

Form and function in public buildings

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Abstract

The American architect Louis Sullivan once proclaimed “Form follows function.” We tested this maxim by obtaining random samples of four types of buildings, obtaining samples from three countries of respondents unacquainted with the buildings sampled, and asking the respondents to guess which function went with which building. If form follows function, it would enhance legibility, presumably improving wayfinding and the quality of experience. χ^2 analyses of the contingency tables indicated that form had a small effect on perceived function. Thus, for the building types sampled, form did not follow function.

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One of the most famous maxims in contemporary design is that “Form Follows Function”. As expressed by the American architect Louis Sullivan, ...it stands to reason that a thing looks like what it is, and vice-versa...[T]he outward appearances resemble inner purposes...[I]f we call a building a form, then there should be a function, a purpose, a reason for each building,...and that the building, to be good architecture, must, first of all, clearly correspond with its function...[I]f a building is properly designed, one should be able with a little attention, to read through that building to the reason for that building. (Sullivan, 1918, pp. 43–46)

1. Introduction

This paper addresses the question of whether individuals can correctly identify purposes of buildings from the external appearance of those buildings, or to put it in

another way, “How well does the form of the building communicate its function?” This question fits into a broader concern for the legibility of the city (Lynch, 1960). A legible city should aid wayfinding, making it easier for people to move around “to find a friend’s house or a policeman or a button store” (Lynch, 1960, p. 4). If form follows function and thus clarifies the city image, it should contribute to a sense of “emotional security” and “satisfaction” (Lynch, 1960, pp. 4 and 5).

Researchers have shown that people make inferences from the physical appearances of places and these inferences are often accurate. A *visual* feature (such as grilles on windows) may serve as a useful probabilistic cue for a *nonvisual* attribute of a place, such as fear of crime (Craik & Appleyard, 1980). This process may have helped humans survive. Confronted with something that could threaten or enhance survival, our predecessors would have had to be able to recognize what it is, evaluate it, and act on that evaluation. Lawrence (1986) analysed Swiss housing forms from 1860 to 1960 to infer cultural meanings in relation to the plans. From environmental cues, people infer the social status—upper vs. lower class—of areas (Lynch, 1960;

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Royse, 1969; Duncan, 1973). Nasar (1989) found that respondents from two cities (Columbus, OH and Los Angeles, CA) viewing drawings of six homes that varied in style, made the same inferences about the friendliness and status of the residents. A follow-up study comparing urban respondents in Columbus, OH with small-town respondents in New London, CT shared meaning across the two groups (Nasar & Devlin, 2000). Other researchers have found that such inferences made from exteriors (for houses, neighborhoods and restaurants) accurately depict the residents (Craig & Appleyard, 1980; Cherulnik & Wilderman, 1986; Sadalla, Verschure, & Burroughs, 1987; Cherulnik, 1991). For example, Sadalla et al. (1987) had homeowners rate themselves on personality and identity scales. Then, other respondents viewed slides of the home exteriors and rated the homeowner on the same personality and identity scales. The ratings inferred from the house exterior agreed with the homeowner's self-concept. Thus, the studies showed that individuals inferred consistent and accurate meanings about residents from looking at house exteriors. A study of office exteriors (Nasar & Kang, 1989) found consistencies in the meanings respondents inferred from the exterior of small suburban offices. Research has also found agreement on the building style or form for a presidential library (Nasar, 2002) and for the new headquarters for The New York Times (Nasar, 2001).

We would expect connotative meanings to affect behavior—people wanting to visit or spend time in places that conveyed positive meanings and avoiding places that conveyed negative meanings. Thus, understanding the meanings conveyed by places could affect use. For example, to attract clients some companies might want to look as if they were not squandering money; others might want to look as if money did not matter. In at least one documented case the exterior image interfered with the intended use. At the Ohio State University, the Wexner Center for the Arts was funded to attract the typical student to get involved with the latest in contemporary arts. It was supposed to attract the typical football-loving, beer-drinking student inside. Observations of use showed that few people used the Center; and interviews with students revealed that many of them said they avoided it, because they thought the people inside were uppity (Nasar, 1999). As these students had never entered the building, they may well have drawn their inferences about the staff from the exterior form. The exterior appearances may have led them to stay away, preventing the building from serving its main purpose. If the inferred function of a building does not agree with its actual function, the building fails to communicate its purpose and thus might reduce visits by intended users.

Thus, it makes sense to find out whether people can infer the function of buildings from the physical appearance of the building alone.

2. Method

2.1. Stimuli

For a list of building functions, Pevsner's (1976) *History of Building Types* served as a source. Then, random numbers were used to select from the list of four building types for study: city hall, library, live theater, and museum. In the San Francisco Bay Area local telephone book under headings for city halls, libraries, live theaters, and museums, we used random numbers to select three buildings per heading. A researcher visited each of the 12 sites, photographed the buildings and digitally retouched the images to remove all signage. Note that the available empirical evidence (1215 scenes, over 4200 respondents) confirms that preferences obtained from static color images strongly relate to preferences obtained on-site to those same places ($r = .83$) (Stamps, 1993). Figs. 1 and 2 show the stimuli.

2.2. Participants

To control for familiarity, we selected respondents from cities distant from the location of the building stimuli. Interviews took place in Columbus, OH; Tokyo, Japan; and Montreal, Canada. A total of 160 individuals agreed to take part in the study. Table 1 lists demographic characteristics of the respondents.

2.3. Sample size

To determine the sample size, we considered the statistical power (Rosenthal & Rosnow, 1991). If a sample is too small, it would threaten the validity of the study, creating a low likelihood of finding an effect that existed in the population. The main analysis was a 4×4 contingency table (Conover, 1971, p. 185). We did not have a prior estimate regarding effect sizes, so it was not possible to ascertain a priori if we should size the experiment to support or impeach the hypothesis. If the intent was to support, then a suitable target would be a medium target effect size, but if the intent was to impeach, the target would be a small effect size. We split the difference and aimed at an effect size halfway between medium and small. The *dfh* for a 4×4 contingency table is 9. In order to allow for making five tests with a simultaneous *ci* of .05, alpha was set to .01. Power was set to 80%. The minimum *N* (total number of responses) for an effect size halfway between small and medium effect size was 536 (Cohen, 1988, p. 255). We used a repeated measure design, which for a given sample size has greater power than a between-subjects design. Between-subjects design derives power from the number of respondents. Repeated-measure designs use the total number of responses (the number of participants times the number of stimuli). The power



Fig. 1. Scenes in the left column show city halls; scenes in the right column show museums. From top to bottom: Alameda City Hall, El Cerrito City Hall, San Leandro City Hall; Museum of Modern Art, Heritage Architectural History Museum, Ansel Adams Museum of Photography.

analysis indicated a minimum respondent sample size of 45. Furthermore, for a simple 2×2 sign test for proportions, with $\alpha_2 = .01$, power = 80%, and a target halfway between medium and small, the total N would be 289 responses (Cohen, 1988, p. 168), or a minimum of 24 participants, each making 12 responses.

2.4. Presentation protocols

We used double-blinded experiments that satisfied human subject protocols. Respondents received the stimuli in one of the four presentation orders. They were asked to look at each scene and select one category (city hall, museum, library or live theater) that they thought best described the building. The study also used four sets of answer sheets, each with a different order of categories. In Tokyo, stimuli were presented in class on computer screens. In Montreal, the responses were also collected in class using a data projector; in Columbus, responses were collected through interviews obtained on and around a college campus. As explained below, these different protocols should not have influenced responses.

3. Results

3.1. Question #1: Did the Sullivan hypothesis hold up?

First, consider the simple percentage of correct answers. Even without correcting for guessing, only 32% of the responses were correct (613 out of 1918 responses). With four possible responses, blind guessing would be correct 25% of the time, so the average response was only seven points better than random. This suggests that form did not follow function.¹

We also addressed this question by cross-tabulating actual and rated functions (Table 2). The analyses confirm that in terms of human response, building form had a small relation to function. The diagonal from the top left to the bottom right represents the correct

¹A 7-point increase might represent a big deal for the improvement in the effectiveness of a drug for a disease that kills millions of people a year. However, if a computer runs at 3 GHz and has one problem in 10 billion, it crashes every 3.3 s. A 7-point improvement reduces the crash rate to every 3.1 s. Such a small effect is trivial. For the purpose of communication, a 7-point improvement over pure randomness represents a trivial effect, and so we suggest that form did not communicate function.



Fig. 2. Scenes in the left column show libraries; scenes in the right column show live theaters. From top to bottom: Daly City Library, Alameda Library, El Cerrito Library; Cowell Theater, Beach Blanket Babylon, ODC Theater.

Table 1
Demographic characteristics

	Columbus (n = 60)	Tokyo (n = 79)	Montreal (n = 21)
Male	48.3%	46.8%	76.2%
Female	50.0%	53.2%	23.8%
Not reported	1.7%	0	
Age: m	27.6	20.8	24.5
Age: s	6.8	1.5	4.5
Student	86.7%	100%	100%
Faculty or staff	13.3%		
Visited USA		20.3%	
Never visited USA		79.7%	
Visited San Francisco			.05%
Never visited San Francisco			99.5%

classifications of buildings relative to their actual uses. Although respondents tended to pick the actual use more often than expected at random ($\chi^2 = 226$, 9 df, $\alpha \ll .001$), it represented a small to medium effect. Because α reflects both effect size and sample size, we

Table 2
Contingency table for function

Actual	Rated			
	City hall	Library	Museum	Live theater
City hall	147	169	111	53
Library	160	173	111	36
Museum	125	107	123	125
Live theater	82	65	161	170

Entries are numbers of respondents.

calculated the effect size, using Cramer's V, which becomes the ϕ correlation for a 2×2 table. The values were calculated using *Numerical Recipes* (Press, Teukolsky, Vetterling, & Flannery, 1988, pp. 632–635). For the Sullivan hypothesis, Cramers' V was .198. To put that number in perspective, a correlation of .20 is halfway between Cohen's values for small and medium correlations (Cohen, 1988, pp. 77–81), and a smaller value would occur if the data were corrected for blind guessing.

3.2. Question #2: Are there demographic differences in perceptions of functions?

This question focused on one demographic variable—country. Realize that for Japanese respondents the variety of designs in our stimuli included many atypical to Japan and thus unfamiliar to the participants. Nevertheless, we found the respondent’s country had a trivial effect. For this test, we collapsed the data into a 3 × 2 contingency table of country (US, Japan, Canada) by correct responses (hits) and incorrect responses (misses) (Table 3). US and Canada had a higher proportion of hits and Japan a lower proportion than would occur at random ($\chi^2 = 23$, 2df, $\alpha \ll .001$), but according to Cohen’s system, the country variable had a small effect (Cramer’ V = .11).

3.3. Question #3: Did building reuse matter?

Perhaps some of the buildings appeared to have functions different from their original functions. Hard data on original use were available for some of the stimuli. The three libraries, two of the city halls, and the Museum of Modern Art were all original uses. The Heritage Museum was originally a Victorian residence, and Cowell Theater began life as a munitions shed. The remaining stimuli (the Ansel Adams Museum, Beach Blanket Babylon, and the ODC theater) all appeared to be adaptive reuses. None of the facades had been changed. Table 4 shows the contingency table for adaptive reuse. The analysis indicates that reuse or original use did not make much difference in conveying function through form. The statistics ($\chi^2 = .74$, 1df, $\alpha = .38$; Cramer’ V = .02) indicate a miniscule effect.

3.4. Question #4: Does form convey status?

In Columbus, OH, separate data were collected for status from 30 respondents. This sample (50% male and

Table 3
Demographic effect for function

	Hits	Misses	% Hits
US	269	449	37%
Japan	254	694	26%
Canada	90	162	35%

Table 4
Contingency table for adaptive reuse

	Hits	Misses
Reuse	315	643
Original purpose	298	662

Table 5
Contingency table for status (Columbus data)

Status rated for each building	Status rated for each type of use			
	Very low	Low	High	Very high
Very low	3	9	3	10
Low	22	24	15	17
High	28	20	33	24
Very high	10	10	12	12

Table 6
Contingency table for status × building size (Columbus data)

Status	Building size			
	Very small	Small	Large	Very large
Very low	15	4	1	5
Low	25	25	24	4
High	20	26	26	33
Very high	3	8	12	21

50% female) had an average age of 20 years (s.d. 8.2 years), with all but one (3.3%) as college students (13.3% second year, 3.3% third year, 33.3% fourth year, 36.7% masters students, and 10% doctoral students). The interviewer had the respondents rank the status of each of the 12 buildings and of each of the four uses. The order of the questions, buildings and uses were varied across the respondents and the two sets of ratings. Table 5 shows the cross-tabulation. The results indicated that form transmitted Status better than it did function, but still at a low level ($\chi^2 = 13.4$, 9df, $\alpha = .14$; Cramer’ V = .13) (see Table 6).

4. Discussion

4.1. Summary of findings

Table 7 lists the ideas addressed in this paper in decreasing order of impact. A small to medium effect emerged for physical form communicating building function. Small effects emerged in relation to physical form communicating status, country effect on how well form communicates function, and adaptive reuse effect on communicating function.

4.2. Possible limitations

Would buildings of different functions that local populations thought were important communicate those functions to respondents who were not aware of the local importance? Would buildings designed by

Table 7
Summary of findings

Ideas addressed	χ^2	df	α	Cramer V
Does physical form communicate the function of a building?	226	9	$\ll .001$.20
Does physical form communicate the status of the concepts of building functions?	13.4	9	.14	.13
Does the country of respondents have an effect on how well physical form communicates building function?	23	2	$\ll .001$.11
Is there a difference in how well form communicates function between buildings that are or are not used for their original purposes?	.71	1	.38	.02

signature architects score better than those designed by local designers? Would buildings lauded by architectural critics communicate functions better? Each of these ideas could be the foundation for future research: find a sampling frame for each concept (tourists books, competitions, literary journals); obtain random samples from each frame, photograph the buildings, find a respondent population that is not familiar with the buildings, and repeat the present analysis. In doing so it is necessary to include randomization. Random sampling has been one of the most important components of scientific inquiry for nearly a century. Without it, results are likely to be attributable to bias, produce groups that are not comparable, and invalidate the underlying statistical model. Details on how to randomize can be found in Cochran (1977), Deming (1950) or Friedman, Furberg, and DeMets (1998).

Some may question whether responses from college students to this set of questions apply to others. Research covering 3281 scenes and more than 19,000 participants indicated demographic factors had little effect on preferences (Stamps, 1999). In particular, student preferences correlated at $r = .83$ with preferences of nonstudents, and students considered to be representatives of other populations (design students vs. actual designers; liberal arts majors vs. public; resource management students vs. real resource managers, etc.) had preferences that correlated equally well with the intended adult populations ($r = .86$). Further work could explore the generality of our findings for inferred use to adult populations.

Perhaps there is regional variation in building forms intended for uses such that respondents from cities different from the buildings tested did not recognize local codes that cue the uses to local residents. Though we doubt such an effect, given findings of similarity across individuals from different cities in the meanings

inferred from house exteriors (Nasar, 1989), one could test the possibility of local codes by testing buildings on residents from the city where the buildings were obtained, and eliminating from the sample respondents who report familiarity or experience with a building. (The familiarity or experience would probably give them accurate knowledge of the use that would overrule judgments of use inferred from the exterior.)

Finally, one may question the generality of results from the viewing protocols, such as size of presentation room, viewing distance, ambient light levels, time of day, time stimuli were displayed, and alternate presentation orders. However, several studies suggest that these controls are not necessary for obtaining reproducible results for general responses to environments. In one pair of experiments, preferences were obtained for the same 13 scenes but using different participants, different locations, different viewing conditions, different viewing orders, and different scaling methods (Stamps, 1992). The preferences between the two replications correlated at $r = .90$. In another experiment on preferences for 35 houses, two sets of responses were obtained from different groups of respondents, in different cities, under different viewing conditions (Stamps & Nasar, 1997). The results again correlated at $r = .90$. Feimer (1984) reported findings from a large (1148 participants) study of effects of experimental conditions on evaluations of environments. One of the tests compared evaluation scores obtained from two different rooms (a room in a church and another room, at a different location, in a school). The effect of interview site was very small ($r = .006$, $t(103) = .07$, $p = .94$). Thus, while rigid controls on viewing conditions might be quite important in experiments on discrimination of tiny stimulus differences (11.5 mm vs. 11 mm) seen in split seconds (100 ms), the empirical evidence suggests that rigid viewing protocols are not needed when investigating how, given enough space and time, people respond to environments.

4.3. Alternate interpretations

Other interpretations of the implications are possible, depending on how seriously one takes the principle that empirical science derives from experimental data, as opposed to speculations about what might or might not happen under other hypothetical circumstances. From a strictly empirical point of view, research has shown that people infer meanings from housing, restaurant, and small suburban-office exteriors; and this suggests strong commonalities in those inferences (Craik & Appleyard, 1980; Cherulnik & Wilderman, 1986; Sadalla et al., 1987; Nasar, 1989; Nasar & Kang, 1989; Cherulnik, 1991; Nasar & Devlin, 2000). The data in this experiment showed that some building types failed to express, in the exterior form, codes that convey to

ordinary observers the function housed inside. For the buildings in this study, form failed to follow function. Moving beyond the data, one might argue that architectural form and function has a many-to-many relationship, or that certain functions are not distinguishable through architectural form. Alternately, although the building exteriors did not convey their specific function, our data neither rule out the possibility that they may have reflected a higher-level category of function, which they fit, nor did our data rule out the possibility that the exterior appearance excluded certain categories of function, irrelevant to the buildings. To clarify these issues, future research could ask respondents to indicate functions that each building did not house, and it might identify and ask respondents if building fit into higher-level categories of function.

5. Summary and conclusions

Louis Sullivan's enduring maxim that "Form follows function" did not hold up in our study. For an unbiased sample of buildings, each with one of four functions, and for respondents unfamiliar with the buildings, the fit of the actual function to the perceived function was small. We conclude that, for the present, unbiased sample, form did not communicate function; and based on that we speculate that building form may detract from legibility and emotional security or satisfaction of people unfamiliar with cities or places.

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