Environmental Quality and Safety Assessment of Residential Streets

A. S. HAKKERT AND A. H. PISTINER

The use of behaviorally oriented criteria to assess environmental quality of residential streets is considered in this study. The two main aims of the study were (*a*) to establish objectives for environmental design based on residents' perceptions of traffic and design variables and (*b*) to develop a subjective procedure for assessing street environmental quality and to verify the extent to which it agrees with existing procedures developed in Europe. Ten one-way residential streets in Haifa were selected for detailed study. The method of study drew on two sources of information. First, 147 residents of the 10 selected streets responded to a questionnaire in which perception levels regarding a number of street attributes were assessed. Second, a set of systematic observations and objective measurements of traffic and environmental variables was conducted for each street. Multivariate analysis of interview responses, traffic-related parameters, and environmental indicators was conducted to understand better the way in which factors tend to cluster and to develop quantitative relationships from regression analyses of responses to various conditions. The questionnaire data were summarized using the principal components model of multivariate analysis. Four composite variables were extracted and defined from the original 11 variables. Stepwise multiple regression analysis with environmental and traffic variables as predictors yielded correlations of the order of 0.60, indicating that individual perception can be satisfactorily predicted. Street rankings on the basis of environmental quality were assessed according to three different procedures. A fair degree of agreement was achieved (*R* = 0.70).

The street is multifaceted, at once a channel for traffic and a social space. This is particularly true of residential streets, which are the setting of a large number of human activities, both indoors and out.

By means of an effective design, the street can provide an environment that supports human behavior and supplies its needs. It may be assumed that an environment that provides conditions for the proper performance of dwellers' indoor activities as well as opportunities for human contact and outdoor activities is not only desirable but necessary for environmental (residential) satisfaction.

Street design may affect the quality of the residential environment in two principal ways. First, the street pattern and geometric characteristics will influence, to a large extent, the way in which motor traffic uses the street. Under certain circumstances, motor traffic, both moving and parked, may create inhibiting effects on activities such as walking, sitting, and playing.

Indoor activities may also be disturbed by traffic noise and fumes, and a sense of intrusion on privacy may occur as the result of perceived high density (crowding) caused by sensory stimuli such as high traffic density and much parking (*1*). Over the years, a wide range of techniques and design solutions has been developed to restrict traffic volumes and speed and to control parking so that noise, fumes, visual intrusion, pedestrian-vehicle conflicts, and other unpleasant stimuli are reduced to tolerable or desired levels.

Second, design will obviously influence the street's visual appearance, its shape and proportions. Human perception includes the aesthetic experience, which is of ultimate emotional significance. Many streets are flat, uninteresting, and lacking in individual identity. They may lack an appropriate sense of enclosure, stretching visually to infinity through open vistas.

In order to determine the physical dimensions that will give the street a harmonious scale, it is important to consider the dynamic quality of the street (a space that is apprehended), the human scale, and the expected intensity and type of activities that will occur there.

Safety is an important aspect of street life and is generally expressed in terms of accidents, but these are very sparse on any one residential street and are difficult to relate to scientifically or treat statistically. For this reason, surrogate objective variables, such as speed, are adopted. It is, however, important to determine how these surrogate variables are related to safety and also how they are related to other street qualities important to residents.

The general aim of this paper is to explore the relationship between residents' perceptions of street quality and the objective variables related to the various aspects of a street's environmental quality.

The way in which people use the street and for what purposes, as well as the way that residents feel about their home surroundings, will depend a great deal on the manner in which the residential environment is perceived and the relative importance placed upon the factors involved by the people who are subjected to them. Research on how the perception of the impact of roads and traffic is struc-

Transportation Research Institute, Technion-Israel Institute of Technology, Haifa 32000, Israel.

tured by those who are exposed to it suggests that there are three main aspects perceived: severance aspects, including difficulty and danger in crossing the road; noise and fumes (unpleasant conditions); and visual effects (*2*).

Interference with sleep and speech are frequently cited as major reasons for annoyance with residential traffic noise. Robinson (*3*) states that a sound level of 48 dB(A) allows conversation in a normal voice at a distance of 4 m. Beranek (*4*) quotes a maximum indoor level of 40 to 45 dB(A) if television and radio are to be understood comfortably. Subjective ratings of motor vehicle noise heard outdoors are provided by Wilson (*5*). Sound levels below 70 dB(A) are considered quiet, whereas levels between 80 and 88 dB(A) are rated noisy, and levels above 89 dB(A) are rated very noisy. Further details on the relationship between traffic characteristics and noise are provided by Alexandre et al. (*6*), the U.K. Department of the Environment (*7*), and Hothershall and Slater (*8*). Traffic fumes are less noticeable to those indoors but are found to be a great nuisance to those outdoors. Harmful effects generally attributed to traffic fumes include chest pain, poisoning of the atmosphere, breathing afflictions, cancer, sore throats, and coughs (*2*).

The effects of roads and traffic on vision are more complex than those on hearing or smell. However, some of the work carried out in the field, which combined physical measures of visual intrusion with social surveys, shows that factors such as the amount of road, traffic, sky, and greenery visible from the observer's angle of view are significant in determining visual satisfaction (*9*).

The danger of traffic is generally measured by the occurrence of accidents. However, in residential areas, accidents are a rather unsatisfactory indicator for lack of traffic safety. A further dimension in the problem of pedestrian safety on residential streets is the level of safety perceived by those who live on that street. Casualties being relatively rare events, residents do not generally think of their streets as being unsafe in terms of frequent collisions; however, they express a broadly perceived concern about "traffic problems," almost always related to traffic speed and volume, which are closely related to accident potential (*10*). In a recent study on subjective safety conducted in Holland (*11*), which included both questionnaire surveys of residents and objective measurements, it was found that subjective safety as expressed by residents was most strongly related to traffic volume and speed.

Considering the subjective aspects of all these effects, it might be said that in order to conduct a proper evaluation of street problems, whether related to the environment or traffic conditions, it is essential to supplement the professional evaluation with evaluations by residents.

Quantitative measures must be developed on the basis of social surveys and situational characteristics so that an efficient tool may be provided for the determination of design measures or other policies concerning residential environment improvements. Some attempts in this direction have been made by different researchers and will be mentioned later in this paper.

STUDY OBJECTIVES AND METHOD

This study is concerned with using behaviorally oriented criteria to assess environmental quality and with identifying design variables that have the potential to modify the impact of traffic, not only by actually controlling it, but also by affecting residents' psychological feelings or perceptions. The main aims of the study are as follows:

- To examine a number of subjective criteria suggested for the evaluation of environmental quality;
- To explore the relationship between subjective variables representing residents' perception of street qualities and measured objective variables;
- To develop a model of street environmental quality based on residents' perceptions; and
- To examine the relationship between the model and comparable methods developed in Europe.

In order to examine the perceived effects of specific design variables, a number of streets were selected for study. Because it was not financially possible to look at a large number of situations, it was decided to control certain conditions in the selection of streets. Ten one-way residential streets in Haifa, Israel, were selected on the basis of the following criteria: mainly residential land use, location within one section of the city, relatively homogeneous population by social class and income, traffic volumes up to 250 vehicles/hr during peak hours, one-way traffic flow, and presence of on-street parking. The major environmental differences among the streets were their length, cross-section dimensions, horizontal and vertical alignment, visual character, landscaping, traffic speed and composition, and parking density.

The 10 streets selected from a larger sample of residential streets in Haifa can be described as follows.

- Land use: mainly residential with mostly multifamily apartment buildings, generally six to eight apartments per building.
- Land value: generally among the higher values in the Haifa metropolitan region; all streets are located within one geographical section of Haifa.
- Population profile: relatively homogeneous by social class and income, with high rates of home and car ownership.

One-way streets were selected because a large number of the streets in the sample were one way, and it was believed advantageous not to complicate the study with one more variable. One-way versus two-way operation was, however, not a major consideration of this study. It is believed that the results will be generally applicable and not restricted to one-way streets.

The method of study drew on two sources of information for each street: an attitudinal survey of residents and a set of systematic observations and objective measurements of traffic and environmental conditions.

Attitudinal Survey

Approximately 15 randomly chosen residents on each street were selected for 147 home interviews lasting about 20 min each. The number of interviews carried out represents about 5 percent of the number of households on the streets. The main issues explored in the interviews were residents' perception of the street as a community (for outdoor activities and social contact between neighbors); general residential satisfaction; perceived noise and fumes from traffic; sense of safety from traffic; perception of traffic conditions; and perception of visual and aesthetic street qualities, walking conditions, and comfort.

The interviews were conducted by means of a well-structured questionnaire that allowed the subjects to make their own ratings.

Perception levels were assessed regarding a total of 11 street attributes: traffic safety, volume, speed, noise, and fumes; street use by children (street play); street use by neighbors (sitting, walking, etc.); contact among neighbors; street visual quality; pedestrian comfort; and general residential quality.

A series of continuous rating scales was used to assess residents' perceptions. The scales represent attitude continua upon which subjects were invited to mark their own ratings.

Three basic relationships were formulated, the first two of which were assumed and the third was hypothesized:

1. The level of a resident's satisfaction with an isolated street attribute is a function of the perceived effect of the attribute measured for that respondent;
2. A resident's overall satisfaction with the street environment is a function of his level of satisfaction with the individual attributes of the street; environmental quality can be assessed in terms of user satisfaction; and
3. Residents' perceptions will be related to objective measures of traffic and street conditions, and satisfaction levels will vary from one site to the other according to different street characteristics.

Data Collection (Street Survey)

A series of objective measures was needed that could be used as a setting within which to interpret residents' subjective responses. The following street environmental and traffic conditions were postulated to have a potential impact on residents' perceptions: street length, horizontal and vertical alignment, cross-section dimensions (sidewalks, green strips, traffic and parking lanes, building setback), traffic volume and speed, bus service, parking density, landscaping, street enclosure, noise levels, and residential density.

The objective variables to be subjected to statistical analysis were obtained partly from street measurements and partly from street plans and wide-angle photographs taken along each street (photogrammetric analysis). Table 1 details the complete list of objective variables considered.

TABLE 1 OBJECTIVE VARIABLES

No.	Description	Unit
X6	Street length	Meters
X7	Horizontal alignment, expressed as route factor *R* = over-the-route distance (m)/"airline" distance (m)	Ratio *R* (dimensionless)
X8	Vertical alignment, expressed as dominant gradient along street (more than 50 percent of length)	Percentage
	Cross-section dimensions	
Y2	Sidewalk width	Meters
Y3	Moving-lane width	Meters
Y5	Ratio of (sidewalks + green-strip width) to (traffic-lane + parking-lane width)	Ratio (dimensionless)
Y6	Peak-hour traffic volume	Vph
Y7	Average daily transit traffic	Buses per day
Y8	Average traffic speed	Km/hr
Z2	Speed not exceeded by 85 percent of drivers	Km/hr
Z3	On-street parking density	No parked cars in 100 m
	Photogrammetric analysis	
Z4	Road and traffic intrusion in visual field	Planimeter tool units (not to scale)
Z5	"Openness" (measure of green space enclosure)	Planimeter tool units (not to scale)
Z6	Landscaping (amount of greenery in visual field)	Planimeter tool units (not to scale)
Z7	Ratio Z4 to Z6	Planimeter tool units (not to scale)
W3	Noise level (L10) not exceeded for 10 percent of time	Decibels (A weighted)
W4	Average building set back from lot line	Meters
W6	Residential unit density	Units per 100 m
W7	Building density	Buildings per 100 m
W8	Distance between opposing buildings	Meters

Variables *Z4* (road and traffic intrusion), *Z5* ("openness"), and *Z6* (landscaping) were measured from photographs taken down the center of each street at 200-m intervals. The size of specific areas on the photograph was measured by planimeter, but could easily have been expressed as a percentage of the total area.

The methods employed for data collection included field observations supplemented with manual and mechanical counts and use of existing data sources.

STATISTICAL ANALYSIS AND RESULTS

Multivariate analysis of interview responses, traffic-related parameters, and environmental indicators was conducted to understand better the way in which factors tend to cluster and to develop quantitative relationships from regression analyses of responses to various conditions.

Subjective Data Analysis: Principal Components Model

The scores obtained from the questionnaire for each subject and scale were subjected to statistical analysis. First, an 11 × 11 sample correlation matrix was obtained and used as a basis for extracting principal components (based on 147 observations). The principal components model accounts for the variance within a data set by providing those linear combinations of correlated variables that maximize the variance of the weighted sum. The new variables (the weighted sums) are orthogonal to each other, and therefore independent. In a subspace of dimension less than that defined by the complete set of correlated variables, the phenomenon of interest may be studied more conveniently.

The foregoing procedure extracted four composite variables from the 11 original ones. These composite variables provide the categories that form the residents' perceptive structure of interrelationships, and the weights associated with the correlated attributes (variables) reveal the importance placed on each attribute. The combinations of variables and their definitions are given in Table 2.

The weighted sum of the first variable set accounted for the greatest amount of variance within the data (24 percent).

From the relationships exhibited in the data structure, a number of conclusions can be drawn:

1. The issues approached in the questionnaire were grouped into four main categories of residents' perceptions: traffic safety, aesthetics and comfort, street community, and traffic nuisance.

2. From the correlations between variables within categories, the following conclusions may be drawn:

   a. The perception of risks is related to the perception of traffic conditions, particularly traffic speed. The correlation between perception of speed and perception of risk (n = 147) was .56 ($p < .01$). Attribute theory describes, among others, the ways in which people attribute unpleasant phenomena (for example, accidents) to their own behavior, the behavior of others, chance, or circumstances. In view of the foregoing results, traffic conditions appear to be causal attributes that largely amount for residents' perception of risk.

   b. The perception of visual quality is related to the perception of comfort and residential quality. This is in agreement with findings reported by Lynch (*12*):

> Perception includes the aesthetic experience but is also entangled with many other purposes: comfort, human interaction, orientation and the communication of status. . . . The aesthetic experience is conveyed not only by vision but by other senses as well. Sensations of cold and moist, hot, bright, windy, warm or sheltered, sound and smell can hardly be separated from the visual impression.

The correlation between perception of visual quality and pedestrian comfort (n = 147) was .51 ($p < .01$), and the correlation between perception of residential quality and pedestrian comfort was .41 ($p < .01$).

   c. The perception of street use for outdoor activities is related to the degree of socialization indicated by residents. This is in agreement with the ideas expressed by Jacobs (*13*) and by Unterman (*14*): "The casual sidewalk life provides the natural setting for the public contact between neighbors; enhances socialization and sense of community." The correlation between perception of street use by children and perception of street use for walking, sitting, talking, and other outdoor activities (n = 147) was .41 ($p < .01$). The correlation between perception of street use for outdoor activities and the degree of socialization between neighbors indicated by residents (n = 147) was .30 ($p < .01$).

   d. The perception of traffic emissions is related to the perception of traffic volumes. Although other traffic attributes, for example, speed, also affect traffic emissions, only volume was perceived as a causal attribute. The correlation between the perception of noise and traffic volume was .31 ($p < .01$).

3. The amount of variance explained by each variable cluster points out the importance of Cluster 1, traffic safety, which accounts for almost 25 percent of the variance exhibited, followed by Cluster 2, aesthetics and comfort, which accounts for 16 percent of the variance.

Sample distributions and cumulative frequencies according to C_1, C_2, C_3, C_4 (within streets and in general) provided a valuable insight into the problem areas from a resident's perspective and revealed that responses varied significantly from street to street. The general situation in the study area can be described as follows:

1. More than 50 percent of those interviewed found safety and traffic conditions on their streets unsatisfactory;

2. Approximately 25 percent of those interviewed were not satisfied with their street's appearance and walking conditions;

3. More than 50 percent of those interviewed indicated that nothing much was going on in their streets and knew few or none of their neighbors;

4. Less than 15 percent of those interviewed complained about noise and fumes from traffic on their streets.

TABLE 2 VARIABLE COMBINATIONS AND DEFINITIONS

Composite Variable	Variables Combined	Definition
C_1	Traffic speed Traffic volume Traffic danger	Traffic safety
C_2	Visual quality Pedestrian comfort Residential quality	Aesthetics and comfort
C_3	Child street-play Outdoor activity Neighboring	Street community
C_4	Traffic fumes Traffic noise Traffic volume	Traffic nuisance

Clearly, there is wide concern with traffic conditions among the residents interviewed. Speed, dangerous curves, and lack of visibility were the main causes mentioned for lack of safety, followed by traffic volumes.

In relation to street aesthetics and pedestrian comfort, the main complaints were lack of vegetation, lack of continuity in the walking path, parked cars, large asphalt areas, and microclimate (too hot or too windy).

Development of Qualitative and Quantitative Relationships

The relationships between situational characteristics and perception of street conditions were considered on two levels. First, the individual perception was used as a starting point (n = 147 individuals). Second, the average perception per street (n = 10 streets) was used as a measure for assessing street environmental quality in terms of user satisfaction.

It would seem important to explore the relationships between residents' subjective assessments, as expressed by the composite scores developed, and the objective variables measured. Through an understanding of these relationships, ways can be found to improve residents' subjective satisfaction with the environmental quality.

Multiple regression analyses were used to determine the main variables that affect residents' perceptions and to determine their relative importance.

Because the multiple regression procedure requires the predictors to be independent, the objective variables submitted for analysis were arranged into subsets so that variables within each subset were independent. Each subset of variables was alternatively subjected to analysis using the SPSSX statistical package; the equations that best explained the variance of the subjective variables are as follows (numbers in parentheses indicate significance levels; levels below 1 in 10 are considered significant):

$$C_1 = -53.5X_7 - 3.5Z_2 - 8.2X_8 + 417.4$$
$$\quad (.029) \quad (.000) \quad (.028) \quad (.000)$$

$R = 0.62 \qquad n = 147$

where

C_1 = individual perception of traffic and safety,
X_7 = horizontal alignment (curvature) ($2 < X_7 < 3$),
X_8 = vertical alignment (steepness) (2 percent $< X_8 <$ 7 percent),
Z_2 = 85th-percentile speed (35 km/hr $< Z_2 <$ 52 km/hr), and
constant = 417.4.

$$C_2 = -7.4Y_3 - .11Z_5 - 159.9Z_3 + 304 \quad R = 0.63$$
$$\quad (.084) \quad (.007) \quad (.006) \quad (.000)$$

where

C_2 = individual perception of aesthetics and comfort,
Y_3 = effective traffic lane (3.4 m $< Y <$ 7.8 m),
Z_5 = "openness" (measure of street enclosure obtained by photogrammetric analysis) ($180 < Z < 505$ planimeter tool units),
Z_3 = on-street parking density ($0.24 < Z < 0.53$ cars/m of street), and
constant = 304.

Stepwise regression analysis over all respondents (n = 147) with the measured variables of street environment as predictors yielded a multiple correlation (R) of .62 with the variable perception of traffic safety, C_1 (C_1 being the statistical combination representing the three subjective variables traffic speed, traffic volume, and traffic danger).

The independent variables included in the model were street curvature, street steepness (gradient), and traffic speed. They contribute negatively to the perception of traffic safety.

The multiple correlation (R) with the variable perception of aesthetics and comfort (C_2) was .63. The independent variables included in the model were effective traffic lane width, "openness" (a measure of the street enclosure), and on-street parking density. They contribute negatively to the perception of street aesthetics and comfort (see regression equation for C_2 above), C_2 being the statistical combination representing the three subjective variables visual quality, pedestrian comfort, and residential quality.

The regression analysis did not yield significant correlations with the variables perception of street community C_3) and perception of traffic nuisance (C_4). Individual perceptions of these two variables could not be predicted satisfactorily on the basis of the environmental variables within the range of study. One possible explanation for this result is that all streets selected had reasonably pleasant conditions with regard to noise and fumes, which therefore were not perceived as problems.

Effect of Environmental Conditions on Traffic Behavior

Assuming that environmental conditions have an effect on traffic behavior, the correlations between the objective variables were obtained. Their examination focused on the effect of variables such as traffic lane width, street length, parking density, and horizontal alignment on traffic speeds. The results are discussed in the following paragraphs.

The correlation obtained between traffic speed and traffic lane width supports the theory that a street with wide lanes invites faster movements. The correlation with the 85th-percentile speeds, a measure that accounts for the faster traffic, was slightly higher than that with the mean speed ($r = .72$, $p < .01$). Effective lanes 3.5 to 4.5 m wide were found to have midblock mean speeds less than 30 km/hr and S_{85} less than 36 km/hr, whereas wider ones experienced mean speeds from 40 to 46 km/hr and S_{85} from 45 to 52 km/hr.

Because of the powerful effect of width on speed, it is difficult to evaluate, without holding width constant, the importance of street length in relation to speed. The correlation between length and 85th-percentile speeds was found to be .58, and the relationship of length to mean speed was found to be slightly less (.55). One of the wider (effective lane = 7.8 m) and shorter (length = 400 m) streets experienced speeds that appear lower than what might be expected, considering the rest of the pattern of speed versus width. It is possible that speeds are lower when width and length are less and are higher when both are larger. However, further attempts to explore the combined effects of street length and width on speed must be made before any conclusions can be inferred.

The correlation between speed and parking density was found to be .51 when the average speed was used and .56 for the 85th-percentile speed ($p < .01$). It is possible that the absence or presence of on-street parking is a more relevant characteristic than parking density and that better correlations might be found between speed and this latter measure. All streets selected for study had parking on both sides.

The correlations found between speed and alignment were also less significant than those between speed and traffic lane width. The correlation with the 85th-percentile speed was slightly higher than that with the average speed ($r = .40$, $p < .01$). It is possible that reduced sight distances due to curved alignment are more likely to produce a meaningful reduction in traffic speeds on two-way streets than on one-way streets, where the potential conflicts are less obvious. Only one-way streets were selected for this study. Another possible explanation is that alignment on the streets selected was not sufficiently severe to affect speeds significantly.

ENVIRONMENTAL QUALITY ASSESSMENT

In the final section of this paper, subjective ratings developed in this study are compared with subjective ratings developed in past work by other authors. In the search for valid methods to determine the environmental quality of streets, a variety of approaches have been used, and sets of criteria have been proposed, most of them objectively oriented. Apel (*15*) and Topp (*16*) are among the researchers who have studied this subject.

The model proposed by Apel estimates the multiple effects of traffic on the environment as a function of four main parameters, all of which are capable of being measured and quantified: noise, vehicle emissions (fumes), severance and pedestrian risk, and visual character of the street's cross section.

Topp suggested a methodology for determining street environmental capacity. It can be said that the procedure is based on a tradeoff between street appearance and traffic volume and six other main factors concerning street use by both pedestrians and traffic. A measure of the environmental quality of the street can be obtained by comparing the actual traffic volume in a street with its environmental capacity (optimum traffic volume).

In this study, the problem of assessing environmental quality is approached subjectively. In fact, it is the perceived environmental quality that is being assessed, defined in terms of user satisfaction and determined through attitudinal studies.

In order to assess environmental quality, the weighted sum of residents' average ratings of the street was used as an index. The overall resident satisfaction with the street environment was previously assumed to be a function of the level of satisfaction (negative or positive perception) with individual street attributes:

$$S_{jk} = \sum_{i=1}^{n} c_i \, (S_{ijk})$$

where

S_{jk} = overall satisfaction level of resident j on street k;
$i = 1, 2, 3, \ldots, n$ street attributes;
S_{ijk} = satisfaction level with attribute i of resident j on street k; and
c_i = relative weight of attribute i in resident's overall evaluation.

On this basis, environmental quality may be assessed and expressed as the weighted sum of average user (resident) satisfaction levels (positive or negative perceptions) with street attributes, so that

$$E_k = \sum_{i=1}^{n} c_i \overline{S}_{ik}$$

where E_k is environmental quality of street k, and

$$\overline{S}_{ik} = \frac{1}{m} \sum_{j=1}^{m} \overline{S}_{ijk} \qquad j = 1, 2, 3, \ldots, m \text{ residents}$$

The streets in this study were ranked according to environmental quality so that the results obtained (subjective assessment) could be compared with those obtained by two other assessment models developed in Europe by Unterman (*14*) and by Apel (*15*). The Kendall coefficient of concordance was used to assess the correlation between street rankings, which yielded a fair agreement ($W = 0.73$).

CONCLUSIONS AND DISCUSSION

The main conclusions reached in this study are discussed as follows:

1. The residents' perceptive structure of street attributes was provided by four categories of correlated variables (extracted by subjecting the questionnaire data to a prin-

cipal components analysis), defined as follows:

- Traffic safety,
- Aesthetics and comfort,
- Sense of street community, and
- Traffic nuisance.

2. Individual perception of traffic safety can be satisfactorily predicted on the basis of environmental and traffic variables within the range measured. A number of explanatory variables were revealed; street curvature, steepness, and traffic speed were found to be negatively associated with individual perception. In situations where traffic flow is relatively light, residents' perception is most affected by traffic speed. The impact of speed may be modified by the street alignment: the steeper and more curved the street, the more traffic will be perceived as fast and dangerous.

3. Individual perception of street aesthetics and comfort can be satisfactorily predicted on the basis of environmental and traffic variables within the range focused on in the study. Residents' response to the components of the street view was found to depend greatly upon the width of the road visible, the number of on-street parked cars, and the degree of street enclosure. Comfort and visual satisfaction increase with higher degrees of enclosure, narrower traffic lanes, and lower parking density.

4. The results can have important implications for street design and traffic management. Reducing lane width is effective both in slowing down vehicles and in improving visual appearance. Similarly, creating visual constrictions by defining parking spaces and alternating them with strategically located landscaped nodes can both reduce traffic speeds and improve street space enclosure. These measures may be preferable to other measures for reducing traffic speeds, such as bending lane alignment and reducing sight distances, because it has been shown that these are not likely to produce any improvement in residents' sense of safety unless a proper balance between curvature increase and speed reduction is achieved.

5. Environmental quality was assessed in each study street in terms of user satisfaction (expressed as the weighted sum of average residents' ratings of street attributes), and also according to two objectively oriented procedures developed in the Federal Republic of Germany (Table 3). The correlation between street rankings obtained with the different procedures yielded a fair degree of agreement, indicating that the subjective procedure is capable of assessing environmental quality at least as effectively as the objective ones.

6. The current study was exploratory in nature. It covered a wide range of street attributes and studied their interrelationships. The importance of the findings is, as yet, hampered by the limited amount of data collected. In terms of street attributes, the study was small in scale—all 10 streets selected fell into a fairly narrow, homogeneous range. It has been suggested that the study be extended to include a wider range of streets and different neighborhoods, cities, and street functions—perhaps eventually to different countries. In this way, the robustness of the findings can be assessed and eventually extended to design recommendations for improved street quality.

TABLE 3 STREET RANKINGS ACCORDING TO ENVIRONMENTAL QUALITY

Street	Ranking According to		
	Subjective Assessment	Apel (*15*)	Topp (*16*)
Zidquiahu	1	2	2
Nachshon	2	1	1
Disraeli	3	3	4
Hatzalafim	4	9	3
Qiriat Sefer	5	4	6
Ruth	6	8	7
Oren	7	10	9
Margalit	8	5	5
Yannay	9	6	8
Einstein	10	7	10

REFERENCES

1. A. Rapoport. *Human Aspects of Urban Form: Towards a Man-Environment Approach to Urban Form and Design.* Pergamon Press, London, 1977.
2. J. Morton-Williams, B. Hedges, and E. Fernando. *Road Traffic and the Environment.* Social and Community Planning Research, London, 1978.
3. D. W. Robinson. *An Outline Guide to Criteria for the Limitations of Urban Noise.* Acro Report AC 39. National Physical Laboratory of Israel, Jerusalem, 1969.
4. L. L. Beranek. *Acoustics.* McGraw-Hill, New York, 1954.
5. A. Wilson. *Noise: Final Report.* Her Majesty's Stationery Office, London, 1962.
6. A. Alexandre, J. Barde, C. Lamure, and F. J. Langdon. *Road Traffic Noise.* Applied Science Publishers, London, 1975.
7. *Calculation of Road Traffic Noise.* U.K. Department of Environment, London, 1975.
8. D. C. Hothershall and R. J. Slater. *Transport and the Environment.* Crosby, Lockwood, Staples, London, 1977.
9. R. G. Hopkinson. The Evaluation of Visual Intrusion in Transport Situations. *Traffic Engineering and Control*, Vol. 14, No. 8, 1972, pp. 387–395.
10. R. E. Brindle. Residential Area Planning for Pedestrian Safety. Presented at Joint Australian Road Research Board/DOT Pedestrian Conference, Sydney, Australia, 1978.
11. B. Miedema, H. Menkerhorst, and H. H. van der Molen. A Model for the Subjective Experiencing of Traffic Safety in Residential Areas. Presented at Conference on Safety in the Built Environment, Portsmouth, U.K., July 1988, 13 pp.
12. K. Lynch. *Site Planning.* Massachusetts Institute of Technology Press, Cambridge, 1971.
13. J. Jacobs. *The Death and Life of Great American Cities.* Penguin Books, New York, 1961.
14. R. K. Unterman. *Accommodating the Pedestrian: Adjusting Towns and Neighborhoods for Walking and Bicycling.* Van Nostrand Reinhold, New York, 1984.
15. D. V. Apel. *Kraftverkehr und Umweltqualität von Stadtstrassen.* Kohlhammer Publishers, Stuttgart, West Germany, 1973.
16. H. H. Topp. Umfeldverträgliche Verkehrsbelastbarkeit städtischen Strassen: Ein kompensatorischen Ansatz. *Strasse und Autobahn*, Vol. 11, 1984.