severely affected groups of shops, may well be relatively small. It will be important, therefore, to devote as much effort as possible to studying the more-direct costs imposed on retailers' operations.

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Nonlocal Traffic in a Residential Neighborhood: The Problem and Its Management as Seen by Residents

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This study examines the problem of nonlocal traffic in a relatively lightly traveled residential neighborhood adjacent to the Pennsylvania State University campus at State College, Pennsylvania. The purpose of this research is, first, to assess what constitutes a traffic problem for the area residents and, second, to evaluate their preferences among alternative traffic control measures. The data were collected through field observation and a home-interview survey on a sample of streets in the neighborhood. An analysis of variance shows significant overall differences between medium- and light-traveled streets in the residents' perception of the problem and willingness to accept traffic restraint measures; however, the residents' location relative to a particular control device and how it affects their mobility, as well as other socioeconomic factors, account for a great deal of the difference. Controlling speeding in the neighborhood is the residents' most important concern and four-way stop signs are the preferred solution to that problem. The research findings point out some of the inadequacies of traffic engineering practices, such as traffic counts, accident records, and solicitation of citizen complaints when viewed in isolation to be used as a basis for traffic management decisions.

Management of nonlocal traffic in residential neighborhoods has been a complex and controversial issue among transportation planners and the public. According to standard planning principles, streets in residential areas that are designed for local traffic should not be used by nonresidents to minimize travel times, to avoid traffic signals, or for parking (1). Environmental research has shown that high traffic volume and speed directly increase traffic accidents, as well as noise and air pollution; they have also been associated with decline in neighborhood quality and property values (2). Although traffic management strategies have been shown to alleviate some of the above problems, they have met with opposition from area residents and outsiders because they inhibit mobility and are an inconvenience, especially to those who do not benefit directly from the reduction of traffic (3).

IMPACT OF THROUGH TRAFFIC ON RESIDENTIAL ENVIRONMENTS

Studies of the quality of residential environments, as perceived by residents, have identified noise; accessibility; social compatibility with neighbors; maintenance of lawns, buildings, and streets; and safety of both self and property as important dimensions of neighborhood satisfaction (4,5). Through traffic in a residential neighborhood disturbs many of these qualities and threatens that environment. Traffic noise causes the greatest disturbance (2). Noise is related to volume of traffic and the speed and type of vehicle. Perception of noise correlates strongly with objective noise levels (6). However, personality, past experience, and situational variables such as time of sound are important in determining how a sound is perceived (7,8).

The volume and speed of traffic threaten the safety of residents. Families with young children and the elderly are especially fearful. For instance, in one study 74 percent of child and automo-

bile accidents were found to have occurred within 1 km of the child's home and, in more than 70 percent of these, the child is the cause of the accident, presumably because he or she has not yet developed skills to react to traffic movement (9). Property owners are concerned with the effect that increased traffic may have on the value of their property.

A question of interest to environmental researchers has been how people adapt to various environmental stress conditions. Appleyard, for example, found that high traffic volumes lowered social interaction that, in turn, led to a reduction of neighborhood cohesion and, ultimately, to a decline in homeowners' incentives to maintain their residences (2). A high level of traffic has also been associated with rapid population turnovers and with changes of land use from residential to commercial activities (10).

Effects of the volume of traffic form a vexing question. What matters is the perception of traffic and the willingness of residents to do something about its negative impact. The perception is determined by personal characteristics, such as one's frame of reference; by the status of the perceiver (homeowner versus renter, or permanent resident versus student); and, finally, by how the traffic affects the individual (location of home relative to traffic control device).

RESIDENTIAL TRAFFIC CONTROLS

Several types of traffic control have been implemented in the United States to manage nonlocal traffic in residential neighborhoods. Such controls can be categorized according to three types of strategies. Each is briefly described here.

Peripheral Strategies

Peripheral strategies are intended to reduce or stop nonlocal traffic from entering secondary residential streets along the periphery of the neighborhood. Such controls include traffic signs such as "Do Not Enter" or "No Left Turn" or they involve actual construction of physical devices, such as median barriers along arterials to prevent left turns and to increase the traffic capacity of the arterial. Outward flowing one-way streets and cul-de-sacs appear to be the most effective controls. The advantage of this approach is that controls are placed at the very site where the problem begins to occur. The strategy is effective because fewer motorists violate rules on busy streets where the perceived likelihood of enforcement is great (3).

Internal Strategies

Internal controls include stop signs (two-way or four-way) at key intersections, speed bumps and undulations with the intention of slowing down traffic, diverters of various designs, redesign of local streets, and limited-access pedestrian ways. The common version of speed bumps has a bad reputation among residents and local governments alike. The issue of the liability of local governments for injury due to speed bumps has come up in the courts (1). Research is currently being conducted to evaluate a new type of undulation design, and it is expected that the problems will be overcome (2).

The redesign of streets to a limited-access local automobile-pedestrian way can be accomplished by widening certain sections of the tree bank, planting shrubs in appropriate locations, allowing street parking for visitors, and even providing play areas. This approach allows local vehicles to pass through but makes it inconvenient enough so that nonlocal traffic would avoid the area. Such designs have been successfully implemented for years in many European cities and are currently being tried in Cambridge and Boston (11). Various parking strategies can also be used as means to discourage and regulate through traffic and speeding.

The advantage of most of the controls included in this approach is that measures can be implemented on a street-by-street basis depending on the traffic situation and the needs of the adjacent residents. The problems stem from the fact that such controls are not obvious to the outsider, can be very frustrating, may encourage violations, and are difficult to enforce.

External Strategies

Through traffic problems are usually associated with congestion on nearby arterial roads and intersections. The conventional approach is to relieve congestion by either increasing the capacity of the existing network or by expanding that network. The advantage of this approach is that it tries to solve the problem at its origin. The disadvantage is that such solutions are usually too expensive to implement and do not guarantee that motorists will stop going through the neighborhood.

Impacts of Controls

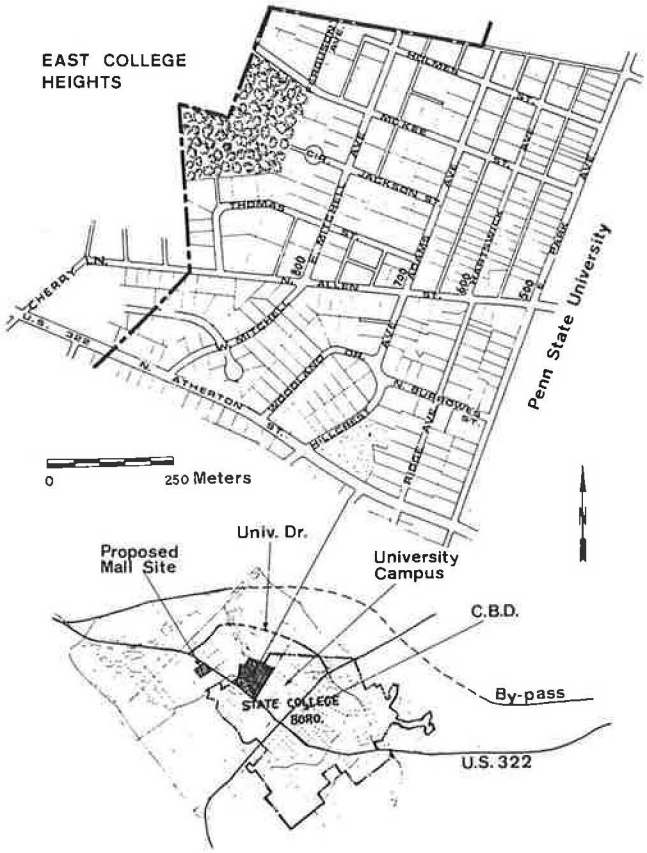
Research findings suggest that a residential neighborhood experiences a significant increase in property values and a reduction in accident rates as a consequence of a program involving street diverters and street closings (12); however, such strategies have been found to create side effects and to be potentially in conflict with a number of community interest groups (13). For instance, residents of the neighborhood in question may have to sacrifice their mobility in order to achieve the increased safety and tranquility that the traffic controls aim to accomplish. Motorists from the rest of the city are denied their right of access to portions of the urban street network, or they are diverted to other more congested streets, thus contributing to further deterioration of the traffic situation on those streets. The conflicts created by some of these strategies end up being contested in the courts, where challenges are made regarding the reasonable exercise of municipal powers (3). Emergency and other public service vehicles may be inconvenienced in their operations. Traffic engineers, who have the responsibility to facilitate the safe flow of traffic, are usually not experienced in handling the problems brought up here. Their engineering handbooks were developed to solve traffic problems on large roadways and have not been adequately adapted for use in medium- and light-traffic residential areas (1).

The problem of through traffic cannot be solved simply through reliance on technical application of solutions. The minimization of adverse side effects requires that the solution be responsive to the problem as it is perceived by local residents. In addition, the solution must anticipate residents' reactions. The present study focuses on these two aspects of the larger issue. It does so through measurement of both residents' perception of the through traffic problem and their responses to several alternative solutions.

EAST COLLEGE HEIGHTS NEIGHBORHOOD CASE

East College Heights is a low-density, single-family residential neighborhood of approximately 0.5 km^2 in the northeast end of the Borough of State Col-

Figure 1. Borough of State College and the East College Heights neighborhood.



lege, Pennsylvania (see Figure 1). State College is a university community of 35 000 that has experienced problems of rapid growth due to increases in student enrollment. The neighborhood is one of the oldest and most stable in the Borough. Its mature landscaping, attractive and well-maintained housing stock, serenity, and walking proximity to the campus make it a highly desirable place to live. Its residents have a long history of taking action to protect the character of their environment from outside threats such as transient parking, through traffic, and conversion of single-family units into rental apartments for students.

The neighborhood is bounded on the west by Atherton Street, a major four-lane arterial that is the only north-south corridor to carry a very heavy traffic load of 22 000 average daily traffic (ADT). Its southern boundary is Park Avenue, another heavy traffic arterial (10 000 ADT) that separates the neighborhood from the university campus. On the north and east sides it is surrounded by open space and park land. The intersection of Atherton and Park is one of the busiest in town, characterized by an F-level of service, where the greatest number of collisions and injuries occurs. Other intersections with high rates of traffic collision involving rear-end or left-turn accidents are at Atherton with Cherry Lane, Mitchell, and Hillcrest.

The traffic problem is created by southbound traffic heading toward the central business district (CBD) and the university on Atherton from suburban communities. In order to avoid the heavy traffic on Atherton and delays at traffic lights at Hillcrest and Park, many motorists cut through the study area (see Figure 1). A motorist can save time if he or she goes through the area during morning rush hours. The reverse movement takes place during evening rush hours. One recent study documented that there were more vehicles cutting through the neighborhood during rush hours than were turning at the intersection of Park Avenue and North Atherton Street (13).

Several direct and indirect solutions have been entertained in the past but have not come to fruition, including completion of the State College bypass, extension of University Drive, and the addition of a third lane on Park Avenue. Six years ago, a no-parking policy was adopted for the whole neighborhood in an effort to solve the problem caused by nonresidents who parked on these streets. The idea of imposing controls to restrict nonlocal traffic is not a new one. In the past, proposals were presented by the planning staff to close streets at one end of the neighborhood but failed due to the residents' opposition. Neighborhood action was triggered recently to control through traffic because of the prospective development of a major shopping mall less than 1 km north of the area along Atherton Street. The mall, according to Pennsylvania Department of Transportation studies, would generate 16 900 additional trips per day, many of which were expected to cut through College Heights (13). In April 1980, the mall developers withdrew their plans after considerable community opposition.

The planning commission staff, at the request of the State College Borough Council, conducted an opinion survey of area residents in January 1980. A questionnaire was mailed to all 365 area households in order to assess the residents' attitudes about through traffic and to evaluate alternative measures to correct the situation. Of the 142, or 39 percent, of the households that responded, 72 percent felt that there was a through traffic problem and 84 percent felt the Borough should take action to control through traffic.

The survey presented five alternatives that consisted of a combination of three basic techniques: post-type bollards to create dead-end turnarounds, intersection barrier diverters, and traffic signs. Residents were asked to rank them according to their preferences. The use of only a system of diverters was the most popular one (13). There was not much consistency in the recorded preferences. It appears that the more complex alternatives were the least popular among the respondents, while the most simple alternatives were the most popular. The main finding from the respondents' comments was that many felt too many restrictions were placed on their mobility. The community service and emergency vehicle personnel, whose opinions were also solicited on the alternatives, complained that they would be required to use roundabout routes that would conceivably cause delays and waste energy.

Study Objectives

Because of the difficulty in interpreting the results, limitations in the design and implementation of the above mail survey, and more recent developments, the planning department, in cooperation with university staff, decided to undertake a new survey in order to provide the necessary detailed and up-to-date information on which a decision could be made to proceed with controls or not. A new instrument was designed with the following objectives in mind:

1. To define more precisely the meaning of a traffic problem as perceived by neighborhood residents;
2. To determine a relation between actual traffic volume and the impact on residents' attitudes and actions;

3. To discover how the relative location of residents' homes to proposed control devices affects attitudes toward particular traffic control devices;
4. To get a better understanding of how factors such as size of household, length of residence, length of intended future residence, ownership, occupation, mode of transportation used to go to work, as well as values toward residential environment influence respondent's opinions;
5. To acquire a more representative sample of the whole area population;
6. To obtain evaluations of additional alternatives that had been suggested on the basis of a review of the relevant literature; and
7. To acquire opinions since the defeat of the proposed mall.

Methodology

A field observation survey was used to record physical characteristics of streets. Objective measures of activity patterns such as traffic counts were taken on each street block at five separate 15-min time intervals each day over a four-day period.

Attitudinal data were gathered by in-home personal interviews conducted during the first two weeks of July 1980. Twelve street segments were selected to represent different parts of the neighborhood defined in terms of volume of traffic and proximity to campus and to arterials. The sample population included all 186 households on those street segments. At 68 households on the selected street blocks, residents could not be found at home and 10 households refused to cooperate. Some 108 interviews were completed, or 58 percent of the study area population. This response rate is considered high for this type of survey and compares favorably with the 39 percent response in the previous mail survey.

The questionnaire is divided into three parts. The first part includes questions about personal and family characteristics of the respondents such as age, sex, length of time residing at present address, ownership of dwelling, size and composition of household, size of hometown, number of years in dwelling, number of years intending to stay, and a five-point scale on appreciation of factors that contribute to the quality of residential environment. The second part of the questionnaire consists of attitudes on traffic perception in general, as well as perception of traffic speed and noise specifically. Impacts of the ways in which traffic interferes with household activities and the actions that respondents take to prevent a worsening of the situation are also included in this part. In the third part of the questionnaire opinions about the effectiveness of 11 alternative measures of controlling traffic are solicited and the popularity of the alternatives under two future scenarios is assessed (see section on Attitudes Toward Alternative Traffic Control Measures later in this paper). The first scenario serves as a baseline situation in which no major changes in traffic patterns are assumed, while the second one assumes a substantial increase of through traffic due to a major commercial development similar to the proposed mall along the Atherton Street corridor. A twelfth alternative labeled "Do nothing" was also included. The attitudes of respondents toward potential impacts of the traffic measures were also assessed.

ANALYSIS AND RESULTS

The analysis is divided into two parts. In the first part the relation is examined among the objective traffic volume and reported impacts of traffic on the personal life of residents, attitudes toward volume of traffic, noise and speed of traffic, and, finally, actions that individuals have taken or are willing to take in order to alleviate traffic problems. In the second part, the relation between traffic volume and the attitudes and preferences toward each of several alternative traffic control measures and the anticipated impacts of those measures are examined. In both parts of the analysis, responses are grouped by street. The 600-700 north blocks of McKee Street are reported together with East Mitchell Avenue, and the 500 north block of Holmes Street is reported together with the same block of McKee Street.

Traffic flows range from 20 vehicles/h to 300 vehicles/h during morning and evening peak hours. This is an otherwise quiet, homogeneous community. Of the respondents, 89 percent are homeowners. The majority of respondents are associated with the university: 36 percent are university professors, and most of the 27 percent who were retired have worked at the university. Some students tend to occupy rental apartments on streets near the university where the percentage of rental dwelling units reaches 40 percent. With the exception of the students, who comprise a small percentage of the total population, the neighborhood seems very stable. Some 60 percent have been living in the same unit for more than 10 years. Due to the proximity of the neighborhood to the university the majority walk or bike to work. There is a consensus of values regarding factors that contribute to residential quality. Traffic safety, ability to get around by walking, and quiet and tranquil environment to walk, ride a bike, and play ranked highest. Accessiblity by car to work and facilities ranked lowest.

Analysis of variance and Pearson's correlation coefficient were used to study the relations among traffic volume, attitudes, and action. The volume of traffic by street forms the categorical independent variable and the attitudes or opinion scores are used as dependent variables. The five-point scale perception of the problem and popularity of solutions were assumed to have interval properties.

Attitudes and Impacts

To the question--how do you feel about the traffic problem in the East College Heights area--73 percent responded that there is a problem, but only 25 percent felt that the problem is serious. Those 60 percent of the respondents who indicated that they had participated in the previous mail survey felt that traffic was a more serious problem than those who had not participated, suggesting that the previous results were biased. They suffered from a selection bias. Some 52 percent said that it was only morning and/or evening rush-hour traffic on their block that bothered them; 66 percent felt that traffic on their street is speeding. According to police reports speeding is an occasional phenomenon; but, from discussions with residents, it is evident that whenever speeding occurs, it bothers the residents because they feel it should never happen.

Noise was not found to be a problem in general: 60 percent felt the traffic noise to be acceptable. However, residents of properties located close to intersections with arterials--especially Atherton Street--felt that noise from traffic on the arterial is a very serious problem. Noise complaints correlate highly with traffic volume, while perception of the traffic problem correlates highly with speed complaints. According to respondents, traffic has been an increasing problem in this neighborhood.

When asked--which of the following everyday ac-

Table 1. Reported attitudes, impacts, and actions as they relate to through traffic.

Survey Categories	Light-Traffic Street				Medium-Traffic Street						
	Far from Campus	Close to Campus			Far from Campus				Close to Campus		
	E. Mitchell (and 600-700 N. Mckee)	Hartswick	500 N. Mckee (and 500 N. Holmes)	Ridge	Woodland	Hillcrest	W. Mitchell	800 N. Allen	600-700 N. Allen	500 N. Allen	All Streets
Traffic volume[a]	29/26	21/30	45/153	75/87	99/150	99/165	258/138	84/141	276/234	318/306	
Attitudes[b]											
Overall traffic problem	2.40	2.45	2.63	2.42	2.78	2.11	2.00	1.83	0.175	2.33	2.32
Speed	2.27	2.27	2.54	2.28	2.28	2.00	1.85	1.50	1.50	2.16	2.12
Noise	2.77	3.00	2.54	2.57	2.85	2.33	2.42	1.83	2.00	1.83	2.52
Impacts											
Backing from driveway (%)	36	36	10	42	50	77	100	50	100	83	56
Interference with indoor activities (%)	40	27	36	42	42	44	42	66	62	66	44
Accidents (%)	22	9	27	0	35	33	50	50	37	0	28
Actions											
Talk to neighbors (%)	54	36	27	42	50	55	85	83	50	0	55
Sign petition (%)	31	27	36	57	7	22	78	33	25	0	33
No. of observations	22	11	11	7	14	10	14	6	8	6	108

[a] Estimated number of vehicles per morning/evening peak-hour derived through extrapolation of 15-min counts obtained from field observations (13).
[b] Computed mean from five-point scale (1, very serious problem; 5, no problem at all).

tivities does traffic interfere with--backing the car out of driveway was the most frequently cited, followed by crossing the street on foot and working, sleeping, or having a conversation in the house. Backing the car out was found to be highly correlated with the volume of traffic and with the perception of the problem, while the interference with indoor activities was particularly associated with noise complaints. To the question--have you or any other member of your household had any traffic accident or incident, such as a near miss, in this neighborhood--28 percent responded yes. The police have reports only on a very limited number of accidents. The reason for this discrepancy may be that many accidents reported in the interview were not felt to be worth reporting or were near misses.

In terms of actions exercised by residents to prevent a worsening of the situation, a majority of respondents had already talked to their neighbors about the traffic problem. Many had already or had considered attending meetings and had signed petitions. It was interesting to find out that the actions had very low correlations with the objective traffic counts. The problem is not considered to be severe enough to warrant massive behavior change such as planting shrubs, fencing yards, spending less time outdoors, or even relocating.

A significant difference exists overall in the perception of traffic between residents of light-traffic streets and those who live on medium-traffic streets. However, resident's perception of the traffic problem is not always directly related to the actual volume of traffic on the street. For example, it is worth noting that residents of the 500 block of North Allen Street, which is the most heavily traveled in the neighborhood, do not differ much in their perception of the traffic problem from residents of the quiet blocks of McKee Street. Residents on busy Woodland Drive are the least concerned about the problem. A look at the composition of residents of these streets offers a possible interpretation for some of these differences. We are dealing here with the most transient and most stable blocks in the area. Most residents on Allen Street are students who have the shortest duration of stay. Only 33 percent plan to live there indefinitely. Other findings suggest that the Allen Street residents do not care as much about what happens to their street. It is the only block on which residents reported that they do not discuss the problem with neighbors, nor have they participated in any meetings or sent any letter of complaint to Borough authorities. On the other hand, 85 percent of the residents on Woodland plan to stay indefinitely in their present residences and 78 percent of them have been living in the same dwelling for more than 10 years. It is probable that, during this period, Woodland Drive residents have adapted to the traffic situation on their street. They seem to prefer to live with what they are used to rather than to take a chance on measures that may prove to be an inconvenience. Finally, on quieter streets like McKee Street and East Mitchell Avenue, a few speeding cars can draw attention and provoke residents. Table 1 provides estimates of traffic volume in number of vehicles per peak hour, the computed means of answers to the problem perception questions, and the traffic impacts and action taken by residents categorized by street.

Attitudes Toward Alternative Traffic Control Measures

A total of 12 alternative measures, including a do-nothing approach, was presented and residents were asked to indicate for which alternatives they would be willing to allocate local tax money for construction and enforcement. A brief description of these measures follows.

Peripheral Strategies

1. No turn signs and traffic light. Install signs to prohibit left turns at the intersections of Atherton with Mitchell, Woodland, and Ridge as well as Park Avenue with Holmes and Burrows. In addition, install a traffic light at Cherry Lane and Atherton that allows only a few cars to turn at a time.
2. Median on Atherton. Construct a center barrier along Atherton from Park to Cherry Lane, with a break at the Hillcrest intersection.
3. Cul-de-sac. Close off end of local streets that intersect with arterials (e.g., Mitchell, Woodland, Ridge, Holmes, and Burrows).

Internal Strategies

4. Parking. Remove parking restriction on one side of streets with heavy traffic problem to reduce

the speed of traffic (e.g., Allen, Mitchell, and Woodland).

5. Four-way stop signs. Add four-way stop signs at key intersections (e.g., Mitchell and Allen and Allen and Ridge).

6. Enforce speed limit. Improve enforcement of legal speed limit in whole neighborhood.

7. Diverters. Install physical barrier diagonally across the road at the intersection of Allen and Hillcrest to prevent straight-through traffic while allowing passage for emergency and service vehicles.

8. Limited-access pedestrian street. Alter design of streets, give priority to pedestrians, and allow residents and emergency service vehicles to have complete slow access.

9. Speed bumps. Install undulations in streets with speeding traffic.

External Strategies

10. Third lane on Park Avenue. Add a third lane on Park Avenue between Atherton and Allen Streets.

11. University Drive Extension. Build the proposed University Drive Extension as an alternate north-south connection.

The only three measures that were received positively were the extension of University Drive, the enforcement of speed limits, and the installation of four-way stop signs at key intersections. The most unpopular choice was the restoration of on-street parking. Four additional measures were popular among those who consider traffic to be a serious problem; these include diverters, cul-de-sacs, speed bumps, and no-turn signs on Atherton Street. A five-point scale, ranging from strongly in favor to strongly against measured the popularity, while another five-point scale ranging from definitely would improve to definitely would not improve measured the effectiveness of each alternative in terms of improving the through-traffic problem in the neighborhood.

The peripheral strategies, including the no-turn sign, median on Atherton, and cul-de-sac measures, are clustered together. Residents who favored this group of measures assigned the highest priority to their implementation. The internal strategies are broken down into three subcategories that are highly intercorrelated. The most popular group includes four-way stop signs and enforcement of speed limits. Both of these measures are soft--that is, they still allow traffic to pass through the neighborhood though traffic is expected to be slowed. The second category includes more novel, drastic, and difficult-to-accept measures such as diverters, limited-access pedestrian street, and speed bumps. On-street parking was considered a category by itself. The only other measure whose popularity correlates highly with it is the limited-access street in which parking is both an integral part of the street and one of the tools for discouraging speeding traffic. The two external strategies--the addition of a third lane on Park Avenue and the extension of University Drive--are also found to be highly correlated. Finally, the do-nothing approach is the least popular and is negatively correlated to most other suggested measures.

In order to examine the relation between perceived effectiveness of measures and their popularity, the popularity rank and the effectiveness rank for each street on each measure were compared. Diverters ranked high in effectiveness (4) but low in popularity (9). Residents who are against diverters seem to be expressing a real concern regarding their ability to move around freely by car. The limited-access street alternative ranked low in effectiveness but high in popularity. The measures of extending University Drive and controlling speed limits were considered to be the most effective and popular alternatives, although there are some doubts about the effectiveness of the latter. The on-street parking and do-nothing approaches were considered the least popular and least effective. Table 2 presents the Pearson's correlation coefficients between the popularity scores of the alternative measures. The diagonal cells in the matrix provide the coefficients that relate effectiveness with popularity for each measure.

Another important question to be examined was the influence of traffic volume and location of household on the preference of the measures. For the examination of a street-by-street breakdown of opinions, an analysis of variance was used. The effects of the different impacts are considered both overall, by using an F-test to test the hypothesis that the population means are equal and in pairwise comparisons among means of opinion by using the multiple t-ratio to detect statistically significant differences between pairs of streets (14). Table 3 presents the mean popularity index of the measures for all respondents on each street.

Three measures proved significantly different overall between medium- and light-traffic streets, the enforcement of speed limits, speed bumps, and the do-nothing approach. Three other measures were found to be significantly different among individual streets. For example, the no-turn signs on Atherton were favored by residents of West Mitchell Avenue, while they were opposed by residents of the 800 block of North Allen because this measure would result in channeling through traffic to Cherry Lane and Allen Street. Residents of Allen Street are strongly in favor of internal strategies, especially those that aim at reducing speed.

The socioeconomic characteristics of respondents did not prove to have great influence on their responses. The number of years that the household intends to stay in their present dwelling appears to be one of the variables that proves significant but is contrary to what was expected. If volume of future traffic is assumed constant, residents who plan to stay indefinitely do not consider traffic to be a serious problem and their preference of control measures differs from those of the rest of the population.

The mode of travel used to go to work by the primary income earner was found to be significant in influencing a household's attitudes toward traffic. Those who bike or walk to work consistently think traffic is more of a problem and are more willing to accept solutions that inhibit the free use of the car, such as limited-access pedestrian streets, diverters, speed bumps, and cul-de-sacs. Occupation seems to influence responses. The retired residents seem more conservative than university professors in their preferences of alternatives; they do not consider traffic to be such a serious problem. There were very few households with young children (ages of less than 10 years), and they are too dispersed throughout the neighborhood to be able to make any generalizations. However, larger households (four or more) tend to be more concerned about the traffic problem.

The size of the city where the respondent has spent most of his or her life was expected to influence responses in that big-city folks were expected to perceive the traffic problem of State College as minimal; however, the opposite result was found. An interpretation of this attitude might be that former residents of big cities expect near perfection from a small college town such as State College.

Table 2. Correlation of popularity scores for traffic control measures (Pearson's coefficient).

Traffic Control Measure	No Turn	Median	Cul-de-Sac	Parking	Four-Way Stop	Enforce Speed	Diverters	Limited Access	Speed Bumps	Third Lane on Park	University Drive Extension	Do Nothing
No-turn signs	0.77[a]	0.45[a]	0.42[a]	0.07	-0.00	-0.00	0.09	0.15	0.04	0.00	0.07	-0.36[a]
Median on Atherton		0.69[a]	0.31[a]	0.05	0.14	0.01	0.14	0.30[a]	0.16	0.12	0.07	-0.15
Cul-de-sac			0.64[a]	0.05	0.12	0.13	0.52[a]	0.29[a]	0.16	-0.04	0.04	-0.34[a]
Parking				0.74[a]	0.13	0.04	0.07	0.24[a]	0.04	0.00	0.03	0.04
Four-way stop signs					0.75[a]	0.54[a]	0.09	0.16	0.10	0.02	0.08	-0.26
Enforce speed limit						0.56[a]	0.02	0.18	0.13	-0.00	-0.11	-0.20[a]
Diverter							0.66[a]	0.26[a]	0.37[a]	0.05	0.08	-0.18
Limited-access street								0.60[a]	0.35[a]	0.25[a]	0.32[a]	-0.19[a]
Speed bumps									0.77[a]	0.08	0.08	-0.23[a]
Third lane on Park Avenue										0.82[a]	0.19[a]	-0.04
University Drive extension											0.73[a]	-0.07
Do nothing												0.58[a]

Note: Coefficients on the diagonal signify the correlations between popularity and effectiveness.
[a]Significant at 0.05 level.

Table 3. Resident attitudes toward traffic control measures by street.

	Light-Traffic Street				Medium-Traffic Street						
	Far from Campus	Close to Campus			Far from Campus				Close to Campus		
Traffic Control Measure	E. Mitchell (and 600-700 N. Mckee)	Hartswick	500 N. Mckee (and 500 N. Holmes)	Ridge	Woodland	Hillcrest	W. Mitchell	800 N. Allen	600-700 N. Allen	500 N. Allen	All Streets
No-turn signs	3.18	2.81	3.27	3.28	3.57	3.11	1.92[a]	4.16[a]	3.50	3.66	3.14
Median on Atherton	3.36	3.45	3.63	3.00	3.50	3.11	2.64	3.66	3.50	3.66	3.32
Cul-de-sac	3.68	3.09	3.63	3.28	3.42	3.55	2.78	3.50	2.87	4.00	3.37
Parking	3.54	4.54[a]	3.09	3.71	4.07	3.66	3.42	3.50	3.25	3.33	3.63
Four-way stop signs	2.68	2.27	2.45	3.14	2.35	2.66	2.78	1.16[a]	1.37[a]	2.66	2.43
Enforce speed limit[a]	2.40	1.63	2.36	2.42	2.42	2.66	2.21	1.16[a]	1.75[a]	1.33[a]	2.14
Diverter	3.63	3.27	3.63	2.71	3.14	3.33	3.35	3.16	3.00	3.66	3.34
Limited-access street	3.40	3.45	3.54	3.42	3.35	2.88	2.50	3.33	3.37	2.83	3.22
Speed bumps[a]	3.27	3.36	3.90	3.28	3.71	3.22	2.92	2.66	3.24	2.83	3.29
Third lane on Park Avenue	3.86	3.45	3.36	3.57	3.14	2.33[a]	2.92	3.00	3.62	2.00	3.24
University Drive extension	1.95	3.00	2.72	2.28	1.71	1.55	2.07	1.66	2.87	1.83	2.15
Do nothing[a]	2.95	4.18	3.18	2.71	2.78	3.22	3.85	4.33[a]	4.00	3.66	3.39
No. of observations	22	11	11	7	14	10	14	6	8	6	108

Note: Computed mean from five-point popularity scale (1, strongly in favor; 5, strongly against).
[a]Statistically significant difference from overall mean (0.05 level).

Finally, those who consider through traffic to be a serious problem were found to be concerned about the effect of traffic on the value of their properties and less concerned about the restrictions on their mobility or the congestion on other streets.

CONCLUSIONS AND IMPLICATIONS

The study makes contributions in three areas:

1. It provides better and more detailed information for State College officials than what was available from the previous mail survey;
2. It confirms findings from the research literature regarding acceptance of traffic control measures in residential areas; and
3. It contributes to existing knowledge of how residents perceive problems in neighborhoods characterized by medium-to-light traffic.

The survey provided a more representative view of residents' attitudes. It defined more precisely what the residents felt to be the extent of the traffic problem, and it offered more alternative traffic control measures to choose from. It is not the volume of traffic or the noise but speed and safety that primarily concern residents.

The most popular internal solution was found to be speed control. The solution of diverters that was found to be the first choice in the original survey was among the least popular alternatives in the present study. Current levels of traffic volume do not warrant any more-severe measures than four-way stop signs, and the majority of residents assigned medium-to-low priority to implementation of even that measure in relation to other Borough projects. However, there were some streets on which more drastic measures were thought to be necessary and all streets would opt for strict controls in the event that through-traffic volume increases in the future.

The majority of respondents are very concerned about preserving their neighborhood and want to be assured that their present level of mobility will be maintained. Many residents see a continuous turnover of the properties on the more heavily traveled streets to students and transient households as a threat that, in the long run, may expand into all areas of the neighborhood. However, residents still have to realize that they have to give up the current level of mobility in order to improve the traffic situation.

Enforcement of speed limits has been a continuing problem in the East College Heights area, especially since there is only occasional speeding and the cost of law enforcement under such conditions is prohibitive. Control of speeding by other means such as stop signs, speed bumps, and altering the design of the street must be explored further. This analysis confirms previous studies about the difference of

opinions held by traffic engineers and the public about the appropriate use of four-way stop signs and speed bumps (1).

The survey showed that residents were unfamiliar with the concept of altering the design of the street, but after an explanation they were very much willing to accept it. The East College Heights area has a positive experience involving two streets (Ridge Avenue and Hartswick Avenue) with a much narrower street pavement, 4.8 m wide as opposed to 9 m on other streets. In addition to the benefit of discouraging through traffic, such a design is more environmentally sound, is aesthetically pleasing, and provides energy savings. It provides more open space and land for vegetation and controls run-off. Narrow pavements reduce heat reflection in summer and, finally, it is less expensive to install smaller areas of pavement (15).

Another important conclusion of this study seems to be that objectively measured traffic volume, accident records, and accounts of citizen complaints to authorities are not sufficient to provide a complete picture of the extent of a traffic problem in a neighborhood. This is especially so with respect to relatively light-traffic residential areas. It was found that residents appeared to be bothered more by occasional speeding by unexpected nonresidents or the passage of a truck on lightly traveled streets, than they were by the constant flow of traffic in more heavily traveled areas. The variation in the type of residents on the respective streets was found to contribute to the differences in the perception of the problem. It has been observed that a few influential neighbors can change the opinion of the block. The police record only major accidents, but it was found that it is the number of incidents, near misses, or the fear of an accident that might influence resident's perception. Finally, citizen complaints may be exaggerated or omitted depending on the personality of the resident or the environmental context. This analysis in itself is not sufficient to establish criteria for residential traffic management, but it does provide important empirical findings that can point out the inadequacies of current practices to decision makers.

Because of the novelty of the alternative measures suggested, there are only a few case studies that can be analyzed and evaluated. If a traffic-restraint program is to be implemented, it should start with simple solutions on a street-by-street basis and should then be modified and improved as conditions warrant. We are considering here relatively inexpensive projects, some of which can be implemented as part of the standard street maintenance program. The public should be fully informed about the implications that are known about the alternative control measures and should be made fully aware of how they can participate in the decision-making process. Citizens must realize that they have the power to shape their neighborhood, if they want to. It was surprising to find that, even in a small, sophisticated, and concerned community, about half of the respondents in the survey indicated that they do not feel confident that they can change their street and their environment. It is believed that traffic management should be accomplished in a positive manner and with goals of improving and maintaining the residential environment and making it a good place to live in--not as a reaction to individual complaints or as the aftermath of a serious accident but as an integral component of ongoing neighborhood preservation plans.

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