Measuring Pedestrian Behavior

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The lack of a criterion measure of pedestrian performance may, in part, account for the relative neglect of pedestrian safety. The measure developed here is based on observation of pedestrian behavior in normal traffic. Observation is limited to a small number of behaviors that are critical for accident causation in order to reduce the information load on observers. Unambiguous coding rules and intensive training of observers resulted in achievement of very high intercoder reliabilities. The technique was used successfully in an evaluation of a pedestrian safety curriculum for primary grades. At intersections, the behaviors of some 1500 children were coded, and about 750 were coded at midblock crossings. The remarkable finding was the prevalence of dangerous behavior patterns in the school trip, where the probability of an accident is low. Although the measurement technique was developed while observing child pedestrians, it is equally applicable to adults.

The social costs of pedestrian collisions with motor vehicles are immense, contributing almost 20 percent of the fatalities attributable to motor vehicles. Yet pedestrian safety is consistently underplayed in the United States in terms of research, program development, and interest. Although there are many reasons for this, the absence of a reliable and valid criterion of pedestrian performance is an important contributor. This paper describes the development of such a criterion measure. The developmental work was done on children, who are greatly overrepresented in pedestrian fatalities, but the techniques developed are appropriate for pedestrians of any age.

A performance measure should be reliable, valid, feasible, and cost effective if it is to be useful in evaluating behavioral change. The first decision is where to test: Behavior on ranges and in other restricted environments has never been shown to be predictive of behavior in real traffic and, on the face of it, such situations are both too simple and too obtrusive. Even Dueker's technique (1) of eliciting crossing of a real street where there was controlled but real traffic (one automobile) is too simple to permit generalization to other kinds and complexities of situations. The behavior to be measured must therefore (a) be unconstrained, (b) be recorded unobtrusively, and (c) occur in many different situations of normal complexity. That is to say, it must occur in normal walking trips.

Measuring behavior in normal traffic is the best guarantee of validity. The validity sought here is construct validity and it is gained by deriving the behavioral events schedule from the in-depth accident analyses of Snyder and Knoblauch (2) and Knoblauch (3). In a large proportion of cases, the proximal causes of pedestrian accidents are the pedestrian's failure to search and detect and his or her sudden appearance, which implies running into the path of a vehicle and unexpectedness of location or blocking of driver's or pedestrian's view.

The second decision concerns measuring techniques: In theory, these can be instrumented, observational, or some combination of the two. However, the only practical approach involving instrumentation is videotape, which is ultimately coded by trained observers. It has serious disadvantages: It is significantly more expensive and provides much less information about the general traffic circumstances, speed, and distance. It is also more difficult to do unobtrusively in some situations than observation. Its single supposed advantage—potentiality for coding by two observers—is both very expensive and unnecessary, since the observers must be trained to the same high degree of reliability whether or not videotape is used. The method of choice was on-the-spot coding of behavior by highly trained observers. This is both feasible in all situations and most cost effective. The question that usually arises is one of reliability. In three previous studies observers have achieved high interobserver reliabilities (4-6). Standard techniques for increasing reliability are simplification of both the observation itself and the recording of it, avoiding informational overload, and providing extensive training. The remainder of this paper describes the development of the observational technique for pedestrian behavior, the reliability achieved, and, briefly, its use as a criterion of countermeasure effectiveness.

PARAMETERS OF PEDESTRIAN BEHAVIOR

In order to focus observers' attention and avoid information overload, only those aspects of pedestrian behavior most likely to be causally related to accidents were selected for coding:

1. Search at the curb,
2. Stopping at the curb,
3. Position within or outside the crosswalk area,
4. Walking versus running,
5. Playing of any sort while crossing,
6. Walking in the street instead of on the sidewalk,
7. Crossing two streets without gaining the curb in between them, and
8. Crossing midblock.

In addition, several situational variables were coded: presence or absence of traffic, size and type of group, and crossing in the presence of an obvious threat to safety. Usually, the behavior of a single individual is coded at any one time. Pedestrians arrive either singly or in groups of various sizes. In the case of groups, a single individual is selected at random before the group is within 3 m (10 ft) of the curb and followed until the far curb is reached. The exception is midblock crossing, where all those crossing are tallied, but only according to whether a visual obstruction was present or not. The reason for identifying group size is that the size of the group is related to its visibility to drivers and possibly also to the responsibility taken by each individual for his or her own safety. Group type permitted the identification of groups of similar age (in this case, children in the primary grades), those that contain an older child, and those that contain an adult. Figure 1 shows the coding form. For each group observed, the symbol was circled if the behavior occurred and slashed if it did not.

DEVELOPMENT OF THE INSTRUMENT

This instrument was developed as a criterion measure for a pedestrian safety education program for children of the primary grades. To ensure stability of measurement, a large number of observations is necessary. Since this can be obtained for small children only by making observations near elementary schools at times of school trips, observers were stationed near unsignalized intersections a block from the school grounds. Their positions were as unobtrusive as possible—in a

Figure 1. Coding form.

School: ____________
Date: ____________
Intersection: ____________
& ____________
Obs. Time: From ______ to ______
Coder: ____________

USC Pedestrian
Performance Test

Traffic Control: ____________

Diagram of Intersection:
(Include # of Xwalks & S.W.)

GROUP TYPE	N	TRAFFIC	SEARCH	STOP	DANGER	PROGRESS	SPECIAL
		T	L R B	S	D	WALK X-WALK	PL. $\overset{2}{\text{STS}}$. ST.
		T	L R B	S	D	WALK X-WALK	PL. $\overset{2}{\text{STS}}$. ST.
		T	L R B	S	D	WALK X-WALK	PL. $\overset{2}{\text{STS}}$. ST.
		T	L R B	S	D	WALK X-WALK	PL. $\overset{2}{\text{STS}}$. ST.
		T	L R B	S	D	WALK X-WALK	PL. $\overset{2}{\text{STS}}$. ST.
		T	L R B	S	D	WALK X-WALK	PL. $\overset{2}{\text{STS}}$. ST.
		T	L R B	S	D	WALK X-WALK	PL. $\overset{2}{\text{STS}}$. ST.
		T	L R B	S	D	WALK X-WALK	PL. $\overset{2}{\text{STS}}$. ST.

Comments:

Midblock ________ / ________ (tally)
(clear) (obstruction)

Turning Only ________________ (tally)

parked car if possible; if not, then away from the corner and as though waiting for someone. The children gave no evidence of awareness of the observers.

During the development of the form, several observers coded together and checked their agreement after each individual pedestrian. Where frequent disagreement occurred, the instructions were clarified and the observers given more training. In some cases some less critical behaviors were eliminated because the observers could not handle the attentional overload. In other cases, some procedural rules helped, for example, check for traffic when the child to be observed was 3 m from the curb. This assured that the action was not submerged in behaviors that required close attention once the pedestrian reached the curb.

Initial training of observers was done by using videotapes of children crossing near schools so that disagreements could be discussed and resolved by reviewing the tapes. However, some aspects of the situation (traffic or danger) were not clear. Training then progressed to the coding of adult behavior (because of convenience of location) and, finally, to coding, in groups of two or more, the behavior of children on school trips, with discussion after each pedestrian was coded. The training required two weeks after the final form was approved, coding for 30 min before school and 20 min after school. As usual, the most difficult behavior to code was search. The coding rules required a definite head movement in the direction of search. Whereas it can be argued that eye movement may sometimes be sufficient if scanning occurs early enough, for children, at least, short-term memory is probably not sufficiently good to make this strategy safe; it is doubtful that it is safe even for adults, except in situations where very few vehicles are in view. Eye movements of more than about 15° engender head movements reflexly, so proper scanning when in the vicinity of the curb would normally involve head movements. It is recognized that search is only part of the process of search and detect, but only search can be observed unobtrusively and in normal situations. Detection is impossible without search; hence, if search is found to be deficient, we can assume that detection is deficient also, though the reverse cannot be argued.

INTEROBSERVER RELIABILITY

The interobserver reliabilities were based on the coding of the same pedestrians by two observers. In this case there was, of course, no communication between them. Two sets of observations are available: one taken after initial training and just prior to the pretest in a curriculum evaluation study and the other taken about four weeks later, after a few days of refresher training, just prior to the posttest measurements. These data are given in the table below. The statistic used, Cohen's Kappa (7), corrects for chance agreements. A Kappa of 0.60 is satisfactory; hence, these data show high reliability for this technique.

Coder Pair	Number of Observations	Kappa
Before pretest		
2,4	89	0.92
3,4	268	0.74
1,3	108	0.80
1,2	212	0.74

Coder Pair	Number of Observations	Kappa
Before posttest		
2,4	69	0.76
1,3	147	0.74
2,3	90	0.89
1,4	139	0.80
1,5	317	0.82
3,5	149	0.82
4,5	154	0.77

EVALUATION OF A PEDESTRIAN SAFETY CURRICULUM

The performance measures described were used as the performance criterion in an evaluation study of the California Pedestrian Safety Curriculum. The observations were made of a sample of children at several locations at each of eight schools at two points in time, about four weeks apart. Individuals are not identified. It is assumed that the same children pass a given point each day, with minor exceptions. The sampling occurs when children arrive in groups. Then the observer selects one for coding. The target child is varied from one group to the next for position in the group, size (age), and sex.

The design of this study was a pretest—posttest control group design, stratified by socioeconomic level. Volunteer schools were stratified into high or low socioeconomic status and then eight were randomly assigned to training or control groups. The group from which these schools were selected had been identified as having the most pupils who walk to school. Two observers, assigned to different locations, coded at each school. The observations were made during the two weeks preceding the month-long pedestrian safety training program and during the two weeks following it. Table 1 gives the numbers of pedestrians coded by school and by group for the pretest and posttest. A total of 707 children were observed for the pretest and 870 for the posttest. The discrepancy is attributed to a heat wave that occurred during the pretest; there is no reason to believe that this affected the trained and control groups differently.

Table 1. Number of children observed at intersections.

	Trained Children			Control Children	
School	Pretest	Posttest	School	Pretest	Posttest
a	89	80	e	176	194
b	147	143	f	25	80
c	15	46	g	92	151
d	120	102	h	43	74
Total	371	371		336	499

Table 2 presents the posttest frequencies of the more critical behaviors. The proportion of children who performed correctly is of greatest interest here. In search (certainly the most critical behavior) only 40 percent of children searched left before they moved into the traffic lane. Back search, to detect potential turning vehicles, was made by a meager 5 percent, and right search was made only about 25 percent of the time. These figures are no different from those obtained in the pretest. Also of prime importance is stopping at the curb before proceeding, since that gives time for detection by both pedestrian and driver. Only 25-30 percent of the children did so. In addition, 20 percent of them stepped into danger. At intersections 30 percent of children ran across the street and 10 percent played as they crossed. Midblock crossings were very frequent—almost half as many as intersection crossings—and the majority of these occurred where vision was obstructed by parked cars. Table 3 shows this analysis.

Table 2. Analysis of posttest frequencies of pedestrian intersection behaviors for trained and untrained children.

	Trained Group		Untrained Group		
Behavior	Correct (%)	N	Correct (%)	N	χ^{2a}
Left search					0.08
Yes	40	148	41	204	
No		223		295	
Right search					0.84
Yes	26	98	29	146	
No		273		353	
Back search					0.79
Yes	6	24	5	25	
No		347		474	
Stops at curb					4.80[b]
Yes	25	93	32	159	
No		278		340	
Steps into danger					0.01
Yes	19	72	20	98	
No		299		401	
Walks or runs					1.42
Walks	73	271	69	346	
Runs		100		153	
Stays within crosswalk					3.33
Yes	80	298	85	424	
No		73		75	
Plays in street					0.23
Yes	9	32	10	48	
No		339		451	

[a] In all cases df = 1.
[b] $p < 0.05$.

The proportion of children crossing incautiously is thus appallingly large. Since the school trip probably represents the greatest exposure for young children, it is amazing that more are not hit. Reiss has suggested that the tendency to walk in groups makes them more visible to drivers (8). Somewhat more than 60 percent of our pedestrians walked in groups. Our observation during three studies at elementary school sites during six months of field work was that drivers behave more cautiously in the neighborhoods of schools at the times when children may be expected to be walking there and when they see several groups of children. The fact that the largest number of fatalities to child pedestrians occurs after school hours has led to theorization that children are more distracted then by play and interesting events. However, our data indicate that children's

Table 3. Analysis of midblock crossings.

	Obstructed Crossings			Clear Crossings			Total		
Group	Pretest	Posttest	χ^{2a}	Pretest	Posttest	χ^{2b}	Pretest	Posttest	χ^{2c}
Trained	126	164		51	44		177	208	
Control	70	205		61	39		131	244	
Total	196	369	20.17	112	83	1.34	308	452	9.63

[a] df = 1, $p < 0.005$.
[b] df = 1, $p < 0.001$.
[c] df = 1, $p < 0.25$.

traffic behavior is extremely hazardous even under the best of circumstances. This is true even after training in a program that is both more intensive and more focused on critical behaviors than most [see Jones and Fleischer (9) for a full report].

CONCLUSIONS

Observations of critical pedestrian behavior have been shown to be highly reliable, provided (a) observations are limited to a small number of behavioral events at a time, (b) the behaviors are unambiguously defined, and (c) the observers are highly trained. Although the data reported were obtained on children, adult behavior can be coded as easily. If it is desired to look at other special behaviors, they can be carefully defined and substituted for any of those used here, since adding observational categories will overload the observers and destroy reliability. Training of observers must be continued until the index of agreement (Kappa) reaches a satisfactory level. With these provisos, this method of structured observation can provide the behavioral criterion necessary for the evaluation of pedestrian countermeasures.

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Use of Pedestrian Conflict Analyses for Hazard Assessment in School Zones

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The purpose of this study was to develop and test a traffic conflicts procedure to assist in the early identification of hazardous school-zone locations. Various pedestrian conflict types and severities were used to collect data and analyze 10 school-zone sites in the Rochester School District. Multivariate linear regression techniques resulted in high correlations between pedestrian conflict levels and site-related traffic and highway variables. A subjective danger index was developed based on various pedestrian conflicts and events. The 10 school-zone locations were priority ranked based on danger index and other conflict measures. A systematic flowchart procedure was used to help select site improvements based on conflict types, safety deficiencies, and corresponding safety improvements. Although pedestrian conflicts were found to be related to known hazardous conditions at the test sites, the relationship between pedestrian conflicts and pedestrian accidents has not been quantified. Further testing of accident-conflict relationships is recommended.

The interaction between pedestrians and motor vehicles results in a serious and costly toll of young lives each year. In the United States, the pedestrian fatality rate for young school children (5-14 years of age) is approximately 5 fatalities/100 000 population. Only the fatality rate for pedestrians over 65 years of age exceeds this rate. In addition, during 1977, there were approximately 1330 pedestrian fatalities among school children in the 5 to 14-year-old age group. An additional 34 000 pedestrians in this age group were injured (1). The school walking trip represents between 10 and 20 percent of the young pedestrian accidents, or 10 000-20 000 accidents annually (2).

Developmental factors have been found to affect a child's safe conduct in traffic. Among the factors are the following:

1. Misunderstanding by children regarding traffic rules and the physics of an automobile,
2. Lack of experience and limited judgment in traffic situations,
3. Restricted visibility due to a child's small size,
4. Limited powers of concentration, and
5. A child's tendency to be playful and impulsive (3, 4).

The vehicle and roadway also contribute considerably to the safety problem. One West Virginia study found that the most significant factors of influence on school-zone speeds were the approach speed limit, the distance of school buildings from the roadway edge, traffic volumes, and the length of school zones (5). The control