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Assessing the Built Environment for Pedestrians Through Behavior Circuits

C.J. KHISTY

Planners are generally concerned with those social and physical attributes that are distributed in time and space. These attributes typically occur in independent clusters or behavioral settings that vary in scale from an apartment complex to a large urbanized region. Within these settings, attributes can normally be analyzed in terms of identifiable and recurrent elements, patterns, and sequences. If one divides human behaviors by their scale and generality, it will be noticed that the things people do at the widest compass can be called behavior streams or activities. These, in turn, can be further separated into behavior circuits, which are differentiated by specific purpose. A systems view of the behavioral science/transportation framework is first described. The paper then examines the use of behavior settings and behavior circuits in pedestrian planning, designing, and the development of performance standards. Relative to a set of needs and purposes, certain aspects of environmental form typically support or constrain desired human action and communicate meaning and value.

Assessing the built environment from the standpoint of safety is an interdisciplinary inquiry that embraces the applied social and behavioral sciences. This assessment depends on the development of fundamental knowledge of the interaction of man-made physical environment variables with other environmental variables in influencing behavior.

This paper examines the use of behavior settings and behavior circuits in assessing the built environment, particularly the infrastructure built for the transportation of people. The outcome of this investigation can be used productively in assessing either the existing built environment or for planning future facilities. Although this paper focuses on assessing pedestrian planning and safety vis-a-vis the built environment, the techniques described here can be extended to other modes of transportation.

BACKGROUND

With the introduction of the transportation system management (TSM) element (1) in urban transportation planning, there is widespread interest among engineers and planners to improve existing pedestrian facilities and to plan new ones. In this and former efforts there has been a persistent tendency to imitate the classic planning and designing procedures adopted by planners for highway facilities. This has been unfortunate. The current predicament is in part the consequence of a gross underestimation of the complexities of human perception and mental need. All of the planning tools and procedures may be impeccable, but if the physical consequences--the actual objects in space--do not add up to a satisfying, vigorous, and safe environment, the total effort is of little consequence.

In recent years, many designers and planners have formulated new microtheories of the environment in an attempt to plan cities. Lynch (2), in his Image of the City, takes a cognitive approach to the environment in his attempt to get to the visual quality of the American city. Alexander (3) argues that only by tracing the functional requirements of human needs and activities can one provide solutions to problems of the built environment. Carr (4) speculates about criteria for environmental forms in his City of the Mind. Perin (5) separates the activities of human beings into units called behavior circuits. Barker (6) attempts to determine the relations between what he calls the "extra-individual" patterns of behavior, i.e., the behavior that people reveal in a behavior setting. His definition of a behavior setting is an environment that is bounded in space and time and has a structure that interrelates physical, social, and cultural properties that elicite common or regularized forms of behavior. Barker's behavior settings in time, space, and place involve far more than just the physical setting.

These microtheories not only provide an additional research perspective in regard to city planning and design but also provide the techniques for analyzing and solving problems that occur in transportation planning, particularly for pedestrians. The use of behavior settings and behavior circuits will be examined still further in this paper.

BEHAVIORAL SCIENCE/TRANSPORTATION SYSTEM FRAMEWORK

The systems view is an attitude of mind in facing complexity; it reflects a search for the interrelatedness of things in any problematic situation. As a planning tool it means approaching the transportation system as a complex whole within which many elements act interdependently. Several researchers have made contributions in understanding the behavioral science/transportation connection. Parsons' efforts, in particular, have set the stage for a good deal of interaction between behavioral scientists and transportation engineers (7-11).

To start with, a systems view of the behavioral science/transportation framework is useful. Transportation engineering and planning is involved with a diversity of basic activities performed by transportation specialists, such as policymaking, operations and safety, and testing and evaluations. Figure 1 illustrates these activities in the context of transportation modes. Although the use and distribution of transportation by mode is a continuing source of controversy, one can recognize nine major categories, including several fringe and developing groups in transportation (12). Parsons has identified nine categories of human behavior that are affected by transportation. These categories are given below (11):

1. Locomotion (passengers, pedestrians);
2. Activities (e.g., vehicle control, maintenance, community life);
3. Feelings (e.g., comfort, convenience, enjoyment, stress, likes, dislikes);
4. Manipulation (e.g., modal choice, route selection, vehicle purchase);
5. Health and safety (e.g., accidents, disabilities, fatigue);
6. Social interaction (e.g., privacy, territoriality, conflict, imitation);
7. Motivation (positive or aversive consequences, potentiation);
8. Learning (e.g., operator training, driver education, merchandising); and
9. Perception (e.g., images, mapping, sensory thresholds).

Similarly, there are at least 11 properties of the physical environment that have a direct impact on human behavior. Details of these environments are provided below (11,13):

1. Spatial organization: This dimension often includes the shape, scale, definition, bounding surfaces, internal organization of objects and people, and connections to other spaces and settings. Indeed, this is the dimension most people are referring to when they talk about the physical environment. The degree of dispersion, concentration, clustering, and proximity of facilities is also included.
2. Circulation and movement: This property includes people, goods, and objects used for their movement--cars, trains, highways, and rails--and also the forms of regulating them such as corridors, portals, turnstyles, and open spaces.
3. Communication: Both explicit and implicit signals, signs or symbols communication, required behavior, responses, and meanings are covered by this dimension; in essence, these are the properties of the environment that give users information and ideas.
4. Ambience: This dimension usually includes such items as microclimate, light, sound, and odor. Those features of the environment that are critical for maintaining the physiological and psychological functioning of the human organism are included.
5. Visual properties: The environment as it is perceived by its users is generally implied by this property and includes color, shape, and other visual modalities.
6. Resources: The physical components and amenities of a transportation system--paths, terminals, and vehicles--could be included. The measures of these resources could embrace such dimensions as the number of lanes or the square footage of the terminals.
7. Symbolic properties: The social values, attitudes, and cultural norms that are represented or expressed by the environment fall into this category.
8. Architectronic properties: This refers to the sensory or aesthetic properties of the environment.
9. Consequation: This is that characteristic of the environment that strengthens or weakens behavior. Measures of consequation may be items such as costs, risks, and congestion.
10. Protection: Safety factors in general are implied in this category.
11. Timing: All the items mentioned above are scheduled in time and some of them fluctuate with various cyclical rhythms such as daily, weekly, or hourly timings.

Figure 2 illustrates the impact of the environment

Figure 1. Transportation as a system.

	POLICY MAKING	ADMIN-MANAGEMENT	PLANNING	ANALYSIS, SYNTHESIS AND DESIGN	CONSTRUCTION	OPERATIONS	MAINTENANCE	TESTING AND EVALUATION
AIRWAYS								
CONVEYORS								
HIGHWAYS								
PIPELINES								
RAILWAYS								
WATERWAYS								
MULTI-MODAL								
EXOTIC								
QUASI-TRANSPORT								

Figure 2. Relation between aspects of transportation and their effects on people.

Environmental Aspects \ Human Behavior	Activities	Locomotion	Social Interaction	Feelings	Perception	Motivation	Health and Safety	Learning	Manipulation
Spatial Organization		X	X					X	
Circulation and Movements	X	X	X				X	X	
Communication	X	X	X					X	
Ambience	X			X		X	X		X
Visual Properties					X				X
Resources	X			X			X	X	X
Symbolic Properties	X	X			X			X	X
Architectural Properties	X	X	X		X		X	X	X
Consequation		X				X		X	X
Protection							X	X	
Timing		X	X						

on aspects of human behavior relevant to transportation. Further, individual differences among the population that use and provide transportation should also be considered. These dimensions include age, ethnicity, income, car ownership, economic status, health, and skills. Also, some of the basic ingredients that are embraced by transportation design are as follows (14): safety, security, convenience, continuity, comfort, system coherence, and attractiveness. The variables contained in these lists and figures may appear overwhelming, but they do set forth a systems approach to the interconnection between transportation and human behavior.

BEHAVIOR SETTINGS

The behavior-setting survey technique of Barker (6) encompasses several advantages for design practice. The method assumes that the physical environment and behavior are inextricably bound together. Bechtel (15) has applied Barker's methods to practical problems of house design, community planning, and organizational design. He interprets Barker's definition of a behavior setting as follows:

1. A behavior setting is a standing pattern of behavior that occurs over and over again in a given place and at a given time. You can go to the place where it occurs at the time it occurs and see the behavior repeated each time the setting happens.
2. Yet behavior settings, even though they are defined as separate entities, are a part of the flow of behavior in a community. People move in and out of settings, but the settings do not disappear when different people arrive; they have a life of their own. Yet when the community changes, settings change also.

The behavior-setting survey, which is the basis of the analysis, can take as long as a year to do. Various scales are used to quantify behavior within and across settings. These scales provide no fewer than 63 separate bits of information about each setting (15):

> When completed, the behavior-setting survey data are the raw material around which the designer can give form to his structures. The survey can be tapped for information about a room, a building, streets, and sidewalks, or any other aspect of the community in part or in whole. The behavior-setting survey is a complete catalog of behavior indexed to locations, times, frequencies, populations, age groups, intensities, and a complex of other details. Its use is not easy to master but it provides the only known comprehensive way to master design elements of behavior.

The chief advantage of Barker's technique is its directness in collecting valid data. It measures what people do with design features, not what they say they do.

BEHAVIOR CIRCUITS AND TRACKING

The behavior circuit is a unit of analysis or a unit of behavior that can be observed, recorded, and compared. Some behavior circuits may be similar in the actions composing them but have different outcomes. The behavior circuit is thus a unit of analysis that permits combinations of concepts in different areas of social and behavioral sciences to be operational. Perin (5) describes this concept as follows:

> What behavior circuit implies is an anthropological ergonomics, tracking people's behavior through fulfillment of their everyday purposes at the scale of the room, the house, the block, the neighborhood, the city, in order to learn what resources--physical and human--are needed to support, facilitate, or enable them.

Much of the data obtained from behavior-circuit analysis will undoubtedly be untidy, overlapping, and conflicting, and in many cases it will be quite a challenge to create order out of this confusion. By the same token, these data will reveal realities previously unrecognized and, in the long haul, save a lot of time in collecting data regarding attitudes, opinions, values, and preferences on a piecemeal basis.

Intimately connected with behavior circuits is the gathering of data through tracking. Tracking is the systematic following of a pedestrian and the recording of his or her movements. Patterns of pedestrian activity are derived from tracking a large number of subjects. It is not necessary to question the subject or for the tracker to take time explaining his or her activities. Instead, he or she can work expeditiously, making a large number of observations that can be translated into patterns of movement (16). One can, of course, employ direct communication with a sample set of pedestrians or conduct experiments of role play to gain information on the environmental requirements necessary to support this behavior. It may be realized that the mere observation of behavior only provides information on what people are now doing, not on what they want to do, which is often the more important question.

DIMENSIONS OF BEHAVIOR CIRCUITS

All environments have both social and physical attributes. Planners and engineers are generally concerned with those attributes that are distributed in time and space and are at least controllable. These attributes typically occur in independent clusters, behavior settings, or regions that vary in scale from apartment sidewalks to large urbanized regions. Within these settings attributes can normally be analyzed in terms of identifiable and recurrent elements, patterns, and sequences. Psychological and behavioral significances can only be assessed relative to the general environmental context and the forms of man-environment interactions that occur within that context. Relative to a set of needs and purposes, certain aspects of environmental form typically support or constrain desired human action and communicate meaning and value. These aspects can usually be described in terms of the above-mentioned selected 11 properties of the physical environment that have an impact on human behavior.

DESIGN CRITERIA AND PERFORMANCE STANDARDS

The design of pedestrian facilities involves the application of traffic-engineering principles combined with consideration of human convenience and the design environment. Different environments logically require the application of different qualitative as well as quantitative design standards. Failure to take into consideration the sociocultural requirements of the users of the built environment accounts for many of the problems that people experience in dealing with the man-made world.

Design and performance criteria are the preferred means of control where they can be capably administered. Controls are based on standards, which are formal statements about the stable characteristics of environmental features that are presumed to make them universally desirable or acceptable. Standards are a necessity in order to simplify the large and shifting body of information about performance so that decisions are not lost in detail and uncertainty (17).

The design of pedestrian spaces involves not only the application of basic traffic-flow principles but also the consideration of human convenience and the design environment. For example, in the case of pedestrian movement, one could apply the level-of-service concept elaborated by Fruin (14), along with the concepts of task efficiency, reduction of stress, comfort, and safety. However, no quantitative tool by itself can substitute for good judgment.

It is important to find out what characteristics the environment ought to have to support pedestrians at one of the following levels:

1. The survival level,
2. The efficiency level,
3. The comfort level, or
4. The pleasure and enjoyment level.

These levels are, of course, arbitrary and are stated this way only for purposes of illustration. In a way, each type of behavior circuit suggests its own performance standard or criteria for design. Perin classifies behavior circuits as routines "when they recur so often as to have a regularized sequence that the person carries out relatively unconsciously and more or less independently of others" (5). A young person taking a casual stroll in the local park might fall into this category. "Behavior circuits are collaborations when the actions composing them recur frequently, but unlike routines, go beyond the compass of the self to require other persons or equipment for carrying them out" (5). Pushing a child in a stroller on the sidewalk of a busy street, or for an elderly person to operate the "walk" pushbutton at an intersection, could be considered a collaboration. "Behavior circuits are events when the maintenance of various kinds of group relations occur, at any level of frequency" (5). Weaving one's way through a large gathering of people in a shopping mall might be classified as an event, particularly if one is totally disoriented because of ambience. Perin also mentions a residual behavior circuit called "emergencies". One could interpret this category with those situations where the propensity for accidents and of insecurity is obviously high, for example, where the safety requirements influence the form of the structure. There is need for caution to be exercised in applying this classification. What is routine for the 20-year-old may be an event for an octogenarian. At the same time, a close look at all the behavior circuits and their categorization into routines, collaborations, events, and emergencies may result in the planner having to spend time only analyzing the events and emergencies. Perin (5) observes two important consequences as a result of using behavior circuits. First, the observer is alerted "to differences in age, residential location, education attainment, ethnicity, income, car-ownership and so on, casting the imperative for differing environmental resources in kind, interval, density, and so on" (5). Second, the relation between numbers of people and the amount of space needed to accommodate them is brought out strongly. Connected with this relation is the time dimension of behavior circuits. The introduction of time to control the level of use of a facility becomes possible only when the patterns and density of use are known. The time element naturally brings into focus the idea of movement. The time it takes to carry out any kind of behavior circuit is included implicitly as a performance standard.

SECURITY AND SAFETY

Even though the general public today is aware of the benefits of the walking mode, there is great concern regarding the increasing crime rate in large metropolitan areas, particularly for the pedestrian. People's beliefs about security help determine whether they will be pedestrians at all, and how, where, and when they will walk if they decide to do so.

The basics of "defensible space" developed by Newman (18) demonstrate that design features of the built environment can influence crime rates. Defensible spaces avoid features that convey stigma, vulnerability, or isolation. The concept of defensible space depends on a community's sense of territoriality, where the arrangements of pathways, sidewalks, and buildings foster a sense of control and cohesiveness among people living in the community. Second, defensible space requires surveillance through proper lighting and visibility. Security can be enhanced by providing facilities with a safe image. Third, nonstigmatizing design forms provide the basis for defensible space. Newman's work is most applicable to pedestrian safety and security. From the standpoint of behavior circuits, insecurity and accident-prone settings would fall under the category of emergencies. The use of behavior circuits in assessing the built environment for security and safety is particularly valid.

PLANNING PROCEDURES

In ex-post-facto studies of the built environment, one can always examine specific areas that reveal trouble spots through tracking, interviewing, or behavior settings and circuits. Pedestrian volume and density changes, shifts in user attitudes, or recent additions in pedestrian generators may have to be carefully reviewed. The results of demonstration projects of pedestrian facilities can provide excellent insights into problems likely to be faced in new or modified projects. It may also be possible to transfer knowledge gleaned from one situation to another. Some items of pedestrian design problems appear to repeat themselves more often than others, such as the problem of negotiating flights of steps, ramps, and slippery pavements; the hazards of cars turning right on red; street furniture obstructing pedestrians; lack of refuge islands on wide urban streets; and pedestrian facilities used predominantly by children and/or the elderly. It is these problems that ought to be looked into critically while new facilities are being designed, although they may appear to fall in the category of routines and collaborations. However, in general, one would look at events and emergencies very carefully. The use of behavior circuits will enable the planner to identify probable or actual crime problems. The ideal strategy, of course, is to assemble packages of countermeasures that complement each other and mutually permit the achievement of multiple goals. Some security design goals are providing adequate surveillance of pedestrian facilities, controlling access and egress, minimizing exposure time in crime-ridden areas, ensuring adequate communication, and enhancing perceived security.

Lynch (17) feels that, by describing behavior circuits in terms of behavior settings, the intended outcome is obvious. "It is linked to the restrictions and potentials of individual situations, the requirements of the users, the general objectives and the potentialities of future form. It is both a statement of detailed criteria and the essence of the design. It can also be the basis of collaboration between the behavioral scientist and designer because it is based on behavioral knowledge" (17). He further goes on to say that "the requirements of settings may be stated as required thresholds. Since different groups of people will be taking different actions for different purposes in any given situation, program requirements specify for whom the settings are intended and how predicted conflicts are to be handled. Programs of this kind not only link objectives to specifications but allow proposed designs to be evaluated by the way they fulfill explicit requirements. Once built, the environment can be monitored to see if it is performing as predicted" (17). The acid test, of course, is the way in which a plan for pedestrians supports purposeful behavior.

A unified set of procedures for incorporating security features for the pedestrian in the overall planning process is necessary. It is both easier and cheaper to include such security measures in the initial design phases. Richards and Hoel have suggested a plan for mass transit station security (19), and a modified form of their procedure is given below:

Step 1: Assess initial situation;
Step 2: Use behavior setting and behavior circuits through interviews, questionnaires, and observations;
Step 3: Anticipate and document safety problems;
Step 4: Establish safety and security goals;
Step 5: Select possible countermeasures;
Step 6: Evaluate possible countermeasures;
Step 7: Consider limits and constraints;
Step 8: Consider trade-offs;
Step 9: Establish countermeasure strategy; and
Step 10: Evaluate overall project after implementation.

Some of the basic characteristics that could contribute to safety problems can be identified through a variety of ways. Several ways of assessing the current situation are given below:

1. Existing facility: (a) design features; (b) neighborhood characteristics; (c) functional requirements; (d) crime statistics; (e) expert input by police, community leaders, behavior circuits, and behavior settings; (f) interviews with users; and (g) incident reports.

2. Planned facility: (a) design features, (b) neighborhood characteristics, (c) functional requirements, (d) crime statistics, and (e) input from potential users, community leaders, police, business people, behavior settings, and behavior circuits.

CONCLUSION

This paper examines the use of behavior settings and behavior circuits in assessing the built environment for one mode of transportation--the pedestrian mode. It provides a brief introduction to current microtheories of the environment, describes the use of behavior circuits and behavior settings, and comes up with possible strategies for their use in planning and safety programs.

Many disciplines have helped the engineer and planner to assess environmental quality. Difficulties arise in research of this nature because of its interdisciplinary content.

The use of behavior circuits in pedestrian planning and safety is comparatively new. It symbolizes the growing interaction of sociologists, psychologists, and planners to understand and resolve pedestrian problems. This is an instance where the use of behavior circuits gets the planner away from the usual circular reasoning to critically look at the whole complex of behaviors associated with a pedestrian. The use of behavior circuits in pedestrian planning enriches one's understanding of human behavior and enables the planner to get a holistic view of the problem.

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Pedestrian Accidents on Rural Highways

J. W. HALL

Pedestrian accident experience in two New Mexico counties is far in excess of statistically expected levels. These accidents, which occur principally on rural roads, result in a fatality more than 60 percent of the time. This research was undertaken to determine if engineering improvements could reduce the frequency of these accidents. Field studies were conducted at 95 rural pedestrian accident sites in these two counties. It was found that roadway geometrics at these locations were good and that sight distance exceeded standard requirements. Fixed objects, parked vehicles, and other features that might conceal a pedestrian along the roadside were noticeably absent. At the same time, pedestrian safety devices and amenities were employed infrequently at the accident sites. Most locations had adequate right-of-way width to accommodate separate sidewalks or paths for pedestrians. Although more than 80 percent of the accidents occurred at night, roadway lighting is a viable improvement at only a limited number of the rural locations. Two cluster areas of pedestrian accidents may warrant the most immediate attention. The inability of engineering features or deficiencies to explain a significant amount of the variation in the characteristics associated with these pedestrian accidents suggests that other, nonengineering factors may play a more important role in their occurrence.

One of the tasks of highway and traffic engineers is to provide for the safe movement of pedestrians. In several regards, the pedestrian is at a considerable disadvantage in the traffic system. However, engineers attempt to accommodate pedestrians through the provision of special facilities, such as sidewalks and crosswalks, and the use of other features, such as street lighting, which may be of value to both pedestrians and motorists. Because pedestrian activity occurs predominantly in urban areas, attention has traditionally focused on these areas.

PEDESTRIAN ACCIDENT STATISTICS

The problem of pedestrian-vehicle interaction is suggested by nationwide accident statistics. During the past decade, pedestrian fatalities in the United States have averaged 9400/year. Although pedestrians are involved in less than 1 percent of all accidents, they account for 18 percent of the highway fatalities. In 1980, New Mexico accounted for 1.29 percent of the nationwide pedestrian fatalities and 1.16 percent of the nationwide nonpedestrian highway fatalities. Table 1 compares nationwide characteristics of pedestrian accidents with those in New Mexico. As shown in the table, the fatal pedestrian rates based on population, registered vehicles, and vehicle miles of travel are all about twice the national rates. It is also noteworthy that nearly half of New Mexico's fatal pedestrian accidents occur in rural areas versus one-third nationwide.

Data from the 1980 Fatal Accident Record System (FARS) suggest that pedestrians account for a larger share of highway fatalities in the more urbanized

Table 1. Pedestrian accident characteristics, 1980.

Item	United States	New Mexico
Pedestrian accidents	130 000[a]	630
Pedestrian fatalities	8180	106
Fatality index	0.06	0.17
Rural fatality (%)	34	49
Travel-based rates		
Accidents per 100 million vehicle miles	8.52	5.64
Fatalities per 100 million vehicle miles	0.54	0.95
Population-based rates		
Accidents per 100 000 persons	58.6	48.8
Fatalities per 100 000 persons	3.7	8.2
Mileage-based rates		
Fatalities per 1000 miles	2.1	1.5
Urban fatalities per 1000 miles	7.9	9.9
Rural fatalities per 1000 miles	0.9	0.8
Registration-based rate, fatalities per 100 000 vehicles	5.3	10.3

Note: Data in this table are compiled from the following sources: Federal Highway Administration; Fatal Accident Record System, National Highway Traffic Safety Administration, U.S. Department of Transportation; New Mexico accident record system; National Safety Council; and National Traffic Safety Bureau.
[a]Estimate. The accuracy of this number, and the rates based on it, are subject to debate.

states. Analysis of nationwide data shows a highly significant correlation between population density and the pedestrian proportion of highway fatalities. The 10 states with population densities greater than 200 persons/mile^2 report that 20 percent of their highway fatalities involve pedestrians, while in the 10 states with densities less than 20 persons/mile^2, the corresponding value is 12 percent. In New Mexico, where the density is 11 persons/mile^2, pedestrians constitute more than 19 percent of the highway fatalities.

These statistics suggest that the pedestrian accident experience in New Mexico differs somewhat from that of other rural states. To further examine this issue, the state's computerized accident records for 1978-1980 were evaluated. Of the 156 000 accidents during this period, 2090 (1.3 percent) involved a pedestrian, and in 96 percent of these, impact with a pedestrian was cited as the first harmful event. Of these accidents, 16 percent resulted in a fatality. An examination of accidents by county found that, with two exceptions, the reported percentage of pedestrian accidents was in good agreement with the proportionate share of all traffic accidents.

The two exceptions were McKinley and San Juan counties, which are located adjacent to each other