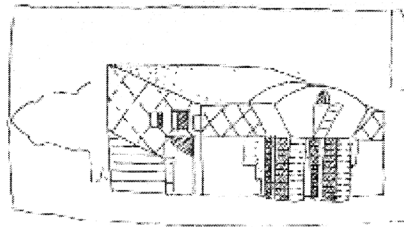
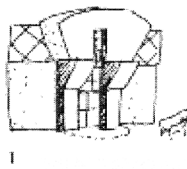
Warehouse Conversion, Guest bedroom, 1977.



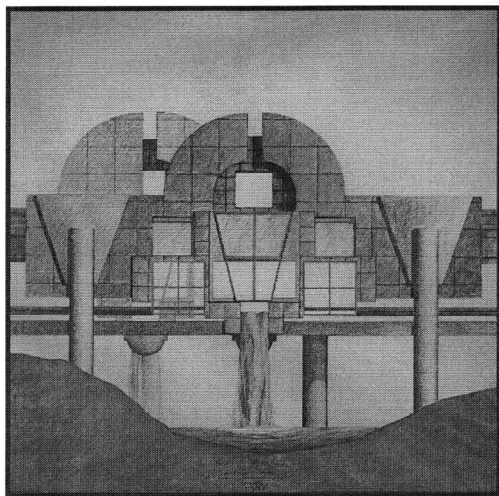
Schulman House, Fireplace sketch, 1976.



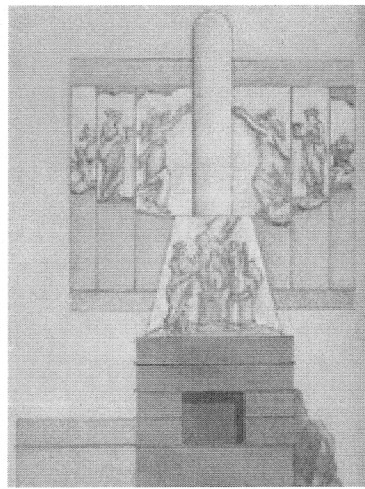
The primitive features.



Abrahams Dance Studio, preliminary studies, 1977.



Fargo-Moorhead Cultural Center, 1977-1978.



Crooks House, Fireplace detail, 1975.

Figure 8 The primitive forms used by Michael Graves in the 1970s

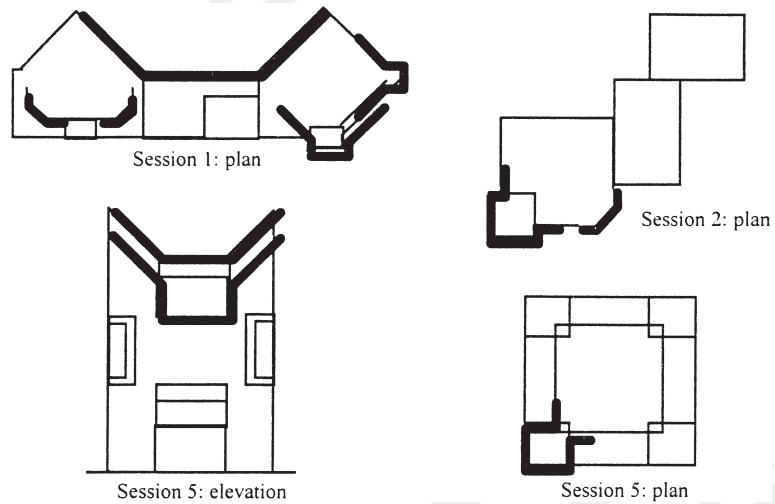


Figure 9 Primitive forms
(originally published in
Environment and Planning
B, 1993, 20, pp. 391-423,
figure 8, Pion Limited,
London)

Table 4 Repetitions of forms and their causes

Features	Session 1	Session 2	Session 5	Session 6	Forces
<i>Elevation</i>					
Horizontal broad siding	+	+	+	+	Constraint
Grid pattern, full-height window	+	+	+	-	Presolution model
Double-pitch roof	+	+	-	-	Presolution model
Exposed column	+	+	-	-	
Brick chimney	+	+	-	-	
Circular metal chimney	-	-	+	+	
Corner plate	-	-	+	+	
<i>Plan</i>					
Bed with walk-around closet in the back	+	+	+	+	Presolution model
Sink in kitchen facing a window	+	+	+	+	Presolution model
Corner windows	+	+	+	-	Presolution model
Stair case around LR	-	+	+	+	
Entrance next to kitchen	+	+	-	+	Constraint
A corner fireplace	+	+	-	-	
An enclosed inner court	-	+	-	+	Constraint
Kitchen in front of DR with views through	-	+	-	+	Constraint
Skylight	-	-	+	+	Presolution model
Symmetry	+	-	+	+	

of developing the site plan. The change of the design goal order changed the sequences of design constraints and, consequently, changed the design method and the resulting form. Thus, design goal order is regarded as an *indirect factor* contributing to the formation of an individual style.

The style generated by the architect in this study can be seen as a weak style⁵⁵ that compares to the works created in his design firm. In other words, if many strong and significant features appear in products representing a style, this style can be claimed as a strong one compared with the one with fewer and less significant features⁵⁶. In this study, the architect spent an average of five hours for each design. The products are very schematic, and fewer features have been added into them; thus the style resulting from the short-term effort is regarded as a weak style. It should be noted that the term 'weak' style at this point signifies the quantity, not the quality of the style.

Finally, seasoned knowledge is a very influential factor in determining the generation of the pattern of an individual style. It is a body of specialized, expert knowledge that a designer acquires through education and practice. If a designer is interested in energy-related issues, he or she is likely to apply more energy-related knowledge for design decision making. The design forms would reveal more lighting-related features. For instance, an experienced architect who participated in another study on design process showed such a tendency. This architect has been practicing for more than 25 years and is teaching energy-related courses and studios in an architecture department at a university.

The second study used to test the concept of seasoned knowledge in this article was on a kitchen design. As with the previous study, the architect was required to think aloud the entire time he was designing. The given design problem was to design a kitchen for a new house with four bedrooms and a two-door garage in Ames, Iowa. The budget was US\$225,000. Several design constraints were required: (1) the client wants views; (2) the design should include at least one entrance and window; (3) reduce the street noise as much as possible; (4) the total square footage of the kitchen is between 200 and 350 square feet; and (5) the whole family loves a colorful appearance and good materials for the kitchen facilities. Again, the entire design process was videotaped.

55 Chan, C S 'A cognitive theory of style' *Environment and Planning B: Planning and Design* 22 (1995) p 468

56 Chan, C S 'Can style be measured?' *Design Studies* 21(3) (2000) pp 277-291

The architect spent 90 min to finish the kitchen design as shown in Figure 10. Because he is an expert in energy-related issues, his design reflected such a character on determining the orientation (see the sketch) and the materials applied on elevation (see perspective drawing). His verbalization

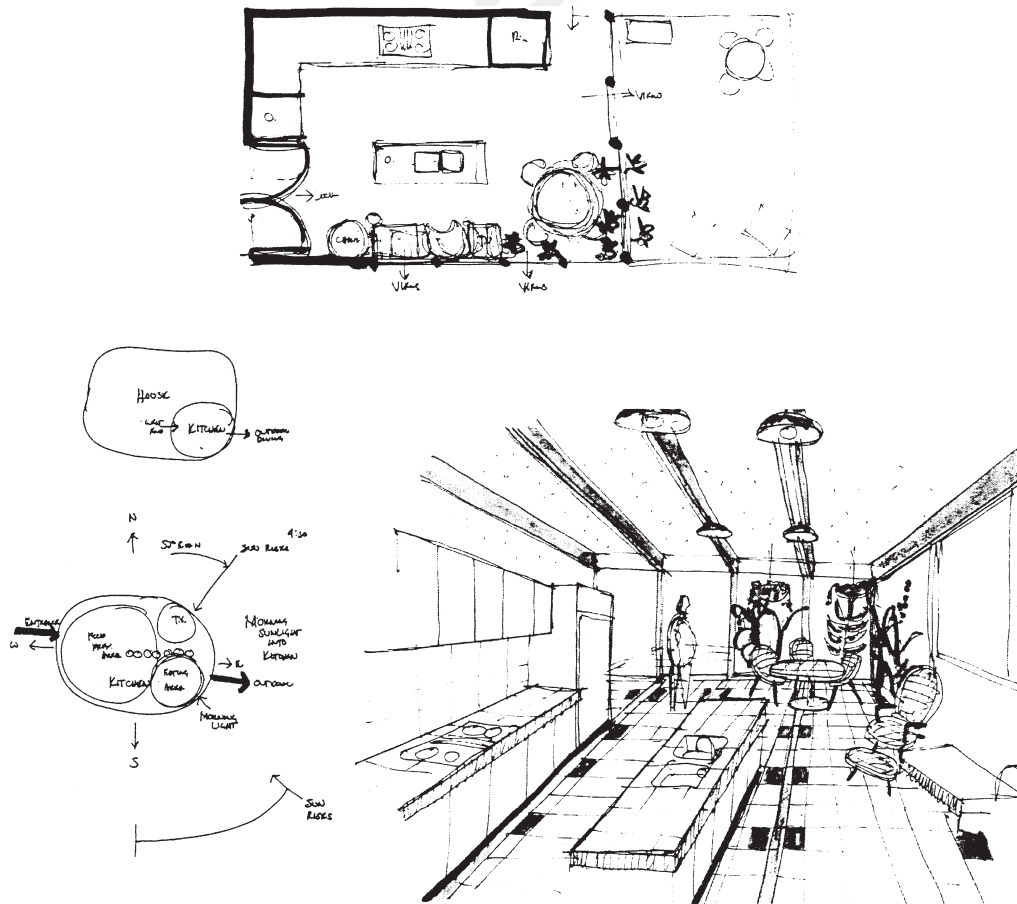


Figure 10 Sketch, floor plan, and perspective drawings of a kitchen design

obtained from the protocol data, as cited in the following, indicates his seasoned knowledge.

If this is my overall kitchen bubble (diagram)... If I orient this within the house on a southeastern corner, where this would be north, east, west, and south; if I orient this within the bigger area of the house, and this kitchen is located in this area here (0:05:41)... then in the winter when the sun rises in the southeastern sky about 53 degrees east of south, I'm a passive solar architect, so I just happen to know these dimensions (0:06:06)...

I will always have morning light into this kitchen. Now I am going to say one thing that is at variance between the old Iowa farmer and a more modern household is that a farmer may have liked to get up at the crack of dawn to go to do his farm chores. No one else seems to want to do that. And therefore if you come into the kitchen early in the morning, if there is some light coming in it just makes it a far more

cheerful situation (0:06:43).

Now in the summer, the sun rises 53 degrees east of north at about 4:30 in the morning. What this means is that this kitchen is in the southeastern corner. I will always have morning sunlight... coming into the kitchen (0:07:13).

And also that in the summer time in the late afternoon, when it's very hot, the sun is beating on the house, having sun beating into the kitchen is not necessarily a good idea. So this is a perfect orientation. I'm going to orient this kitchen in the southeastern location of the house, and I'm going to be making some assumptions here that it would be nice to be able to lead out to an outdoor eating area on the eastern part of this house. And that probably the entrance to the kitchen. A major entrance coming from within the house is probably on the west end. Now if that's the case and I like that in concept... (0:08:24).

If an architect is interested in structure and specializes in truss, his or her design would have more features on truss structure. Seasoned knowledge is a long-term factor that builds throughout a long effort of cultivation of interest and expertise. This phenomenal aspect is more apparent in works by expert designers who have long been devoted to the profession than the works done by students in design studios. Individual style appearing at the studio design stage tends to be more apparent in the selections of media and mode for presentation style.

The concept developed here formulates a theory about individual style. The theory can be applied to differentiate a bad style from good ones. A good style is judged by the characteristic context that is generated by the topological relationships among features⁵⁵. Theoretically, a poor topological relationship is determined by: (1) the disproportion of features and among features (see the example shown in the upper right drawing of Figure 11; the upper left drawing is the original living room facade of Wright's Little House design in 1903); (2) poor aesthetic expressions (as shown in the lower left corner drawing in Figure 11); and (3) the violation or conflicts of functional requirements (as shown in the lower right drawing in Figure 11). These could be the consequences of having poor quantity and quality of design knowledge, image, methods, and design goals. A poor topological relationship will cast a bad characteristic context, which is regarded as a bad style.

8 Conclusions

The discussed theory of individual style provides a notion about the understanding of a style that can be applied as a theoretical basis to studio teaching. For example, the theory can be used to help instructors and students identify students' design tendencies reflected in the design processes,



Figure 11 Examples of bad or poor styles (author)

and thus provide the basis for modifications that can improve their design skills. For instance, a better understanding of design constraints will improve design knowledge. More design experience will accumulate more available presolution models. Investigating various existing and precedent geometric forms will increase the ability and opportunity for creating forms. Exploring algorithms of solving design problems will improve the ability of achieving design goals. A comprehension of the processes that generate a style will enhance the possibility of changing an individual style and diversifying design ability.

On the other hand, if an instructor repeats similar critiques or routinely focuses on certain design aspects, then students may digest the same set of information and reapply it again in designs. If there are repetitions of replicating the learned knowledge in designs, the design constraints, goals, methods, and preferred images might reoccur cyclically. Consequently, some individual (student) styles will be generated within a group (studio) style.

This study was a first step in establishing a process by which the factors of generating styles could be studied, and the findings gathered from this study support the assumptions. In other words, it was hypothesized that certain behaviors determined an architect's style; observation confirmed that this architect did, in fact, exhibit those behaviors. However, it was difficult to establish that the products of those behaviors were definitely

the elements of the architect's style or that his style was recognizable. If several experts in style could examine this architect's works and identify the elements by which his style can be accurately defined, then it would strengthen and contribute to the reliability and validity of this research.

In summary, a style results from executing fixed sequences of design goals (design method), applying fixed sets of constraints (design knowledge) at each goal stage, and exercising preferred presolution models and primitive forms (images). Based upon the observations made in this research, the study of an individual style should be approached from both the common-features and design-process points of view.

Acknowledgements

The writing of this article was supported by a Faculty Improvement Leave Grant. The author would like to express his gratitude to the architects who participated in the two studies, consisting of seven sessions of protocol analysis experiments, highlighted in this article.

Notes

- 1 The term 'mechanism' refers to an instrument or process that does something or gets something into being, especially, any system of parts that operate or interact to generate a style.
- 2 The set of common features found in most elevations are: a low hip roof, a band of casement windows, continuous bands of sill, extended terraces with low parapet and coping, a watertable, corner blocks, planting urns, a massive brick chimney, a continuous wall between sill and watertable, overhanging eaves, and a symmetric facade.
- 3 Features in floor plans are: (1) a fireplace at the center; (2) no basement, no attic; (3) walls extended to form terraces and courts; (4) a major shape in plan that is long and narrow; (5) four principal spaces of living room, dining room, kitchen, and entrance occupy each end of the crossed axis.
- 4 Features found in most building materials are: (1) most houses are wood trimmed with white stucco; (2) oak is the major material used in the Prairie Style (see pp. 210–212 Ref. [14]).
- 5 An individual designer and a three-person team of designers worked on designing a fastening device for 2 h were videotaped⁵⁷.
- 6 It was found in Goldschmidt's paper that the protocol of the individual designer was divided into 28 units by the subject matter ranging in length from 1 to 8 min, whereas the protocol of the team has 45 units ranging from 1 to 9 min⁵⁸.
- 7 A representation means a set of conventions about how to describe a class of things. Knowledge representation signifies a set of conventions available for rationally describing design knowledge. The set of conventions can be seen and elaborated as a hierarchical network of symbols stored in the designers' memory. Each symbol in the network has attributes defining architectural objects.
- 8 Designers have a large set of design knowledge accumulated from experience. Generally speaking, design knowledge consists of two major parts, declarative knowledge and procedural knowledge. The declarative knowledge is factual information and the procedural knowledge signifies actions or know-how information. Schemata are kinds of knowledge representation representing design constraints with design rules embedded. They usually are expressed in the form of production systems. A production system is an ordered set of processes called productions. Each production contains a paired condition and action. The condition part contains declarative knowledge, and the action part has a set of rules representing the procedural knowledge. Whenever a condition is satisfied, then an action is executed. See Newell and Simon, *Human Problem Solving*, pp. 32–33. In architectural design, the application of a constraint from human memory at a particular design stage will make the associated rules available and a solution can be generated.
- 9 Usually, a design problem contains an initial situation for the designer and is referred to as the initial state. A goal state is the stage at which the design problem has been resolved. The process of problem solving from initial state to goal state can be modeled as a series of transformations generating a sequence of problem states. A problem state is a particular stage in which a designer knows a set of things, and is referred to as a knowledge state. The various states that the designer can achieve are called problem spaces. The various ways of changing one state into another are symbolically called paths. A solution path is the path leading to the final solution.
- 10 Presolution models are developed from experiences in which a designer starts out with some constraints in a procedure and arrives at a product.

57 Dorst, K 'Analyzing design activity: new directions in protocol analysis' *Design Studies* 16 (1995) pp 139–142

58 Goldschmidt, G 'The designer as a team of one' *Design Studies* 16 (1995) pp 189–209

11 A design brief describes the nature of a design task, which can be categorized as the owner's background (social, cultural, and economical), building type, design issues (design constraints), site issues (climatic, contextual, or geographical conditions), and space requirements (the quantitative and qualitative requirements). The term 'owner' should be referred to as users in a larger context or in a complicated building design.

12 It is essential to get enough data about the individual designer, the information he has, and how he is processing it. The method is to use the high output rate of verbal behavior as data which are termed verbal protocols. The process is to instruct the designer to report verbally everything he thinks about as he works on the design problem.

13 The notion of the light schemata differs from the notion of pattern language developed by Christopher Alexander in 1977. Pattern language is a method of generating building designs. It is an approach which constructs concepts for a building by combining patterns for smaller parts of the building. "The elements of this language are entities called patterns. Each pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice" (see p. x Ref. [59]). A pattern can be selected from past experience or from precedents that seem most appropriate for the new project. Then a pattern is developed by combining smaller patterns to represent a summary of the building element and to show the overall idea of the building. This method of combining patterns to solve a design problem differs from applying design constraints and their associated rules for solution generations.

14 The term 'semantic solution' refers to a solution that is very abstract and is expressed mostly in verbal terms. The subject in this experiment always developed the first overall idea (solution) of the building in the form of a design scenario that managed his listed design issues. The solution at this stage was very flexible, schematic, and open-ended.

15 Case-based reasoning relates to the comparison a new situation to existing situations, selecting appropriate architectural solutions from memory and adapting those solutions.

16 These were confirmed from interviews with the architect after the studies were completed.

17 The architect verbally described the location, the date, and the form of the images of his early design works. In some instances, he also sketched the images.

59 Alexander, C A Pattern
Language, Oxford University
Press, New York (1977)