DENSITY PERCEPTION ON RESIDENTIAL STREETS

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Abstract

The purpose of the study summarized in this article was to explore which physical characteristics influence people's perception of density on urban residential streets. Three streets in San Francisco, California, were evaluated and compared in terms of visual characteristics, such as variety and distinctness of form, colors, materials, and patterns. These measurements were compared to the perceived density of these streets as indicated by both residents and non-residents. The study found three physical characteristics to be very strongly associated with perceptions of lower density: (1) greater building articulation; (2) less facade area or smaller buildings; (3) a greater number of "house"-like dwellings. These findings have significant implications for urban policy and design practice.

Introduction

Density is an important quality and factor in planning today. Planning departments use density to control and evaluate development. Developers strive for densities which create an adequate return on their investment. The public often judges projects based on common values about appropriate densities. Anything higher than "low density" is usually seen as "too dense." But is density, measured as dwelling units per acre or floor area ratio, really the important quality of the built environment?

The purpose of the study described here is to determine which physical characteristics influence people's perceptions of density on urban residential streets. Social and socioeconomic factors were also examined in this study, but the primary focus was on physical qualities in order to identify possible physical planning and design implications. The study focused on characteristics related to visual complexity: variety and distinctness of forms, colors, materials, and patterns.

Three streets in San Francisco, California, were chosen for comparison which had similar densities (35-47 dwelling units per acre) and approximately the same width, but which varied in the amount of visual complexity. Characteristics which might affect perceived density were first catalogued and quantified. A total of thirty-five people (both residents and non-residents) were then asked to rank the densities of the streets using photographs.

Three physical characteristics seem to be very strongly associated with perceptions of lower density: 1) less facade area or smaller buildings; 2) greater building articulation (that is, recesses between the buildings and variations in the facade plane); and 3) a greater number of "house"-like dwellings (e.g. with gable roof). These characteristics varied directly with the rankings of density and were mentioned by many of the respondents as reasons for their ranking.

These findings have potentially significant implications for housing design and planning. They confirm that there are better ways of measuring the visual impacts of density than the traditional "dwelling units per acre," and that urban policy and design practice could benefit from more such design research.

Background

Cities are not always as they seem at first glance. They are very complex and constantly changing, yet people are continuously making judgments based on the limited pieces which they see. "This looks like a bad neighborhood," or "this is a very crowded area," many say. What do people see which makes them arrive at these decisions? What physical characteristics of the environment have an effect on satisfaction or perceived density?

Density is a controversial and important topic partly because many people have a very negative impression of dense places. These people may not be objecting to or running from the density itself, but from its perceived correlates -- for example, higher crime rates, visual clutter, less privacy, often dull or ugly architecture, or lower socioeconomic conditions. Our research project focused on possible correlates relating to the physical design of streets and attempted to determine what people are looking at when they make judgments about densities.

Conflicting with the apparently widespread preference for lower density are the problems associated with low-density development. There is a growing acknowledgement that the current pattern of sprawling development is an inefficient use of our resources and is expensive to build and maintain. It causes a greater dependence on the automobile, an increase in energy and resource consumption (U.S. Dept. of Housing and Urban Development 1977), an increase in air pollution, and higher costs to government and citizens. The costs of infrastructure and service delivery per capita increase with decreasing density (Real Estate Research Corporation 1974). Some services such as mass transit are directly dependent on population density for efficiency (Tri-State Regional Planning Commission 1976).

Housing at higher densities could be achieved with minimal changes in desirability or perceived crowding, and would conserve natural

resources and reduce housing costs. If new residential developments were designed to appear less dense, people might accept higher-density development more readily.

What little writing and research there is on the subject of perceived density is scattered throughout the disciplines of environmental psychology, social psychology, city planning, urban design, and architecture. The underlying theory is that it makes more sense to look at people's subjective experience of the environment than relying on "objective" measures such as numbers of people per area. Amos Rapoport, one of the originators of the concept, has proposed that the primary determinant of perceived density is "rate of information" or level of perceptual stimulation (Rapoport 1975). Spatially, this means that an area with many different lights, signs, cars, and people would be perceived as more dense; and socially, this means that a high level of social interaction, social and cultural heterogeneity, and/or lack of territorial boundaries and rules would also be perceived as more dense.

Very little has been done in the way of empirical study of perceived density; Rapoport has presented primarily hypotheses and theories. Many studies have been done on the effects of crowding, but to our knowledge only one experimental study has been published which deals with perceived density in urban environments (on a scale larger than a single lot). A study of seventeen different neighborhoods in Los Angeles County (Flachsbart 1979; Robinson, et al. 1975) found that two of six physical-form attributes were correlated with perceptions of density: block lengths and number of intersections per 100 acres. The longer the blocks and fewer the number of intersections, the more often residents overestimated the density of their neighborhoods. Street width, slope, block-shape diversity, and street shape were all found to have no significant correlations with perceived density.

Some field research has been done by graduate students at the University of California at Berkeley. The College of Environmental Design course "The Urban Environment," for which our field study was prepared, has produced some research on perceived density in the past several years. Two of the studies (Beck, Gladman, and Sisson 1987; Aicher, Boland, and Evron 1988) have tested the effect of street trees on perceived density and found that there was either no effect or a positive association between the presence of street trees and higher perceived density. Beck, Gladman, and Sisson also tested for the effect of street width and found a mild association with perceived density. Another study focusing on suburban communities (Beck, Bressi, and Early 1987) tested a number of physical characteristics for their effect on perceived density and found that perceived density is partly dependent on the amount of space between houses, the size of the

front yard, street trees, the variety of house styles, and views from the neighborhood.

Although the student research mentioned above has produced many interesting results and conclusions about urban physical form, its chief contribution has been the development and testing of possible research methods -- site selection, photographic representation, and survey techniques. As a continuation and refinement of these methods, it is hoped that this study represents a more valid experiment. Nevertheless, it is important to use the findings presented here with considerable discretion because of the exploratory nature.

Field Study

At the outset, we hypothesized that in moderate-density neighborhoods in San Francisco, people will perceive more featureless streetscapes as higher in density than more articulated or finely detailed ones. This range is what we call the level of visual complexity. This hypothesis seems to contradict Rapoport's theory of perceptual stimulation. However, greater levels of visual or architectural complexity can be stimulating in ways that do not overload the senses. Complex or communicative environments are interesting to look at, often inviting, and educative. It could be that people value visual complexity itself, as Berlyne has proposed, or it could be such features as irregularity or uniqueness of visual components which they associate with lower density. There may be a threshold of visual stimulation below which a place may be seen as increasingly dull and therefore dense, but above which is seen as increasingly busy or cluttered and therefore dense.

Three streets were selected in San Francisco which varied in their amount of visual complexity, as described below. Recognizing that it would be impossible in such a field experiment to control for all of the non-complexity variables, an effort was made to find streets with similar dwelling-unit densities (units/net acre), similar street widths, and similar building heights, but to allow all the other physical characteristics to vary and to measure them to determine any associations. Florida Street was selected for having a relatively high level of complexity, Greenwich Street for having medium complexity, and Francisco Street for having a low level of complexity. The three streets are shown here on a location map (Figure 1) and with panoramic photos (Figure 2) and block plans (Figure 3).

Complexity

We hypothesized that visually complex urban residential environments would exhibit the following characteristics to a greater degree: building articulation, architectural detail, street furniture, parked cars

Figure 1

San Francisco -- Location of Streets Studied

LOCATION MAP

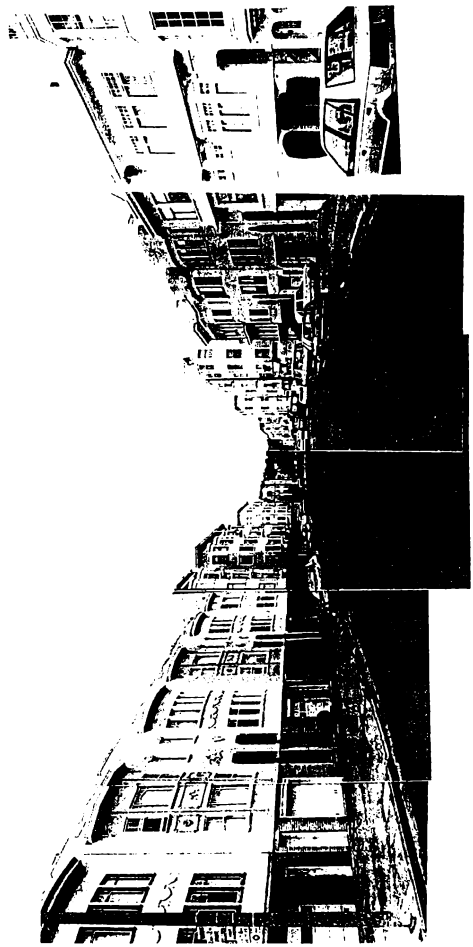
NO SCALE

and curbcuts, landscaping, irregularity of facade silhouette, variety of window and door patterns, variety of building types, and variety of building surface color and materials (Figures 3, 4, 5, and 6). On each street we objectively measured each of these characteristics as well as other physical data such as street activity level, traffic volumes, and maintenance level.

"Building articulation" is used here to mean recesses and projections from the streetwall plane, and separations between the buildings. We

Figure 2

Panoramic Photographs



FRANCISCO STREET
NORTH VIEW

NO SCALE

Figure 2 (continued)

GREENWICH STREET
SOUTH VIEW

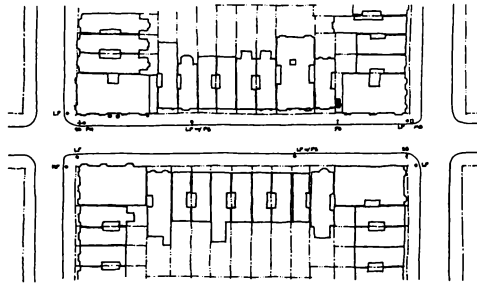
NO SCALE

Figure 2 (continued)

FLORIDA STREET
VIEW NORTH
NO SCALE

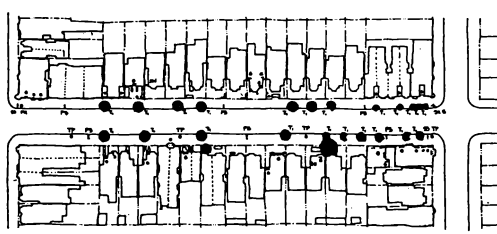
Figure 3

Block Plans With Street Furniture



FRANCISCO STREET
FURNITURE
0' 30' 60'

GREENWICH STREET
FURNITURE
0' 30' 60'



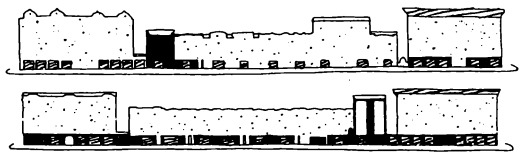
FLORIDA STREET
FURNITURE
0' 30' 60'

LEGEND

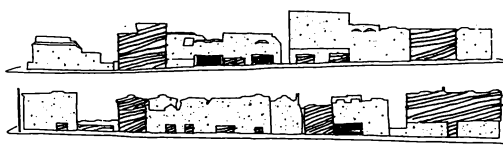
Stop sign	Newspaper Stand	Small Tree
Parking Sign	Mailbox	Med. Tree
Street Sign	Special Paving	Large Tree
Fire Hydrant	Security Grill	Landscaping
Telephone Pole	Security Alarm	Muni Pole

Figure 4

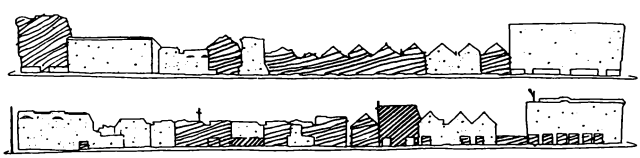
Material Variation



FRANCISCO STREET
MATERIAL VARIATION
0 20' 40'



GREENWICH STREET
MATERIAL VARIATION
0 20' 40'



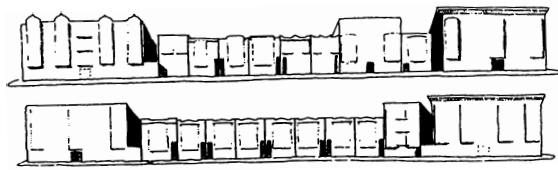
FLORIDA STREET
MATERIAL VARIATION
0 20' 40'

LEGEND

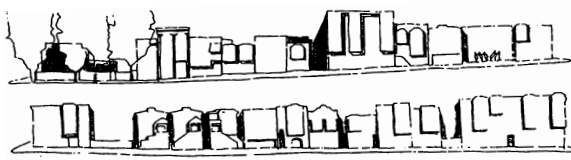
- Stucco
- Wood
- Brick
- Stone
- Asphalt Shingles

Figure 5

Building Articulation



FRANCISCO STREET
BLDG. ARTICULATION
0' 20' 40'



GREENWICH STREET
BLDG. ARTICULATION
0' 20' 40'

FLORIDA STREET
BLDG. ARTICULATION
0' 20' 40'

LEGEND

Mass Articulation (+48")
Element Articulation (18"-48")

Figure 6

Windows, Entrances, and Garage Doors

FRANCISCO STREET
WINDOWS, ENTRANCES & GARAGE DOORS
0 20' 40'

GREENWICH STREET
WINDOWS, ENTRANCES & GARAGE DOORS
0 20' 40'

FLORIDA STREET
WINDOWS, ENTRANCES & GARAGE DOORS
0 20' 40'

LEGEND

Windows
Entrances
Garage Doors

recorded the number of projections or recesses in two categories: between 18" and 48" (element articulation), and 48" or more (mass articulation). "Architectural detail" refers to the relative level of architectural decorative elements on the building facades. Each building of each street was ranked on a five-point scale. "Street Furniture" includes all the objects within the public right-of-way such as signs, landscaping, and benches. "Irregularity of facade silhouette" refers to the shape of the silhouette and was judged on a relative scale. "Variety of window and door pattern" refers to the randomness or irregularity of those elements and is also judged on a relative scale. Buildings were grouped into four "types": apartment, flat, rowhouse, and detached dwelling. "Material and color variation" refers to the percentage of each material or color relative to the total street facade, as well as the degree of variation. For example, there is more variation between green and beige than between beige and white.

The first step was to establish which street was most complex according to our definition. We attempted in selecting the streets to get a range of complexity levels, and the results of the site analysis (Table 1) confirm that we did. Florida Street ranked highest in complexity on six of the ten characteristics, Francisco Street ranked lowest on eight of the ten characteristics, and Greenwich Street was spread out more evenly. A statistically significant association exists between the streets and levels of visual complexity ($X^2 = 16.8$, significant at .01 level).

Since our study was dependent on the assumption that there was a clear ordering of the three streets by level of complexity, we decided to double-check this assumption with a survey of fifteen non-residents. Photographs of the streets were mounted on boards (Figure 7) and the respondents ranked the street in order of complexity. This resulted in the same ranking found in the site analysis (Table 2), with a significant association between the streets and levels of complexity ($X^2 = 36$, significant at .001 level): The most common reasons given by these respondents for ranking Francisco Street least complex were: similarity of buildings, plainness of buildings, alignment of the building cornices, and lack of power poles. The most common reasons for ranking Florida Street most complex were: large number of cars, gabled roof forms, more trash visible, and larger number of trees.

Density

All three of the streets were found to be between 35 and 47 dwelling units per acre. Table 3 shows that a variety of other density measurements were taken so that we might later identify the measures which correspond with perceived density ranking. Open sky is a measure of

Table 1

Streetscape Characteristic Measurement Results

Complexity Characteristics	Ranking High	Middle	Low	
Building articulation	FL	GR	FR	*
Facade silhouette	FL	GR	FR	*
Building-type variation	GR	FL	FR	
Street furniture	FL	GR	FR	*
Parked cars	FL	FR	GR	
Material variation	FL	GR	FR	*
Color variation	FL	GR	FR	*
Window variation	GR	FL	FR	
Architectural detail	FR	FL	GR	
Landscaping	GR	FL	FR	
Total Rankings	**High**	**Middle**	**Low**	
Florida Street	6	4	0	
Greenwich Street	3	5	2	
Francisco Street	1	1	8	
Other Characteristics	**High**	**Ranking Middle**	**Low**	
Activity level	FL	GR	FR	
Maintenance level	FR	GR	FL	

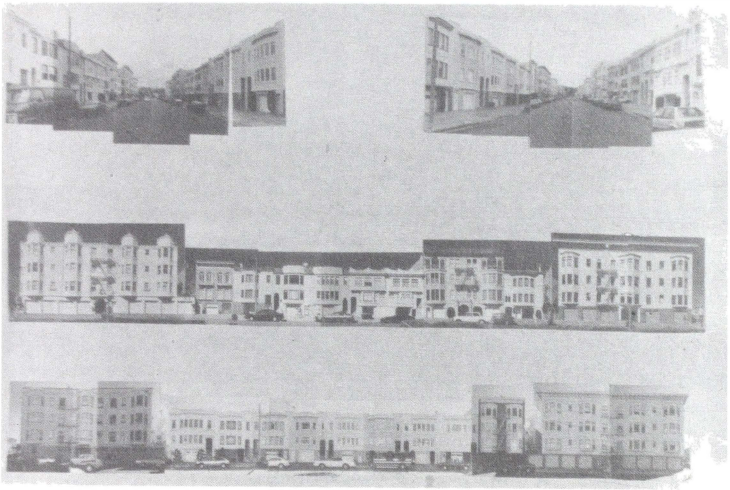
*Ranking corresponds (co-varies) with dominant perceived density ranking (see Table 4).
FR=Francisco St.; GR=Greenwich; FL=Florida St.

the sense of enclosure from the street walls around the observer (measured with photos from a fish-eye lens pointed upward) (Figure 8). View enclosure is a measure of sense of enclosure as the observer looks toward the end of the street (Figure 9).

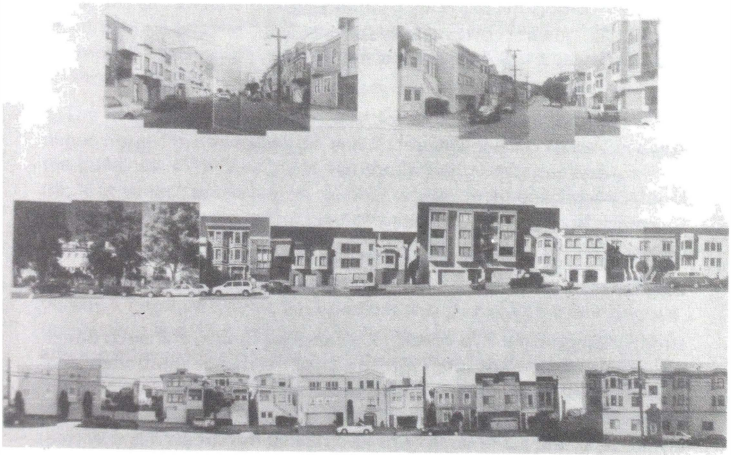
To determine the perceived-density ranking of the three streets, a second survey was conducted. A group of fifteen non-residents (university students) and seven residents of each street were shown photoboards representing the three streets (see Figure 7) and asked to rank the three streets from highest to lowest density. The results (see Table 4)

Figure 7

Photoboards

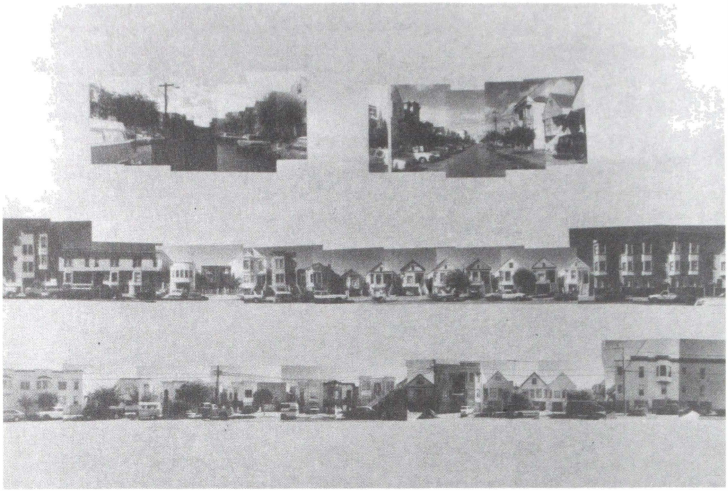


Francisco Street



Greenwich Street

Figure 7 (continued)



Florida Street

Table 2

Complexity Survey Results
(number of respondents)

	Ranking		
Totals	**High**	**Middle**	**Low**
Florida Street	10	4	1
Greenwich Street	4	10	1
Francisco Street	1	1	13

strongly support our hypothesis. Respondents ranked Francisco Street highest in density most often, Greenwich in the middle most often, and Florida lowest most often. There is a statistically significant association between streets and perceived density ($X^2 = 104.6$, significant at .001 level). All of the major subgroups also ranked the streets this way (see Figure 10).

Table 3

Density Measurement Results

Method	Ranking Low	Middle	High
Dwelling units/net acre	FL (35)	FR (41)	GR (47)
People per acre	GR (81)	FR (113)	FL (135)
Floor area ratio	FL (1.2)	GR (1.6)	FR (2.0) *
Facade area/l. f. of street	FL (18)	GR (32)	FR (36) *
Dwelling units/l. f. of street	FL (1.1)	FR (1.3)	GR (1.4)
Street area (SF)/dwelling unit	FR (500)	GR (470)	FL (375)
Parked cars/dwelling unit	GR (.45)	FR (.45)	FL (1.0)
Street area (SF)/parked car	GR (1080)	FR (1000)	FL (555)
Open sky	FL	GR	FR *
View enclosure	FL (45)	FR (42)	GR (39)

*Ranking corresponds (co-varies) with dominant perceived density ranking (see Table 4)
FR=Francisco St.; GR=Greenwich; FL=Florida St.

When asked which physical characteristics most influenced their ranking, the most common responses for ranking Florida Street least dense were: "it has the largest number of single-family dwellings" (15 responses); "it has the most open space between buildings" (7); "there are more smaller buildings on this street" (7); and "there are more trees on this street" (5).

The most common reasons given for ranking Francisco Street most dense were: "the buildings are taller" (14); "there is no space between the buildings" (11); "this street has the largest number of apartments" (8); "this street has the largest number of apartment buildings" (8); and "this street has the largest number of windows" (5).

There were two additional significant results from the research. First, in the surveys, 57 percent of all respondents said that they considered density a negative quality; 31.5 percent said it could be either positive or negative; and 11.5 percent said it was a positive quality. Secondly, although there was a definite consensus within the total sample group, there were variations between the responses from residents of the different streets (see subgroup profile chart, Figure 10). The Florida Street residents surveyed felt less strongly than the rest of the sample about Francisco Street being the most dense and ranked their own street most

Figure 8

Open Sky View

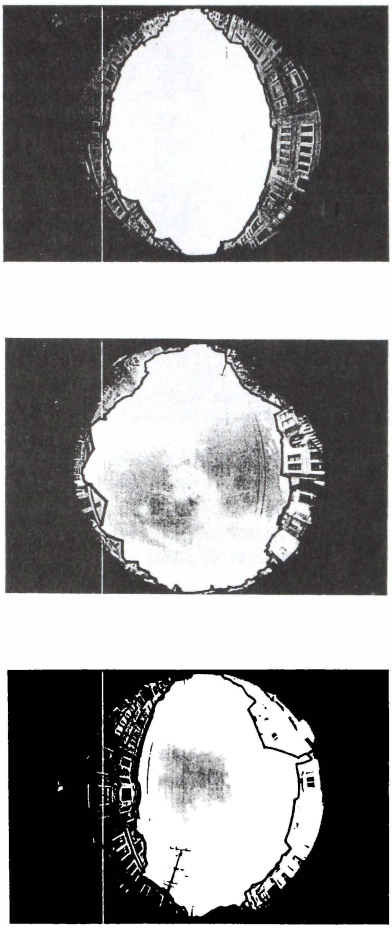


Figure 9

View Enclosure

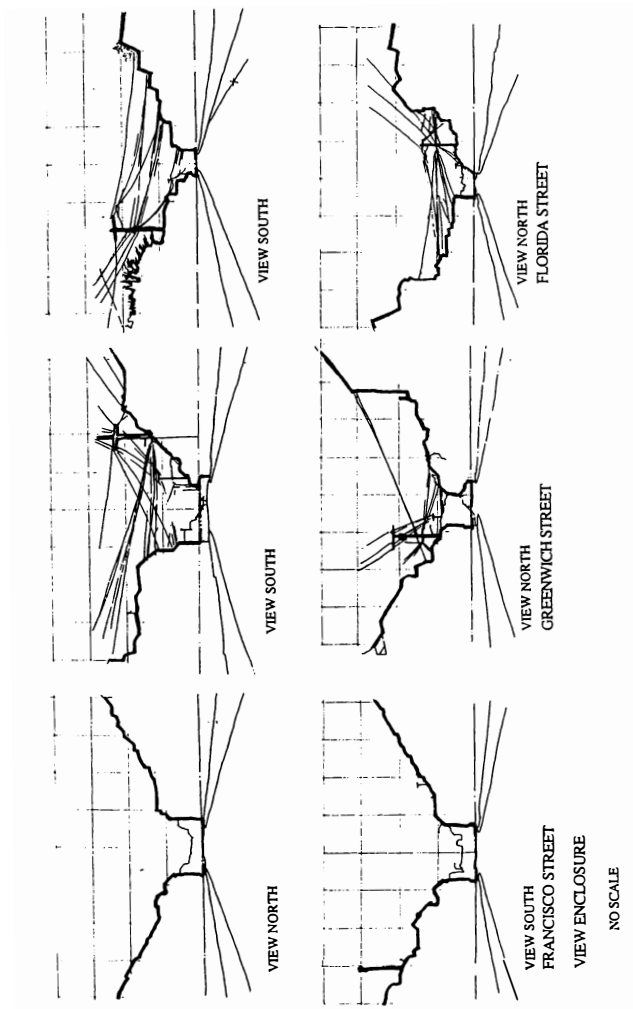


Table 4

Perceived-Density Survey Results
(number of respondents)

	Ranking		
Totals	**Low**	**Middle**	**High**
Florida Street	26	4	5
Greenwich Street	5	29	1
Francisco Street	4	2	29

dense twice as frequently as the total sample group. Florida Street residents had more difficulty ranking the streets because of the number of cars which were continually parked (legally and illegally) on their street. They perceived this as a sign of high density, but still mostly agreed that Francisco street looked most dense.

Conclusions

Because of the clear ranking of the relative densities and the general agreement among the survey participants, there must have been some commonly used visual cue(s) which influenced the ranking. Half of the "complexity" characteristics co-varied with the perceived density and therefore could have had an effect on the rankings (see Table 1). However, other non-complexity characteristics also co-varied with the perceived density, so that the hypothesis is not necessarily confirmed. We believe that three of the streetscape characteristics are largely responsible for the density rankings -- facade area, building articulation, and building typology. These not only co-varied with the perceived-density ranking, but also were mentioned by many of the survey respondents as reasons for their ranking.

First, an increase in the quantity of facade area is associated with increased perceived density. On Francisco Street, the buildings are not separated by recesses, so all of the facade is on the street. The average floor area of the units is greater than on the other streets (indicated by FAR -- see Table 3). Florida Street has recesses separating many of the buildings, and generally has smaller buildings. The impact of facade area on Florida Street is also reduced in the panoramic photos because some buildings are set back and some are obscured by trees.

Second, an increased level of building articulation is associated with decreased perceived density. This is noted as primarily separation

Figure 10

Subgroup Profile Chart

SUBGROUP PROFILES	SAMPLE SIZE	PERCEIVED DENSITY * HIGHEST (FR GR FL)	MIDDLE (FR GR FL)	LOWEST (FR GR FL)	DENSITY IS (%) +	O	−	SEX M	F	RACE W	B	H	A	HOUSEHOLD DATA (MEDIAN VALUES) INCOME BRACKET	RESIDNT (#)	LENGTH (YRS)
TOTAL SAMPLE	35				4 (11)	11 (31)	20 (57)	18	17	29	1	2	3	3	2.0	3.25
NON-RESIDENTS	15				1 (7)	4 (27)	10 (67)	9	6	12	1	0	2	—	—	—
FLORIDA ST. RESIDENTS	6				2 (33)	1 (17)	3 (50)	3	3	3	0	2	1	3	3.25	1.75
GREENWICH ST. RESIDENTS	7				1 (14)	3 (43)	3 (43)	5	2	7	0	0	0	4	2.0	1.5
FRANCISCO ST. RESIDENTS	7				0 (0)	3 (43)	4 (57)	1	6	7	0	0	0	3	1.0	5.0

* FREQUENCY HISTOGRAMS IN % OF SAMPLE SIZE
FR = FRANCISCO ST. GR = GREENWICH ST FL = FLORIDA ST.
DENSITY PERCEPTION: + = POSITIVE; O = NEUTRAL ; − = NEGATIVE
INCOME BRACKET: 2 = $20-40,000 ; 3 = $40-60,000 ; 4 = $60-80,000

between buildings and major projections on a facade. The recesses between the Victorian buildings on Florida Street break up the streetscape and give the appearance that the buildings are physically detached. The bay windows and door recesses here also add articulation and break up the facades, whereas the ones on Francisco Street do not project as far into the street and have less visual impact.

Third, a greater number of buildings equated with single-family houses is associated with lower perceived density. Florida Street has a number of smaller, "house"-like buildings (i.e. visually detached, gable roof) which were noted by survey respondents as a cause for their density rankings. The "building types" measurement of our site analysis does not reflect this characteristic. Respondents associated the gabled, visually separated row houses on Florida Street with single-family houses, but associated the flat-roofed row houses on Francisco Street with apartments. They were less influenced by the multiple doorways in some buildings than by the overall building form.

There are several other physical characteristics whose presence also co-varied with the perceived density, but which were not mentioned by the respondents (or only by a few). These may just be coincidentally co-varying on these streets, or they may have a subconscious effect on attitude which the respondents did not think of or failed to mention. Also, there are some characteristics which may have an effect on perceived density if isolated from the others, but, in the three streets examined, are counteracted by more persuasive cues. One example of this is the number of parked cars on Florida Street mentioned earlier. Another example is the level of maintenance, which varies from highest on Francisco Street to lowest on Florida Street. Some people might associate higher density with poor maintenance and trash, but in this case that perception was outweighed by other factors.

The facade area, building articulation, and typology may all have a simultaneous affect on perception, or only one may be inferentially responsible for the density ranking. Although people mentioned these characteristics as reasons, we cannot be sure that they weren't justifications after the fact. But assuming that what people say they see is closely related to what they do see, we can be reasonably certain of these conclusions.

Implications

This study was exploratory in nature, but has potentially significant implications for the planning, architecture, and development fields. Where higher densities are desired or necessary, building separation, facade articulation, and archetypal house forms might induce lower perceived densities. The amount of facade area facing urban streets

could be manipulated by step-backs or recesses, and could be regulated through design review or planning codes.

The differences among resident subgroups, although slight, raises several important questions. Florida Street residents were by far the most dissatisfied with their street environment, and this may have had an effect on their density rankings. Several of the six residents interviewed complained about the number of cars parked illegally and problems with drug dealing on the street. And this variation may point to differences in the way residents and non-residents rank the density of an environment. Residents' intimate knowledge of an environment is an important factor to take into consideration, and more research needs to be done on the relationship of such non-physical issues as satisfaction to perceptions of density.

A clear implication is that the measurement of density in terms of its visual impact (facade area, enclosure, and related indicators such as Floor Area Ratio) could better predict its effect on behavior and satisfaction than measurements such as persons or dwelling units per area. Planners and policymakers should keep this in mind when using density to estimate impacts.

In many ways, this discussion has only uncovered the tip of the iceberg. Would the results be the same with higher-density mixed-use environments or lower-density suburban streets? How are various streetscape characteristics linked cognitively to density rankings? How does a resident's familiarity with an environment change the way it is perceived relative to others? Are there inherent differences in the visual complexity of housing as density increases? Is there a level of complexity or visual stimulation which is optimal for human comfort or satisfaction? Many planners and architects are asking these questions in response to the growing need for higher-density housing and its conflict with preference for low density. Future research should attempt to address these questions and build a body of results which can be applied in a straightforward way to planning and design practice.

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