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The Relationship of Complexity and Order in Determining Aesthetic Preference in Architectural Form

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Abstract This investigation, based on empirical research, examined the role of complexity and order in the aesthetic experience of architectural forms. The basic assumption of this study was that perception in architectural form is a process of interpreting a pattern in a reductive way. Thus, perceptual arousal is not determined by the absolute complexity of a configuration. Rather, the actual perceived complexity is a function of the organization of the system (order). In addition, complexity and order were defined and categorized into four variables according to their significant characteristics; simple order, complex order, random complexity, and lawful complexity. The series of experiments confirmed that there is a point on the psychological complexity dimension which is optimal. By demonstrating that consensual and individual aesthetic preference can be measured to have a unimodal function of relationship with complexity, the results of the experiments indicated that complexity and orderliness are effective design factors for enhancing aesthetics of a building facade. This investigation offered a conceptual framework that relates the physical (architectural form) and psychological factors (complexity and order) operating in the aesthetic experience of building facades.

Keywords: Complexity, Order, Aesthetic Preference

1. INTRODUCTION

The concept of complexity has been at the center of aesthetic theories not only in architecture but also in numerous fields such as experimental psychology, environmental psychology, and urban and landscape planning. Many psychological studies demonstrate that humans prefer relatively complex patterns in their visual field. Furthermore, The overall finding in this area of research is that there is an optimal range of perceptual input, such that both overly simple and chaotically complex visual fields are disliked.

According to the studies in the field of experimental and environmental psychology, stimulus complexity is one of the critical properties which determines the aesthetic quality of visual stimuli. The existing literature suggests that some degree of ambiguity and complexity are necessary for accomplishing a visually appropriate environment because they help to achieve an optimal perceptual rate which is related to richness and diversity of perceptual input. Even though complexity might not be a primary concern for many fundamental design and planning decisions, it should be remembered that ambiguity and complexity are important design components that enhance the visual quality of the environment. Furthermore, as the Kaplans indicated, complexity is one of the properties the environment must possess to enhance people's well-being and effectiveness (Kaplan & Kaplan, 1982). The basic problem is how complexity can be achieved in design, particularly when something as varied, complicated, and all-inclusive as architecture is treated as a design problem.

There are two principal ways in which complexity relates to architecture. The first is associated with classification complexity. In this case, complexity occurs whenever building appearance violates one's schema through ambiguity or contradiction. The second concerns perceptual complexity which involves the rate of information across a given milieu. Thus, this investigation, based on empirical research, intends to examine perceptual complexity in architectural form as a predictor of aesthetic experience.

The general objective of this study is to examine the role of complexity and order in determining the aesthetic experience of architectural form. More specifically, this study examines how the complexity, in relation to its order, of the building facade affects the observer's visual perception of the built environment. Even though complexity and order are essential aesthetic properties in architectural form, few studies define those terms in a practical manner.

For this purpose, complexity and order are defined and categorized into four variables according to their significant characteristics. Second, aesthetic appreciation as a function of complexity in building facades is examined. It is expected that these

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results will generate a model for predicting the aesthetic value of architectural form relative to complexity.

This research is intended to confirm the importance of complexity and order as essential design properties. The purpose is neither to address the philosophical problems of architectural form nor to evaluate the artistic value of architectural form. The intention of this study is to inform architects about issues that are essential to the achievement of aesthetically pleasing building facade design.

2. THEORETICAL BACKGROUND

2.1 The Theory of Psychological Complexity

Complexity refers to the amount of information in a given stimulus. Based on research by Berlyne (1960, 1974) and his colleagues, the Kaplans (1982) have suggested that complexity is necessary for visual reference. However, as an environmental property, the meaning the Kaplans ascribe to complexity is different from that described by Berlyne. They suggest that it should be based on visual 'richness' or 'diversity' rather than on the number of different countable elements. Although there are substantial differences in viewpoints that are concealed by this generic concept, many studies have characterized and generalized the function of pleasantness and of preference judgments of visual patterns on complexity. In this regard, Walker's (1980) theory of psychological complexity and preference is representative. It is comprehensive and it involves a limited set of definitions and predictions. The model's main theoretical concepts are as follows:

1. Psychological complexity: A property of all psychological events in interactions between an individual organism and its environment. Analogous concepts include neural net complexity, subjective uncertainty, and amount of perceived information. It is also distinguished from *a priori* complexity (assumed distal stimulus properties), consensual complexity (group mean ratings), and subjective complexity (individual ratings).
2. Optimal psychological complexity level: A relatively stable characteristic of an individual organism. Analogous concepts are optimal arousal level, optimal degree of risk, and information processing capacity.
3. Simplification: Semipermanent decreases in the psychological complexity of an event as a result of continued interaction. Analogous concepts are neural net organization, uncertainty reduction, and chunking of information.

These three definitions constitute the theoretical vocabulary in the following predictions about the functions relating aesthetic preference to psychological complexity.

Considering the relationship between preference and complexity, probability of choice and affective values are presumed to be inversely dependent on the distance between the psychological complexity of a given event and optimal psychological complexity level. Thus, an inverted U-shape function should be obtained when the participant expresses preferences for a range of visual stimuli including some that are more complex and some that are less complex than his/her optimal level.

In summary, all functions relating complexity to affective response and experience to affective response should be unimodal (inverted U-shape, monotonic increasing, or monotonic decreasing), but the particularly appropriate function is determined by characteristics of the individual organism and environment under consideration. This predictive flexibility makes the theory of psychological complexity and preference an especially attractive model for the study of preference for architectural form.

2.2 Stimuli properties and arousal potential

According to Berlyne (1971), aesthetically pleasing or rewarding events always produce observable changes in arousal level. The characteristics on which the pleasantness or unpleasantness of a stimulus hinges are those that determine arousal changes and thus make up "arousal potential". The point is that pleasantness or rewards are associated with biologically important effects that are not confined to the sense organs and the nervous systems. Those values depend on the kinds of stimulation that reach the sense organs and the relations between the processes that they bring about in the brain. These consequences depend mainly on form, structure, or relations among elements, or on the collative stimulus properties. Additionally, Berlyne extrapolated other aspects of stimuli and provided a theoretical rationale for it. The arousal potential of a stimulus is determined by its collative, psychophysical, and ecological properties.

According to Berlyne, the collative or structural properties, such as novelty-familiarity, simplicity-complexity, clarity-obscurity, and expectedness-surprisingness, are the most significant of all for aesthetics. Berlyne (1971,1974) reviewed several studies showing that preference is related to collative variables in the inverted U-shape. However, he noted that this is not always the case, especially when small ranges or the entire range of the collative property in question are included in an experiment. For example, Munsinger and Kessen (1964) investigated preference for random polygons ranging from 3 to 40 sides. Number of sides or turn was taken to be an index of complexity. Peak preferences were found for polygons with medium complexity but also for those with very simple and very complex. The results indicated meaningfulness of the patterns, such as simple geometric triangle or naturalistic or fanciful objects, also accounted for an appreciable part of the variation in preference ratings. When meaningfulness of the polygons was controlled for, however, an inverted U-shape emerged between preference and complexity. Even with this procedure, preference for very simple polygons remained. Thus, Berlyne concludes that there are two types of pleasing patterns: (1) very simple patterns, which are pleasing but uninteresting, and, (2) complex patterns, which are both pleasing and interesting.

Psychophysical properties are physical qualities of the stimulus, such as intensity, pitch, hue, or brightness. There is even less consistent evidence that preference is related to psychophysical variables in an inverted U-shape. Vitz (1971) found such a relationship for loudness of pure tones, whereas Berlyne, McDonnell, Nicki, and Parham (1967) and Guilford (1954) found monotonic relationships. Guilford (1940) found a monotonic relationship between preference and color saturation, whereas Granger (1955) found an inverted U-relationship. In all of these studies, a wide range of stimuli was investigated. Thus, the contradictory results are not due to restriction of range, but to stimulus domain.

Ecological properties refer to the innate or learned signal value, meaningfulness, or associations of a stimulus. If semantic categories are defined in terms of prototypical stimuli, there is evidence that preference is generally related to meaningfulness in either a monotonic increase or in a inverted U-shape (Rosch, 1975). This is the case for furniture (Whitfield & Slatter, 1979), houses (Purcell, 1984), and examplars of semantic categories (Martindale, Moore, & West, 1988). In all cases, the most prototypical stimuli are maximally preferred.

All these findings suggest that semantic categories might be better predictors of pleasantness than collative variables (Martindale, Moore, & Borkum, 1990). The reason research in environmental psychology has produced confusing results for predicting the relationships between preference and complexity may be caused by lack of control of these semantic variables. For example, the research by Kaplan, Kaplan, and Wendt (1972) demonstrates that content of the stimuli -natural scenes versus urban scenes- is a better predictor of preference than is complexity.

In summary, the theory of psychological complexity and preference is a theory of an organismic -environmental interaction. First, psychological complexity is a hypothetical characteristic of an individual organism and its environment, which is subject to individual differences and must be distinguished from distal stimulus complexity. Stimulus (or a priori) complexity is a stable property of the physical environment serving as a methodological approximation to psychological complexity. Second, preference is jointly determined by the optimal complexity level, which is an individual difference variable, and psychological complexity. Thus, the arousal level of an individual is correlated with his/her perception of the interestingness (or preference) of the environment. The arousal level is dependent on the structure of the environment and on the personality and motivational or needs level of the individual. It, therefore, conforms to Lewin's (1946) formula for behavior determinism, B = f (P, E). These interactional assumptions about behavior are useless, however, unless stimulus materials are chosen so as to make the assumptions reasonable and meaningful (Heyduk, 1972). As reviewed in the former section, psychological complexity is a viable interactional construct only if experimental materials are selected based on their intrinsic appeal. When stimuli are irrelevant or uninteresting to a research participant, an individual might respond to stimuli as an impartial observer, producing orderly data on the basis of organismically-irrelevant dimensions of the stimuli that would not be part of his/her psychological environment outside the experimental setting. For such individuals, judgments of complexity and preference will have nothing to do with psychological complexity or its relationship to preference. Finally, the assumption in this investigation is that as stimulation varies so does the perception of the aesthetic quality of the source. Thus, if one could measure the stimulation afforded by different patterns of the physical environment and understand the affective responses of different people to these, then one could have an empirical theory of environmental aesthetics.

2.3 General Hypothesis

In architectural form, it is assumed, that contrast-coherence, dissimilarity-similarity, discontinuity-continuity, and distance-proximity work in combination with the Gestalt laws, and are more paramount in our perception and in the determination of complexity. These properties are not determined by a single element, but rather they are determined relatively between the elements. This relationship is usually denoted as an 'order' in architectural terms, and "making sense" is comprised of the two-dimensional attributes of complexity and coherence in the Kaplan's conceptual theory (Kaplan, 1973).

By now, it has been made clear that the degree of complexity in an architectural facade can be increased or decreased by altering several characteristics: number, shape, relationship, and surface treatment (material) of building elements. Therefore, it can be argued that the operational concept of four different complexity variables - random complexity, lawful complexity, simple order, and complex order- can also be manipulated by altering the building elements. The characteristics of building elements and complexity variables used for this investigation are summarized in Table 1.

Table 1. The synthesized model for operational concepts of complexity with its treatments

Treatment Building Elements	**Complexity Variables**			
wall surface, window, column, door, shading ornament	Random Complexity	Lawful Complexity	Simple Order	Complex Order
Number of Elements less elements<more elements	Decided by the number of elements which are not constrained by Additional regularities.	Decided by the number of elements which are constrained by additional regularities.		
Shape of Elements simple shape<complex shape				
Surface Treatments less materials<more materials				
Absolute complexity is linear to perceived complexity. (Non-metric properties)				
Relationship of Elements			Measured by Coding* method which follows the law of Iteration, symmetry, distribution, continuation, and chunk	Additional regularity: Regularities are made conspicuous by drawing auxiliary lines in a building façade.
Absolute complexity is varied according to the degree of orderliness. (Metric properties)				

*Coding Theory and its method were fully described in the "An analytical study on the quantitative information rate of architectural façade by applying Coding method", Journal of the Architectural Institute of Korea, (2001), v17 n3, pp. 101-108.

Now consider aesthetic preference. A theory of psychological complexity and preference should be applicable to the aesthetic response to architectural form. If we have an array of architectural facades representing a sufficient range of complexity levels we should obtain one of the following different functions when an evaluated variable, such as aesthetic preference, is plotted against a structural variable, such as psychological complexity:

1. a monotonically increasing or decreasing function,
2. an inverted U-shaped function, or
3. a double inverted U-shaped function (non-monotonic or bimodal function).

Former investigations have proved that the basic inverted U-shaped function should occur whenever a person is asked for his or her preference among samples from a dimension of complexity ranging from very high to very low and when the choice is made in terms of the intrinsic properties of the stimuli (Walker, 1973). These results have been demonstrated by using various stimuli covering sound sequences such as musical scores (Crozier, 1974; Heyduk, 1972), visual patterns such as simple geometric shapes (Berlyne, 1963, 1971, 1972, 1974; Normore, 1974; Vitz, 1966), and natural and man-made environments (Nasar, 1988b; Ulrich, 1983; Wohlwill, 1976). Thus, if a person is presented with an array of architectural stimuli that vary in complexity, and is asked to make a judgment of how well he or she likes the building forms relative to each other, an inverted U-shape function should be the result.

Monotonically increasing or decreasing functions may occur if the range of stimulus complexity selected for the experiment is located at either end region of very high or very low complexity. Walker (1973) also indicated that monotonically increasing function can occur whenever the choice is not based on the intrinsic qualities of the stimuli, but rather on the instrumental role of the stimuli in reducing the complexities of other complex psychological events.

The double inverted U-shaped function characterizes Adaptation Level Theory, and the Discrepancy Theory of Affect. It is obtained in any situation in which adaptation level theory is applicable (Walker, 1973). Affective theory insists that needs, values, and motives play a part in structuring perceptual processes. When a single stimulus stands out from the others in a series because of increased exposure, higher intensity, or repeated occurrence it becomes the dominant stimuli. It is apparent that the amount of influence exerted by a stimulus on Adaptation Level or its contribution to the pooling that results in the formation of Adaptation levels, will increase from series of stimuli to predominant stimulus, since there is more stimulation and involvement of the participant. With psychological complexity and preference theory, therefore, Walker indicates that this adaptation may result in a temporary reduction in the complexity of an event and a correlated reduction in preference. The following experiments, however, were controlled to minimize those variables within the manipulation of stimuli and during the experimental procedures. Finally, if the statistical representation is an U-shaped or non-monotonic pattern, it can not be hypothesized that the human perceiver experiences an optimal level of complexity relative to aesthetic preference.

3. METHODS

3.1 Research participants

One-hundred thirty-six undergraduate students (seventy-five males and sixty-one females) participated in the experiment. The ages of the majority of the participants ranged from twenty to twenty-two (127 of 136 research participants). Because there were potentially contradicting results in which learning and experience influence complexity and aesthetic preference ratings, the data from twelve participants who had former experience in art and architecture were excluded in this study. The data from ten participants who demonstrated poor reliability or lack of discrimination in their use of the rating scale were also excluded from the data analysis. Therefore, the remaining 114 data sets (fifty-seven males and fifty-seven females) were used for the data analysis of this study.

3.2 Stimulus material (Building Simulation)

For this research, four scale models of building facades, varying in level of complexity, were employed. In order to control the degree of complexity of design elements of a building facade and to limit the role of confounding variables, a simulated model was chosen to be the stimuli. For the control of confounding variables the configuration of building elements was limited to the following criteria: shape of elements, number of elements, and relationship of elements.

The architectural buildings used as stimuli for this study were selected based on the following three criteria:

1. Medium rise buildings (under five stories) were chosen to control variation of building size that might affect the response. Tall buildings might distort perceived building elements due to perspective.
2. The expressive character of buildings, such as churches with crosses, or houses and apartment complexes which may contain overt building shapes such as gable roofs, were avoided to stabilize the symbolic variables. It is expected that these controls minimize conceptual pre-disposition.
3. Because this study dealt directly with building forms, architecture that was distinctive in its geometric shape and building elements had priority in the selection.
4. According to the criteria described above, one sample prototype building, Villa La Roche-Jeanneret designed by Le Corbusier, was selected for the experiment (Figure 1). This building, built in 1923-25, represents the typical style of Modernism with its pure architectural form.

The north elevation that is the main facade of this building has fifteen windows (9 of those windows are divide by several mullions), two garage doors, two doors and two shadowing-overhangs over each door. While keeping the same number of these elements, the original building facade was simulated for varying degrees of complexity having common features in complex order and random complexity but varying in simple order. Complex order that is determined by regularity lines on a building facade was kept constant through all stimuli with the regulating lines A and B, which were used to order the facade in the original design by Le Corbusier (Figure 1). Therefore, two main regularity lines A and B were applied consistently to all of four different simulated models. There is one additional feature in complex order that each bay, divided vertically by main features of building elements, has the same Euclidean distance. All four simulated models also had very low random complexity because all building elements were governed by the regularity lines A or B. It should also be mentioned that the total number of building elements were not changed because varying the number of elements -for example, increasing or decreasing the total numbers of window elements- necessarily destroys the entire configuration of the selected building form. If the number of elements on building facade is held constant for various combinations of variables, degrees of random complexity and lawful complexity counterbalance each other, because those two variables are defined by the same parameters but distinguished by the presence of additional regularities. If random complexity increases, lawful complexity decreases in the same ratio, and vice versa. Therefore, lawful complexity was excluded in the manipulation.

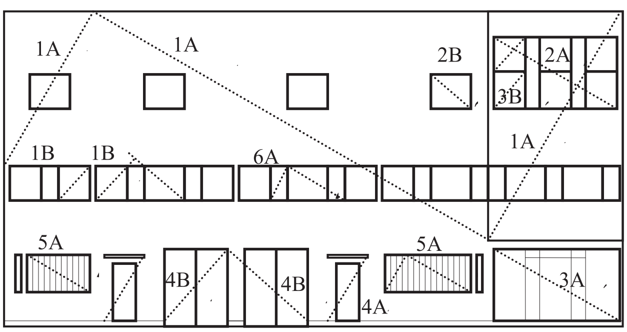


Figure 1. North Elevation of Villa La Roche-Jeanneret with its regularity lines

From this common format, complexity differences were achieved by varying simple order. This was achieved by altering the shape and relationship of the building elements while keeping the total number fixed. Here, level of complexity in simple order was represented by information load and it was quantified by using the Coding rules developed by the author.

Table 2. Summary of building simulations used in the Experiment of aesthetic preference for building complexity

Stimulus Designation	**Simple Order** **Total number of Information Load(I)**	**Complex Order** **Additional regularity lines**	**Random Complexity** **Number of free parameters which do not governed by additional regularity**
A	35 complexity low	Regularity lines A and B. Five vertical bays in the building elevation have equal ratio.	All building elements are governed by regularity lines A or B.
B	42		
C	48		
D	54 complexity high		

An attempt was made to construct a range of building complexity while making certain that all simulations of the set had the same fundamental building qualities. The range was achieved by varying total information load in simple order which on an *a priori* basis seemed likely to promote differences in the psychological complexity of perceptual interactions with the different simulations. However, it must be made clear that the manipulations indicated in Table 2 did not exhaust the possibilities for creating a perceptible span of visual complexity and may not even represent a broad enough range for demonstrating the expected relationship between aesthetic preference and building complexity.

The size of each photo arranged on the questionnaire was $5^{1/2}$" x $3^{3/4}$". Because the order of photo arrangement may influence response, eight different forms were used, each having a random order of four different photos. Therefore, no more than seventeen persons among 136 research participants used the same questionnaire relative to sequence of model photos. Final photos of the four different simulated models used for this experiment are shown in Figure 2.

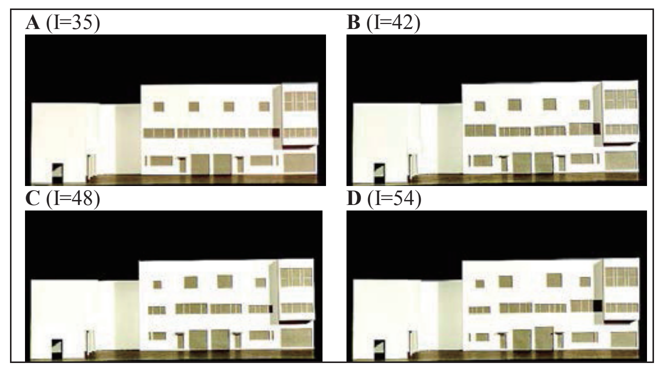


Figure 2. The tested building elevations in the Experiment with those information loads

3.3 Procedure

The participants were asked to mark the aesthetic level of each building elevation under the rating scale corresponding to the appropriate categorical scale markers. Each selection is to be rated for "how much do you like it" in terms of its beauty. It was asked to select the number that best reflects their judgment of aesthetic pleasantness using the twelve-point scale ranging from 'nothing at all' to 'extremely high aesthetically pleasing'.

4. ANALYSIS AND RESULTS

4.1 Static aspects of rated complexity and aesthetic preference: Group analysis

The function of mean rated aesthetic preference versus consensual complexity appears in Figure 3 as the monotonic decrease with the point of modal preference at building simulation A. Summary statistics are also shown in Table 3. A significant degree of agreement among the individuals in rating the level of aesthetic preference was again found (Kendall's W = 0.356, df = 3, $p < 0.001$). There was also a statistically significant difference in the median values among the treatment groups (χ^2 = 120.631, df = 3, $p < 0.001$). The unimodal relationship supports the notion that complexity accounts for some of the variance in participant's judged aesthetic preference for a range of building complexity. However, finer-grained analyses are needed to clarify whether the relationship between complexity and aesthetic preference is of the sort expected by the theory of psychological complexity and preference.

Table 3. Descriptive statistics for judged aesthetic preference in the Experiment

Stimuli	Sample Size	Mean	Std. Dev.	Std. Error	Median	Sum of Squares	Mean Rank
A (I=35)	114	5.78	2.69	0.25	6.00	4583.00	3.15
B (I=42)	114	5.17	2.27	0.21	5.00	3593.50	3.06
C (I=48)	114	3.43	2.12	0.20	3.00	1829.50	2.23
D (I=54)	114	2.40	2.03	0.19	2.00	1112.00	1.55

Note: 0 = least aesthetically pleasing, 10 = most aesthetically pleasing, I = information load

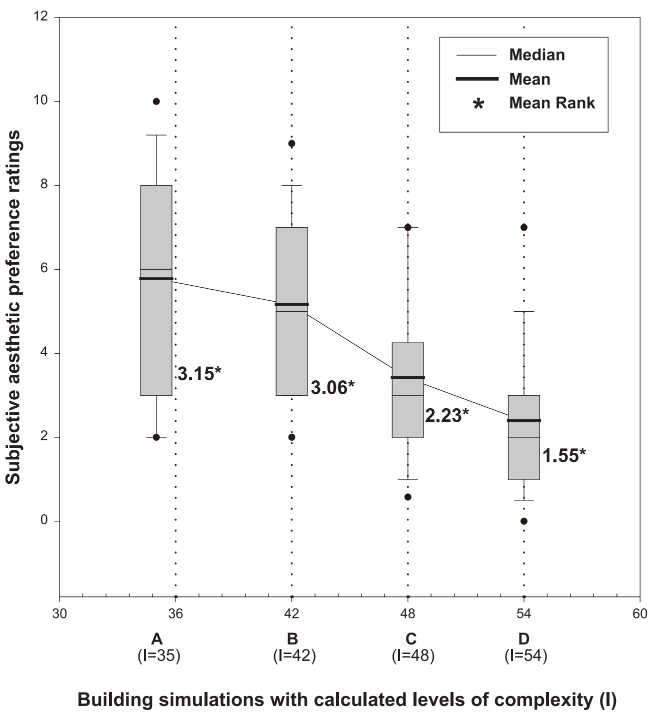


Figure 3. Mean rated aesthetic preference of building simulations with calculated levels of complexity ordered according to construction procedures (*a priori* complexity)

Note: Aesthetic rating scales: 0 = Nothing at all, 0.5 = Extremely less aesthetically pleasing, 1 = Very less aesthetically pleasing, 2 = less aesthetically pleasing, 3 = Moderately aesthetically pleasing, 4 = Somewhat more aesthetically pleasing, 5 = More aesthetically pleasing,….,7 = Most aesthetically pleasing, …………, 10 = Extremely high aesthetically pleasing (almost maximum)

A somewhat stronger statement about the theory's usefulness for describing the data is implicit in Figure 4, where mean aesthetic preference for each of the four building simulations was examined in separate graphs. These graphs show mean rated aesthetic preference and complexity of building simulations by participants exhibiting peak preference for each of the four building stimuli. For example, the lower right quadrant of Figure 4 demonstrates that those participants whose peak preference was for D (N=8) and decreased monotonically in order of C, B, and A. The lower left quadrant of Figure 4 also shows that participants with a modal preference for B (N=35) rated building simulation C higher on the average than did the eight participants whose peak aesthetic preference was for D and even than those participants who preferred A best (N=61). All four quadrants of Figure 4 display either monotonic increase and decrease or inverted U-shape unimodal functions in aesthetic preference while complexity ratings are all monotonically increased in the same order of A, B, C, and D. These relations indicate that every possible strong prediction about relative preferences which may be made is confirmed: the mean rated aesthetic preference for any building simulation by any group of participants is typically higher than the mean rated aesthetic preference for the same simulation by another subset of participants whose group optimum is further away from that simulation. These data support the use of rated aesthetic preference as a measure of relative distance from optimal psychological complexity level on a between-subject as well as a within-subject basis.

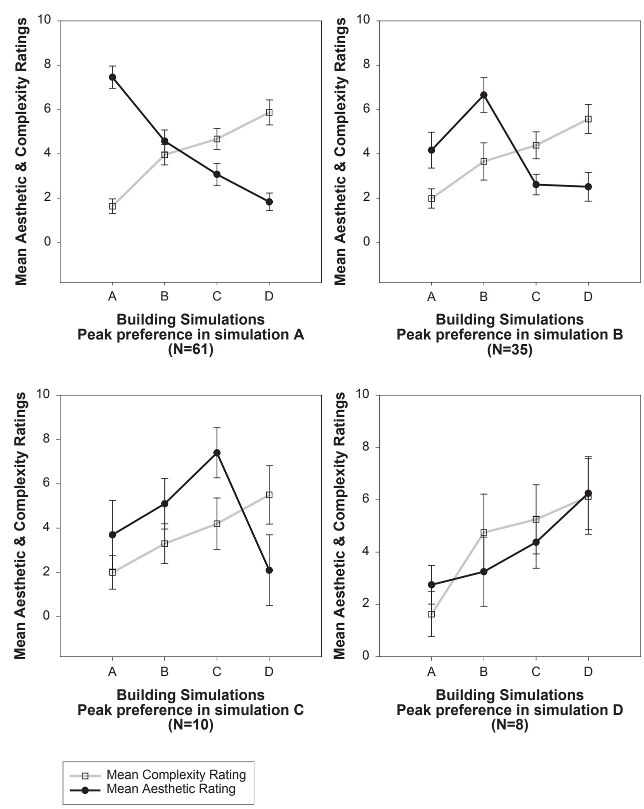


Figure 4. Mean rated aesthetic preference of individual building simulations by participants exhibiting peak preference for each of the four simulations

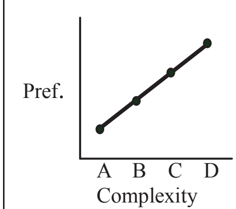
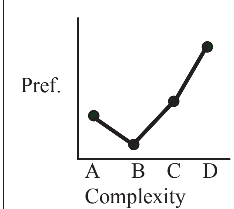
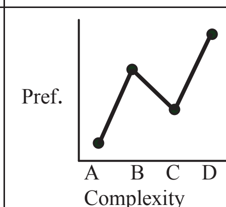
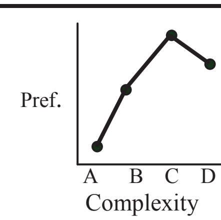
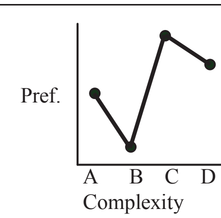
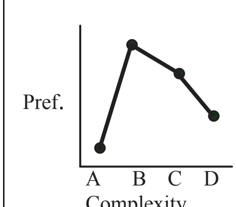
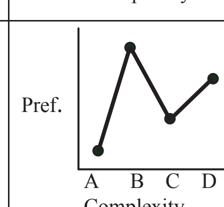
4.2 Static aspects of consensual complexity and aesthetic preference: Individual analysis

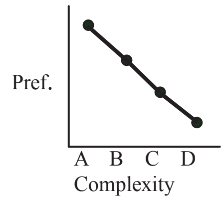
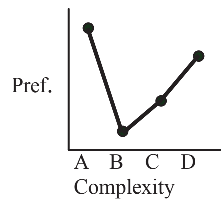
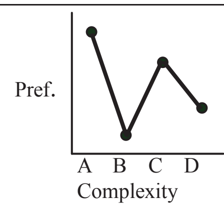
The theory of psychological complexity and preference is a theory of an individual in a psychological environment. Therefore, it can be argued that group analyses offer an impoverished and somewhat misleading view of the theory's usefulness. A far more complete means of verifying and utilizing experimental results is the individual protocol analysis, where each participant's data are tested against theory predictions on their own merits rather than simply contributing to a group mean.A useful individual protocol analysis which is clearly adaptable to preference data is Coombs' unidimensional unfolding technique (Coombs, 1964: Coombs, Dawes, & Tversky, 1970). The focus of the method is in the subjective differences between the stimuli of different levels of complexity and whether these change with parity. To apply the technique, preference ratings given by the participants are reduced to rankings under the conservative assumption that the rating scale values are not on an equal-interval scale. The preference order supplied by the participants can then be compared to any one of several measures of the relative complexity of the stimuli; *a priori*, consensual or subjective complexity, which is the individual ratings of complexity (Walker, 1973). Here, a set of ordered relations of the preference ratings is called an I-scale. The stimuli and the ideals of the respondents are represented by two corresponding sets of points on a line representing an attribute continuum. This line is called a J-scale, a joint distribution of two sets of points (Coombs, Dawes, & Tversky, 1970). This analysis method examines whether the respondent's complexity ordering (J-scale) replicates the preference ordering (I-scale) when complexity ordering is folded over upon itself at the modal preference point. The objective of the method is to test for the existence of one common latent attribute underlying people's preferences for a set of alternatives or in another instance to construct a one-dimensional space to account for the observed preferences. This procedure is simply a non-graphic means of testing the concept of unimodal preference; it is equivalent to seeing if an individual's ranked aesthetic preference produces an inverted-U, monotonic-increasing, or monotonic-decreasing curve when plotted against complexity (Heyduk, 1972).

Table 4 illustrates the case of a four-stimulus paradigm investigating whether a participant's protocol conforms to theoretical expectations about the preference and complexity relationship. In the group analysis, the results already confirmed that *a priori* complexity and consensual complexity yield the same ordering of the four stimuli (D > C >B > A), indicating that simulation D is the most complex and simulation A is the least. If it is assumed that the consensual complexity ordering is the appropriate psychological complexity ordering for all participants, each individual's preference order relation may be examined in the light of the consensual complexity scale. There are twenty-four ways of ordering preference for four stimuli, and eight of these twenty-four preference order relations constitute the group of acceptable single-maximum preference curves when plotted against consensual complexity. These curves are one monotonic increasing function, one monotonic decreasing function and six inverted-U functions. All other sixteen orderings of preference do not allow the assumption of a single optimal level of psychological complexity on the complexity continuum: all form U-shaped and other non-monotonic functions.

Out of the set of 114 individual preference order relations, a certain number will support the notion that optimal complexity determines preference, and all others will not. Table 5 shows the number of acceptable and unacceptable preference order relations observed in the Experiment.

Table 4. Examples of acceptable and unacceptable relationships between preference order and complexity using a unimodal criterion

Modal Preference	Hypothetical preference order		Examples of Preference for complexity curve
D	Acceptable protocol (Monotonic increase)	D C B A	
	Unacceptable protocol (Bimodal function)	D C A B D A C B D A B C	
		D B C A D B A C	
	Acceptable protocol (Inverted-U function)	C D B A C B D A C B A D	
	Unacceptable protocol (Bimodal function)	C D A B C A D B C A B D	
B	Acceptable protocol (Inverted-U function)	B C D A B C A D B A C D	
B	Unacceptable protocol (Bimodal function)	B D C A B D A C B A D C	

A	Acceptable protocol (Monotonic decrease)	A B C D	
	Unacceptable protocol (Bimodal function)	A D C B A D B C A B D C	
		A C D B A C B D	

Notes: i) The consensual complexity ordering is assumed to be appropriate in all cases: D is the most complex and A is the least.
ii) "D C B A" represents D preferred over C preferred over B preferred over A.
iii) Examples of preference curve for complexity represent one typical sample of the group

Table 5. Number of acceptable and unacceptable preference order relations in Experiment

Modal preference for	D	C	B	A	Total
Theory relevant classification of **acceptable** preference order	Monotonic increase D C B A	Inverted-U C D B A C B D A C B A D	Inverted-U B C D A B C A D B A C D	Monotonic decrease A B C D	
Number of observed relations	3	7	25	41	76
Theory-relevant classification of **unacceptable** preference order	U-shape or Bimodal function D C A B D B C A D B A C D A C B D A B C	U-shape or Bimodal function C D A B C A D B C A B D	U-shape or Bimodal function B D C A B D A C B A D C	U-shape or Bimodal function A D C B A D B C A C D B A C B D A B D C	
Number of observed relations	5	3	10	20	38
Total	8	10	35	61	114

Note: The consensual complexity ordering (D > C > B > A) is assumed to be appropriate in all cases.

A major advantage of the Coombsian analysis is that it is a relatively easy matter to specify the number of protocols. On a strictly *a priori* basis, the chance expected proportion of acceptable individual preference order relations (preference for complexity curves) in a four stimuli situation is 1/3, since there are twenty-four possible orderings of four building simulations and eight are single maximum functions of complexity. As Table 4 demonstrates, however, for an individual whose optimum point is nearest the simplest or most complex stimuli of the set (either A or D), only one out of the six ways of ordering the other three produces an acceptable protocol. Whereas in cases of peak preference for intermediate complexity (either B or C), the chances of the rest conforming to the theory (i.e., the chances of an acceptable preference order rating) are 1/2. This suggests that the expected value should be adjusted using the actual distribution of individual peak preferences. For this purpose, the expected proportion of supporting protocols can be determined by the following formula (Heyduk, 1972),

$$\frac{(A+D)1/6+(B+C)1/2}{114}$$

where A, B, C, D, refer to the number of participants having modal preference for those simulations and 114 is the total number of the participants. In this experiment, those values of A, B, C, and D were 61, 35, 10, and 8, respectively. If the distribution had been random for subjects in this experiment, the chance expectation figure would not have been affected. Since more than half of all participants most preferred one of the least or the most complex simulations, however, the conditional chance proportion (0.298) was somewhat lower than 0.333.

By comparing the random expectation distribution to the sample distribution, a clear picture of the extent to which the data supports psychological complexity theory may be obtained. Table 6 shows the results of individual protocol analysis of preference for consensual complexity. The appearance of 76 acceptable preference order relations when 34.0 is the expected number strongly indicated a unimodal relationship between individual rated preference and consensual complexity. It must be proved, however, that this qualifies as support for the theory of psychological complexity. This is because a great number of participants (61) had preference ratings that at an ordinal level were perfectly correlated in a negative direction with consensual complexity. Even if these protocols produce monotonic decreasing functions, it could be argued that independent of any hedonic consequences of interaction, consensual complexity could have served as a means of ordering preference for these participants. The second line of Table 6 is a second individual protocol analysis, this one excluding those participants who had modal preferences for simulation A or D. This removes from consideration all participants for whom a perfect positive or negative correlation between preference and consensual complexity was possible, thereby permitting a stricter assessment of psychological complexity theory's ability to explain the data. Even though the expected success proportion is 0.5 for this analysis, it can be seen that the chi-square value is significant at the .005 level. Practically, it appeared that a higher proportion of participants rated preference order relations for inverted-U functions than U-shape or bimodal functions.

Table 6. Individual protocol analyses of rated preference for consensual complexity

	Observed number of theory supporting protocols	Expected number of theory supporting protocols	Expected proportion of theory supporting protocols	χ^2 ($df = 1$)	P
All participants (N = 114)	76	34.0	0.298	74.1	< .001
Participants who most preferred C or B (N = 45)	32	22.5	0.500	8.0	< .005

4.3 Static aspects of subjective complexity and aesthetic preference: Individual analysis

Although D > C > B > A is the best universal ordering of complexity (J-scale) for unfolding 114 individual preference order ratings (I-scales), it does not mean that every individual in the experiment had his/her most complex reaction to D, his/her next most complex reaction to C, and so forth. This fact demonstrates one limitation of the general procedure of comparing all individual preference orderings to a single consensually-appropriate complexity ordering. A more serious problem with using group complexity is that it prevents a test of the individual psychological complexity concept. The difficulty with the analysis of individual protocols is removed when a J-scale (complexity ordering) is constructed for each participant on the basis of his/her personal complexity ratings. This allows the comparison of individual preference to individual complexity, a procedure more in line with the philosophical premises of the theory of psychological complexity and preference.

Clear prediction is that subjective complexity should be a more sensitive basis for testing the preference-complexity relationship in a participant population than any sort of group-based and group-applied order, including consensual complexity. This should be so because of idiosyncratic individuals for whom D > C > B >A is an inappropriate statement of psychological complexity relationships and thus an inappropriate basis for judging unimodality. If, for example, one such individual expressed preference order of A > B > C > D, which A preferred over B preferred over C preferred over D, the preference order ratings would have a monotonic decreasing function if consensual complexity were assumed to apply and thus would conform to theoretical expectation. It may be possible, however, that building simulation C was perceived to be more complex than D, in which case the complexity order of the set could have been C > D > B > A from his/her standpoint. If this aspect of a private interaction were reflected in the participant's own complexity ratings and the preference information utilized, the resulting preference order would have a U-shape and thus would not conform to theoretical expectation (Case A in Figure 5). In addition, the opposite cases can be easily assumed. For example, if one such individual expressed greatest preference for B and liked D second best, the preference order ratings would have a double maximum if consensual complexity (D > C > B > A) were assumed to apply and thus would not conform to theoretical expectation. It may be possible, however, that perceiving simulation B could have been the most complex of the set from his/her standpoint, and preference would have been plotted against the participant's own complexity ordering B > D > C > A. Then, the resulting monotonic function would have rightly been judged to support the theory (Case B in Figure 5).

Table 7 permits a comparison of the best group approximation of psychological complexity to individual subjective complexity as strategies for ordering the preference judgments of all 114 participants. Theoretically, the comparisons of rated preference to subjective complexity ratings should produce more theory supporting protocols than comparisons to consensual complexity ratings, but the result was not. Subjective complexity actually did a poorer job of generating unimodal preference functions. Interpretations of the failure of an individual complexity measure to be a better predictor than a group measure must be tentative because of the limited amount of discriminating data. One partial explanation with some empirical support is that the use of subjective complexity adds another source of error variance to data already undermined by the variations in rated preference, thus preventing a clearer expression of the theoretical relationship between preference and complexity.

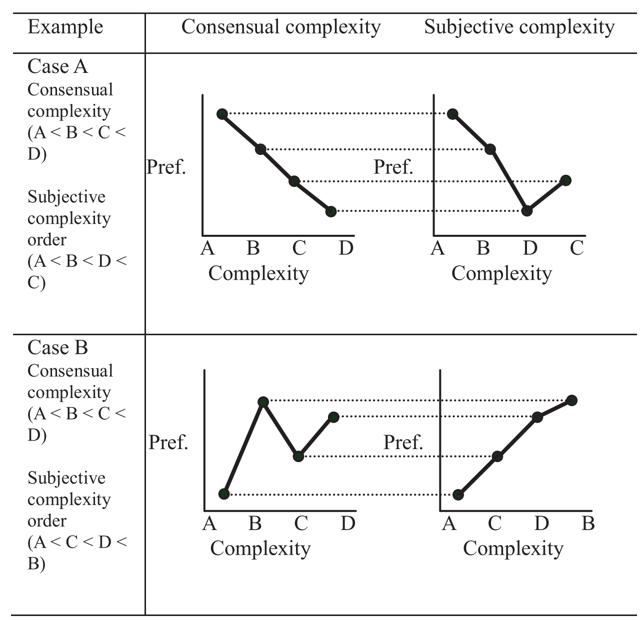


Figure 5. Sample cases for changing theory supporting protocols due to consensual and subjective complexity orders

Table 7. Individual protocol analyses of rated preference for subjective complexity compared to group consensual complexity (N = 114)

Alternative bases for ordering preference	Observed number of theory supporting protocols	Expected number of theory supporting protocols	Expected proportion of theory supporting protocols	χ^2 ($df = 1$)	P
Consensual complexity	76	34.0	0.298	74.1	< .001
Subjective complexity	70	33.7	0.296	55.5	< .001

4.4 Gender and preference for building complexity

The design of this experiment was such that several potential determinants of preference for building complexity were controlled. Among 114 participants who were administered in a group, eight different forms having random order of four different photos were equally represented. Age, cultural and social backgrounds for the participants were also controlled. Thus, for this subset of participants, administration conditions, type of participants, and order of rating were variables that could not differentially bias results. In the experiment, however, one dimension of extraneous variation in terms of demonstrable influence on building complexity was gender. The equal distribution of males and females in the participant population (fifty-seven in each group) permits an examination of gender differences in mean preference for complexity, and in the number of acceptable individual preference relations. The issue was whether this extraneous factor was an interesting independent variable in its own right. Table 8 and Figure 6 show that both males and females supported the theory of psychological complexity in building simulations to an equally strong degree with no differences between the genders.

Table 8. Comparisons between males and females in complexity and aesthetic preference ratings

	Male				Female			
Complexity ratings	N	W, χ^2	df	p	N	W, χ^2	df	p
Kendall's W	57	0.718	3	< 0.001	57	0.743	3	< 0.001
Friedman RM ANOVA	57	122.717	3	< 0.001	57	127.112	3	< 0.001
Preference ratings	N	W, χ^2	df	p	N	W, χ^2	df	p
Kendall's W	57	0.393	3	< 0.001	57	0.332	3	< 0.001
Friedman RM ANOVA	57	67.242	3	< 0.001	57	56.723	3	< 0.001

Notes: i). Kendall's coefficient of concordance = W,
ii) Friedman repeated measure ANOVA = χ2

Table 9 and Table 10 show individual protocol analyses by gender of rated preference. Individual preference protocols were unimodal with respect to consensual (group mean rated) complexity. Given a participant's most preferred building simulation, the ordinal aspects of preference for the other simulations were predictable with a frequency significantly greater than chance in each gender group.

The results for testing gender differences in the mean preference for complexity and in the number of acceptable individual preference relations demonstrated no differences between male and female. Furthermore, test results for both males and females agreed with predictions made by the theory of psychological complexity and preference that preference is unimodally related to psychological complexity.

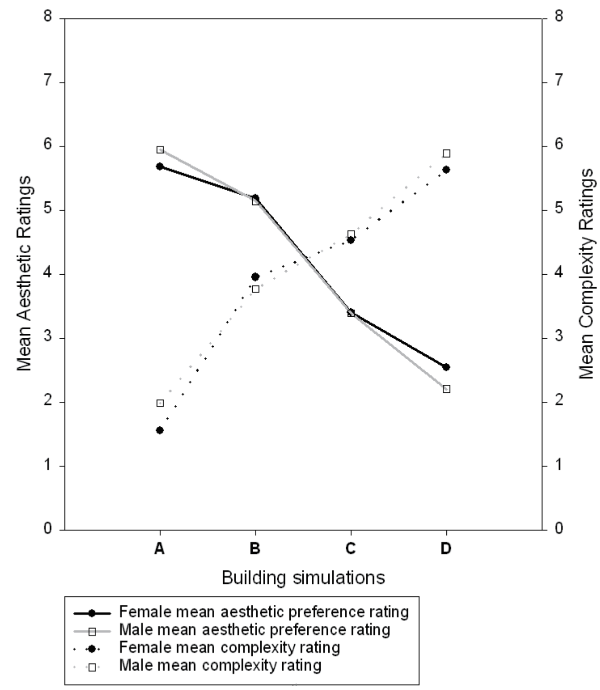


Figure 6. Mean rated preference and complexity of building simulations for male and female participants

Table 9. Observed number of modal preferences and theory supporting protocols in each gender

Modal preference for	Male	Female	Total
	Observed numbers (Number of theory supporting protocols)	Observed numbers (Number of theory supporting protocols)	
A	29 (23)	32 (18)	61 (41)
B	19 (14)	16 (11)	35 (25)
C	6 (3)	4 (4)	10 (7)
D	3 (1)	5 (2)	8 (3)
Total	57 (41)	57 (35)	114 (76)

Table 10. Individual protocol analyses by gender of rated preference (N = 57 each)

Gender	Observed number of theory supporting protocols	Expected number of theory supporting protocols	Expected proportion of theory supporting protocols	χ^2 ($df = 1$)	P
Male	41	17.8	0.313	43.8	< .001
Female	35	16.2	0.284	30.5	< .001

5. SUMMARY AND DISCUSSION

5.1 Summary and discussion

This research established psychological complexity theory as a plausible theory of rated aesthetic preference regarding architectural facades. Here, the level of complexity was varied by altering the simple order while complex order and random complexity were kept constant for all stimuli. This does not mean that complex order and random complexity have no influence on the level of complexity in building facades or the ability to determine aesthetic pleasantness. Rather, altering complex order or random complexity may influence the level of complexity in building facades as much as simple order does. The issue of complexity variables, however, would be tested explicitly in the future researches.

In the course of comparing rated preference relationship to complexity, the possibilities of drawing strong theoretical conclusions from empirical results were limited at times by the limited complexity range of the four building simulations constructed for the experiment. In the Experiment, the unimodal function of the preference order showed a monotonic decrease in proportion as consensual complexity increased. The fact that the least complex simulation was closest to optimum for more participants than any other meant that many individual preference protocols were related to complexity in a monotonic decreasing fashion. The appearance of monotonic function relating mean preference and complexity variables was a strong indication that aesthetic preference was a specifiable function of building complexity. However, a regular looking relationship between mean preference and complexity suggests far more interesting and meaningful phenomena at the individual subject level. Not only are different individuals expected to show peak preference at different points along the same complexity continuum, but the ordering of complexity along the abscissa and thus the shape of the preference-complexity curve may also vary from subject to subject, such that a single complexity ordering is not likely to represent the ordering for all people. Group analyses are insensitive to these issues.

In addition to constituting a better use of available data, individual protocol analysis permitted a more rigorous interpretation of the theoretical significance of obtained effects. A group of individual participant's ordered preferences was compared to the set of possible orderings and the subset of acceptable unimodal orderings. In this manner, the theoretical significance of the data was determined statistically without requiring strong assumptions about interval scale data. In the experiment, a great percentage of individual protocols conformed to complexity theory expectations. By demonstrating that individual preference was an inverted-U, monotonic increasing, or monotonic decreasing function of complexity at a frequency far greater than chance, regardless of the maximum preference point, the results of the experiment indicated the value of an individualized approach to the study of preference for building complexity.

Individual preference protocols were unimodal with respect to consensual complexity in both experiments. Given a participant's most preferred building simulation, the ordinal aspects of preference for various complexity building simulations were predictable with a frequency significantly greater than chance. The results from the Experiment of rated preference generally agreed with predictions made by the theory of psychological complexity and preference (Walker, 1980).

In architectural facades, there is a point on the psychological complexity dimension which is optimal. These findings may be useful during the design process for designing building elements or arranging those elements on building elevations to generate aesthetically pleasing architectural facades.

5.2 Implication for future research

It can be argued that the experience of building facades is mediated not only by perception but also by the behavioral and cognitive aspects of the situation. Consideration of this argument raises important theoretical issues. If we are to have a subject, aesthetics, then in general it must be concerned with the features or qualities of the architectural forms. Aesthetic psychology, therefore, studies the responses of people as part of the task of distinguishing and classifying the features of the materials- in this investigation, the architectural forms -to which they are responding. For example, activity and context may play a role in desired levels of complexity. For purposes of short-term exploratory activity (vacationing and recreation), people may prefer novel stimuli, different from those to which they are adapted. However, for permanent activities (such as the choice of residential environments), they may be more dependent on adaptation levels. This has important design implications suggesting complexity levels for different areas. Thus, places such as entertainment establishments, downtown districts, shopping malls, and children's play areas should probably be complex, and change over time to maintain novelty (while preserving continuity for orientation), while residential areas should be at middle levels of complexity (although there are ranges of variation in both). There may be areas (for example, clinics) where sensation seeking is not the goal and higher redundancy is necessary for more purposeful and routinized behavior.

According to psychological theory, learning and experience also increase the ability to grasp order, and training leads to more emphasis on relationships than on elements. A sense of order is essential in all perception, and design should help produce a clear sense of order in addition to complexity. However, it can be assumed that trained architects more easily detect order in building form than laypersons. Design projects in the real world involve users, owners, or an institution other than the designer. Therefore, understanding the various levels of complexity and order required for different user groups is also important in design process. All the hypothesized inquiries described above could be verified using the empirical methods employed in this investigation.

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