CHANGING STREET LAYOUTS TO REDUCE RESIDENTIAL BURGLARY

by

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For presentation to the Annual Meeting of the American Society of Criminology (Atlanta, November 16-20, 1977): *Crime Prevention Through Environmental Design Panel.* The Society awarded an earlier version of this paper the First Place Prize in the 1977 Student Competition.

This research was supported by grant #76DF050005 awarded to the Governor's Commission on Crime Prevention and Control by the Law Enforcement Assistance Administration. Points of view stated in this report are those of the authors and do not necessarily represent the official position of the Governor's Crime Commission or the Law Enforcement Assistance Administration.

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August, 1977

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INTRODUCTION[1]

> "Studies of urban streets . . . have concentrated almost exclusively on increasing their traffic capacity . . . with no parallel accounting of the environmental and social costs."[2]

Crime is a very real social cost. This paper hypothesizes that *relatively accessible street layouts are associated with relatively high rates of residential burglary*. Residential burglary is emphasized because it is a frequent crime of much concern in the study city, Minneapolis.[3]

To test the hypothesis, the study progresses through two complementary phases. The individual block phase limits accessibility to the number of directions by which a vehicle can enter or leave a street segment. The census tract phase limits accessibility to the permeability of an area--the degree to which the accessibility of the typical street segment within the area influences the ease of traveling through the area--again with respect to vehicles. If neither phase rejects the hypothesis, then changing streets to reduce residential burglary will be a wiser policy experiment than it would be if the hypothesis were rejected.

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[1]Dr. Theodore Anderson deserves a special thank-you for suggestions conveyed in his role as independent study advisor for this paper. Drs. David Lanegran and John S. Adams must also be thanked for their advice.

[2]Donald Appleyard and Mark Lintell, "The Environmental Quality of City Streets: The Resident's Viewpoint," *American Institute of Planners, Journal of the*, March, 1972, p. 84.

[3]Of seven crimes considered, residential burglary was most frequent from July, 1974, through June, 1975. A survey of Minneapolis adults found they were more concerned about property crimes like residential burglary than about crimes of confrontation. Community Crime Prevention Project, *Crime in Minneapolis: Proposals for Prevention* (St. Paul: Governor's Commission on Crime Prevention and Control), May, 1977.

If residential burglary rates are associated with street layouts, the block and tract analyses will also answer these questions:

Do all types of inaccessible blocks have low residential burglary rates?

Do burglaries seem to have shifted, or displaced, from less accessible to more accessible blocks in the same tract?

Do traditionally theorized causes of crime explain the relationship between street layout and residential burglary?

Do street layouts ill-suited for residential burglaries seem conducive to other types of crime?

Concepts and studies inspiring the hypothesis will be discussed initially. Next, the individual block analysis will be presented. Then, the census tract analysis will be discussed. Finally, conclusions and policy recommendations will be cited.

CONCEPTS AND STUDIES INSPIRING THE HYPOTHESIS

Oscar Newman and Jane Jacobs maintain that feelings of proprietorship influence residents to protect their home territory by increasing surveillance of activity occurring there. Possible witnesses add to chances of and fear of detection for criminals. Newman further believes less accessible blocks, cul-de-sacs and dead ends, in particular, encourage proprietorship.[1]

Experiments in St. Louis and Brooklyn are measuring the effects of redesigning streets. In St. Louis, various residential streets were closed at one end. Residents reportedly express proprietary feelings by surveillance of activity and by questioning the intentions of strangers. The residents feel that crime has lessened.[2]

St. Mark's Avenue in Brooklyn was redesigned to slow traffic. Parking and play areas now occupy the midblock area of the street. Residents feel that crime has decreased, and they define the street as their own--illustrated by their combined efforts to clean *their* street weekly.[3]

The concepts and studies cited above emphasize the influence of street layout on the surveillance behavior of residents. According to the concepts and studies cited below, less accessible streets are traveled less by nonresidents

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[1]Oscar Newman, *Defensible Space*, (New York: Collier Books), 1972, p. 60. Jane Jacobs, *Death and Life of Great American Cities*, (New York: Random House), 1961, pp. 30-37.

[2]Op. cit., Newman, pp. 60-62.

[3]Ibid.

than are other streets. Consequently, houses and apartments along less accessible streets will not be as familiar to nonresident criminals and will not be as frequently burglarized as will housing along more accessible streets.

An interdisciplinary concept, environmental cognition, explains the potential influence of street layout upon travel behavior:

> "Environmental cognition is the study of the subjective information, images, impressions, and beliefs that people have of the environment, the ways in which these conceptions arise from experience, and the ways in which they affect subsequent behavior with respect to the environment."[1]

Four information handling mechanisms influence what people think of their environments and how they behave in them. The mechanisms are:

(1) *object recognition*, which occurs through repeated experience with an object or situation in the environment, enabling one to form an internal model of the object or situation;

(2) *anticipation*, which involves remembering which objects or situations come next in a sequence of objects or situations;

(3) *generalization*, which is the treatment of newly experienced objects or situations as similar to those which are already internal models; and

(4) *responsible innovation*, which means solving the problem of how to get from one place to another when the path is not clearly represented in one's mind.[2]

Object recognition and anticipation enable people to function adequately in

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[1] Gary T. Moore and Reginald G. Golledge, eds., *Environmental Knowing*, (Stroudsburg, Pennsylvania: Dowden, Hutchinson and Ross, Inc.), 1976, p. 3.

[2] Stephen Kaplan, "Adaptation, Structure, and Knowledge," *Environmental Knowing*, pp. 32-45.

areas or along streets they have frequented. However, the same people may experience problems when they travel through strange areas or along strange streets.[1] The risk of being recognized or apprehended is enhanced if a burglar is unfamiliar with the hours at which residences are typically unoccupied, the numbers of potential witnesses typically strolling by residences or the amount of landscaping covering windows and doors from the view of neighbors--information obtained largely by living near or traveling by the residences.[2]

One empirical study particularly indicates that accessibility can influence familiarity. Ann Devlin studied maps sketched by wives of Navy officers two weeks, and then again, three months, after the wives moved to Idaho Falls, Idaho. Devlin discovered that the earlier sketch maps consisted almost entirely of major arteries. In the later sketch maps, minor arteries also appeared, suggesting people learn less traveled routes later than they learn major routes.[3]

Another empirical study shows that lack of familiarity can distort perceptions of the relationships of places to each other. Subjects were divided into two groups based on their length of residence in their city. Each subject was presented pairs of locations in the city and asked to estimate the distance between the two locations in each pair. The newer group estimated distances more poorly than did the other group, suggesting the newer group would experience more difficulty in using the city than would the other group.[4]

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[1] Ibid.

[2] A survey of incarcerated residential burglars conducted by the Community Crime Prevention Project early in 1976 found those interviewed most commonly sought unoccupied residences and most commonly avoided places where passers-by or neighbors might see them.

[3] Ann Devlin, "The 'Small Town' Cognitive Map: Adjusting to a New Environment," *Environmental Knowing*, pp. 58-66.

[4] R. G. Golledge, R. Briggs and D. Demko, "Configurations of Distance in Intra-Urban Space," *Association of American Geographers, Proceedings of the*, (1969) 1:60-65.

Altogether, existing theoretical concepts and empirical studies inspire the belief that appropriate changes in street layouts can decrease residential burglary rates by encouraging surveillance behaviors among block and area residents or by reducing the familiarity of nonresident criminals with those blocks and areas. To test the hypothesis that highly accessible street layouts are associated with high residential burglary rates in Minneapolis, this study conducts analyses at the levels of individual blocks and of census tracts.

THE FIRST PHASE: INDIVIDUAL BLOCK ANALYSIS[1]

This phase of the study compares the residential burglary rates of individual blocks representing various layout types. From the relatively less to the relatively more accessible types studied, the layouts include dead ends, cul-de-sacs, L-types, T-types and through blocks (Figure 1). Relative accessibility was measured by the number of directions from which a vehicle like a car could enter or leave a representative block.[2] Cul-de-sacs were considered easier to enter or leave than were dead ends because of the turnaround areas of cul-de-sacs.

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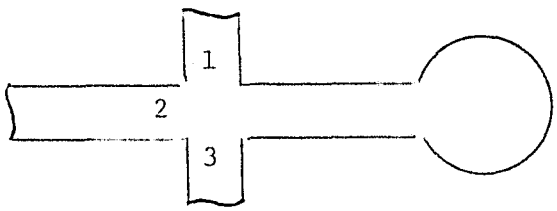
[1] A more complete version of the first phase, "Street Layout and Residential Burglary" by Julia Brown Nutter, Carol Bevis and Douglas Frisbie, was presented to the National Conference on Criminal Justice Evaluation (Washington, D.C., February 22-24, 1977); Panel 7, *Using the Physical Environment to Reduce Crime and Fear of Crime*. It was also published as Chapter 12 of *Crime in Minneapolis*, op. cit.

[2] A block was defined as a street segment with an intersection at each end and no intersection between the ends. Blocks were classified according to their less accessible intersection.

This cul-de-sac block can be entered or left from three directions:



This T-type block is approachable from five directions:

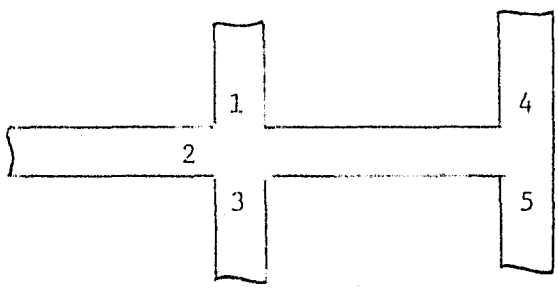
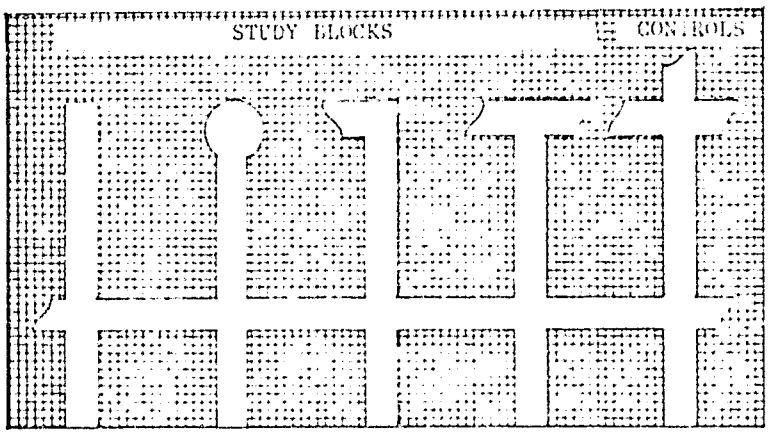


Figure 1

Representative Street Layouts



Thirty census tracts were selected by simple random methods from the 127 tracts in Minneapolis. The numbers of street blocks of each type (except through blocks) within the sampled tracts were handcounted from maps current to the period over which crime data were collected. A sample of eleven to sixteen blocks was randomly selected for each of these "study" types.

For each of the study blocks, the nearest through block feeding traffic into the study block was selected as a control. Choosing controls that are near study blocks should diminish social differences that might cause differences in burglary rates between study blocks and their controls. Numbers of residences and residential burglaries were counted for both sides of each block.[1]

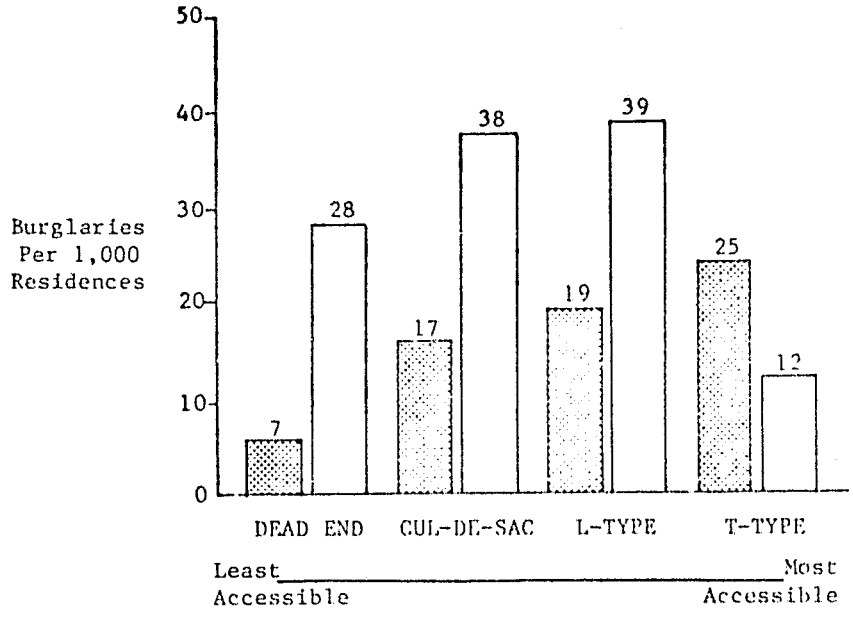
The results show that dead end, cul-de-sac and L-type blocks have lower

[1]Police records for the period July, 1974, through June, 1975, provided residential burglary counts. R. L. Polk & Co. directories for 1975 provided residence counts.

residential burglary rates than do their more accessible control blocks (Figure 2).[1] However, burglary rates along T-type blocks exceed rates along the controls for T-type blocks.

Figure 2

Residential Burglary Rates for Study and Control Blocks



Rates were based on a total of 1,918 residential units.

Study.

Control. Control blocks are the through blocks nearest to their corresponding study block.

[1] The chances are at least 95 percent (according to a signs test applied to pairs of blocks) that similar results would have been achieved had all dead end, cul-de-sac and L-type blocks in Minneapolis been studied instead of samples.

THE SECOND PHASE: CENSUS TRACT ANALYSIS

This phase studies the relationship between street layout and residential burglary rates for all 127 census tracts in Minneapolis, using regression analysis. Regression analysis measures the degree of association or correlation between a dependent variable (residential burglary rates) and independent variables (including street layout). It does this by first estimating a burglary rate for each census tract on the basis of its street layout and then comparing this estimate with the actual burglary rate for the tract. The more closely the estimated rates match the actual rates, the higher the correlation is between residential burglary and street layout. How closely they match is measured by r^2 when there is just one independent variable and R^2 when there is more than one independent variable.

When the goal of a regression analysis is to test theory, as it is here, the independent variables must be selected and ordered according to theory and reasonable interpretation of previous research, not by "blind" methods.[1] The notion that street layouts influence residential burglary rates is relatively recent. Testing this new idea is made more severe than it would otherwise be by entering measures of traditionally theorized causes of residential burglary into the regression formula ahead of a measure of street layout.[2]

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[1] In the language of social statistics, this means that stepwise regressions should be avoided. Inclusion of polynomial and interaction terms merely because they increase R^2 should also be avoided. See Fred N. Kerlinger and Elazar J. Pedhazur, *Multiple Regression in Behavioral Research* (New York: Holt, Rinehart and Winston, Inc.), 1973, especially pp. 49, 72, 77, 281.

[2] The later a measure enters the regression formula, the smaller its contribution to R^2 tends to be.

Several sources suggest economic deprivation and racial discrimination are traditional social causes of crime.[1] Empirical studies across a number of large U.S. cities show that social variables measured by the Census Bureau generally fall into the following groups: socioeconomic status, life cycle and, to a lesser extent, ethnicity.[2] The social variables selected for this study, juvenile poverty and race, by being representative of the two traditional causes and the three empirical factors, seem sufficient measures of social contributions to crime (Appendix A).

Disproportionate representation of poor juveniles and of blacks among the burglar population could cause the social variables to correlate positively with residential burglary rates at the scale of census tracts if burglars choose residential targets close to their own homes. In Minneapolis, 69 percent of residential burglary suspects live less than one mile from the crime sites with which police offense reports associate them.[3] Yet, the distance from the centers of most census tracts in Minneapolis to their respective boundaries is much less than one mile.

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[1]Michael Lewis, "Structural Deviance and Normative Conformity" in *Crime in the City*, Daniel Glazer, ed., (New York: Harper & Row), 1970, p. 176; Robert A. Gordon, "Issues in the Ecological Study of Delinquency," *American Sociological Review*, December, 1967, 32:927-944; Sarah L. Boggs, "Urban Crime Patterns," *American Sociological Review*, December, 1966, 30:899-908; and Patricia Garstang Williams, "Understanding Urban Crime . . . Some Important Contributions" in *The Spatial Dynamics of Crime*, Gerald F. Pyle, et al., (Chicago: University of Chicago), 1974, pp. 9-39.

[2]Brian J. L. Berry, ed., "Comparative Factorial Ecology," special issue of *Economic Geography*, June, 1971; and Risa Palm and Douglas Caruso, "Factor Labeling in Factorial Ecology," *Association of American Geographers, Annals of*, 1972, 62:122-33.

[3]"Suspect" refers to persons listed in police records by name or by a description given by witnesses. These persons may or may not have been apprehended, arrested or convicted. Suspect data should consequently be considered as only indicative of what all offenders are like. See *Crime in Minneapolis*, op. cit., pp. 86 and 143.

A tract could contain few poor juveniles and blacks, but be within one mile of tracts that have high percentages of these groups. Consequently, the proximity of a tract to poor juveniles and to blacks is measured in two ways: (1) the percentage of the tract population consisting of poor youths or of blacks and (2) the estimated percentage of the *rest* of the population within one mile that consists of poor youths or of blacks (Table 1).

TABLE 1

SOCIAL VARIABLES

CONCEPT	MEASURE
Poor Juveniles	Percentage of tract population that is under 18 and living in households with incomes below the official poverty level.
Nearby Poor Juveniles	For tracts with centers within one mile of the center of the tract in question, the percentage of the population under 18 in households with incomes below the poverty level.
Blacks	The percentage of tract population that is black.
Nearby Blacks	For tracts with centers within one mile of the center of the tract in question, the percentage of the population that is black.

The permeability of street layouts, that is, the ease of traveling through areas, can be measured at the tract scale with graph theory. In graph theory language, a map of a street layout is a planar (two-dimensional) graph consisting of edges (blocks in the layout) and vertices (intersections in the layout). Beta, the graph theoretic measure considered for this study, is a ratio comparing

the number of edges to the number of vertices (Table 2).[1]

TABLE 2

PERMEABILITY MEASURE
(For Planar Graphs)

$$\text{Beta} = \frac{e}{v}$$

where e = edges and
v = vertices

Beta is a very basic measure of street layouts. It does not take into account aspects of layout like the lengths of blocks, the angles at which blocks meet, or whether blocks are straight or curved.

Certain values of beta do, however, conveniently correspond to pure examples of dead end, cul-de-sac, T-type, L-type and through block layouts (Figure 3). In general, small betas indicate layouts in which, to reach one intersection from another, a vehicle like a car must often detour from more direct routes taken, for instance, by air vehicles.

In Minneapolis, many areas contain railroads or other physical barriers creating dead end, L-type and T-type streets that detour vehicles and, to a lesser extent, pedestrians around the physical barriers. Those areas possess relatively low beta indices. In other areas of Minneapolis, radial streets provide shortcuts across the typical, rectangular pattern of streets. These areas possess relatively high beta indices.

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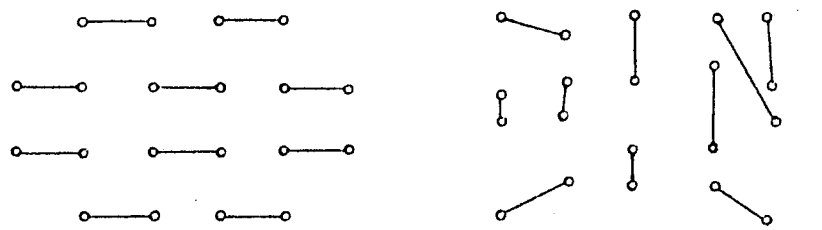
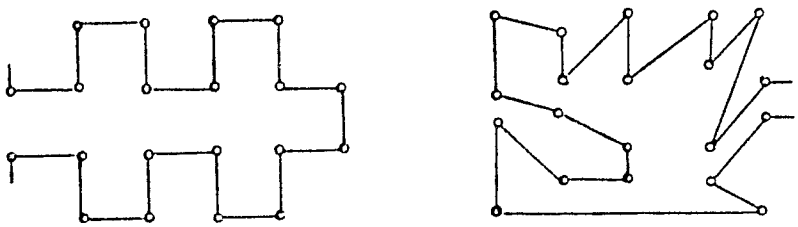
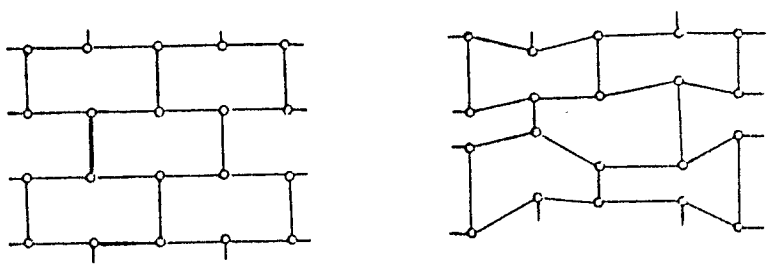
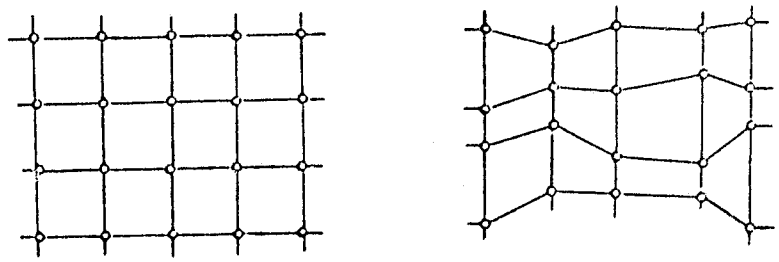
[1] K. J. Kansky, *Structure of Transportation Networks: Relationships between Network Geography and Regional Characteristics* (Chicago: Department of Geography Research Paper Number 84), 1963, p. 14-19. Two other ratios, alpha and gamma, were also considered. Appendix B explains why beta was chosen instead.

Figure 3. Beta Values for Pure Layout Types

Type	Beta	Examples
Dead end or Cul-de-sac	0.5	
L-type	1.0	
T-type	1.5	
Through[a]	2.0	

[a]Through layouts with more than four blocks meeting at each intersection would have beta values exceeding 2.0.

In summary, the social variables and the permeability variable, beta, effectively measure two aspects of accessibility. Social variables measure locally committed crime. That is, they reflect the influence of straight-line distance ("as the crow flies") to targets from the homes of residential burglars that are poor and young or that are black. The permeability variable reflects barriers forcing those burglars who do operate away from home to detour from straight-line paths connecting their residences to potential crime sites.[1]

Data for calculating the social variables come from 1970 Bureau of the Census publications. Numbers of blocks and intersections used to calculate beta were handcounted from maps current to the period over which residential burglaries were counted. Blocks are defined as street segments, as they were in the first phase of this study.

The census tract analysis not only tests whether the street layout and residential burglary relationship applies at the area scale and whether it applies even after social variables are considered. The analysis also explores the possibility that street layout may be conducive to crimes other than residential burglary. To these ends, the tract analysis studies six regression formulas. The crime rates to be estimated by the formulas are: residential burglary, commercial burglary, commercial robbery, resident street robbery, resident assault by strangers and resident rape by strangers (Table 3).

Assaults and rapes between relatives, dates and other acquaintances are excluded because the assailants and victims would probably be physically proximate to each other regardless of changes made in street layouts. Assaults,

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[1] While most residential burglary suspects in Minneapolis do live close to the residences they are suspected of burglarizing, the percentage (31 percent) residing more than a mile away from their targets is too sizable to be ignored.

rapes and street robberies occurring to victims while outside the census tract in which they live are also omitted from crimes per 1,000 residents. This avoids inaccurately high rates for downtown tracts and other areas with many nonresident users, but few residents. To provide tests as equal as possible to that applied to residential burglary, the same set and order of independent variables used for residential burglary are used in formulas estimating the other crime rates.

TABLE 3

DEPENDENT VARIABLES

CONCEPT	MEASURE
Residential Burglary	Residential burglaries per 1,000 housing units
Commercial Burglary	Commercial burglaries per 1,000 commercial units
Commercial Robbery	Commercial robberies per 1,000 commercial units
Resident Street Robbery	Street robberies within the tract to tract residents, expressed per 1,000 residents
Resident Assault by Strangers	Assaults within the tract to tract residents by nonacquaintances, expressed per 1,000 residents
Resident Rape by Strangers	Rapes within the tract to tract residents by nonacquaintances, expressed per 1,000 residents

Crime frequencies were obtained from offense records of the Minneapolis Police Department for the period July 1, 1974, to June 30, 1975. The numbers of businesses currently in each tract were obtained from R. L. Polk & Co. files. Resident and residence counts for 1970 come from Bureau of the Census publications.

Formulas for estimating crime rates are in Appendix C, as are r^2 and R^2. The relationships found between crime rates and the social variables are analyzed in Appendix A.

The census tract analysis supports the hypothesis that high residential burglary rates are associated with highly permeable street layouts. Residential burglary rates and beta are positively related in a formula with beta alone, and also in a formula with beta and the social variables.

Beta entered alone into a regression formula accounts for 10 percent (R^2 = .10) of the variation in residential burglary rates. Low residential burglary rates on inaccessible streets thus do seem to result in low rates for the census tracts containing them. The residential burglaries that would otherwise have occurred on the less accessible streets have not merely displaced to more accessible streets in the same tracts. And, contrary to the possibility that the relationship between beta and residential burglary is entirely due to social causes, beta explains 6 percent of the variation in residential burglary rates (contribution to R^2 = .06), even *after* accounting for traditional social variables by entering them earlier into the regression formula.

While the contribution of beta to R^2 is sufficiently large to be theoretically meaningful, it is sufficiently small that the burglary and beta relationship cannot be expected to apply in all sections of Minneapolis.[1] Figure 4 shows for which tracts a formula including both beta and the social variables estimates residential burglary rates more accurately than does a formula containing the social variables only.[2]

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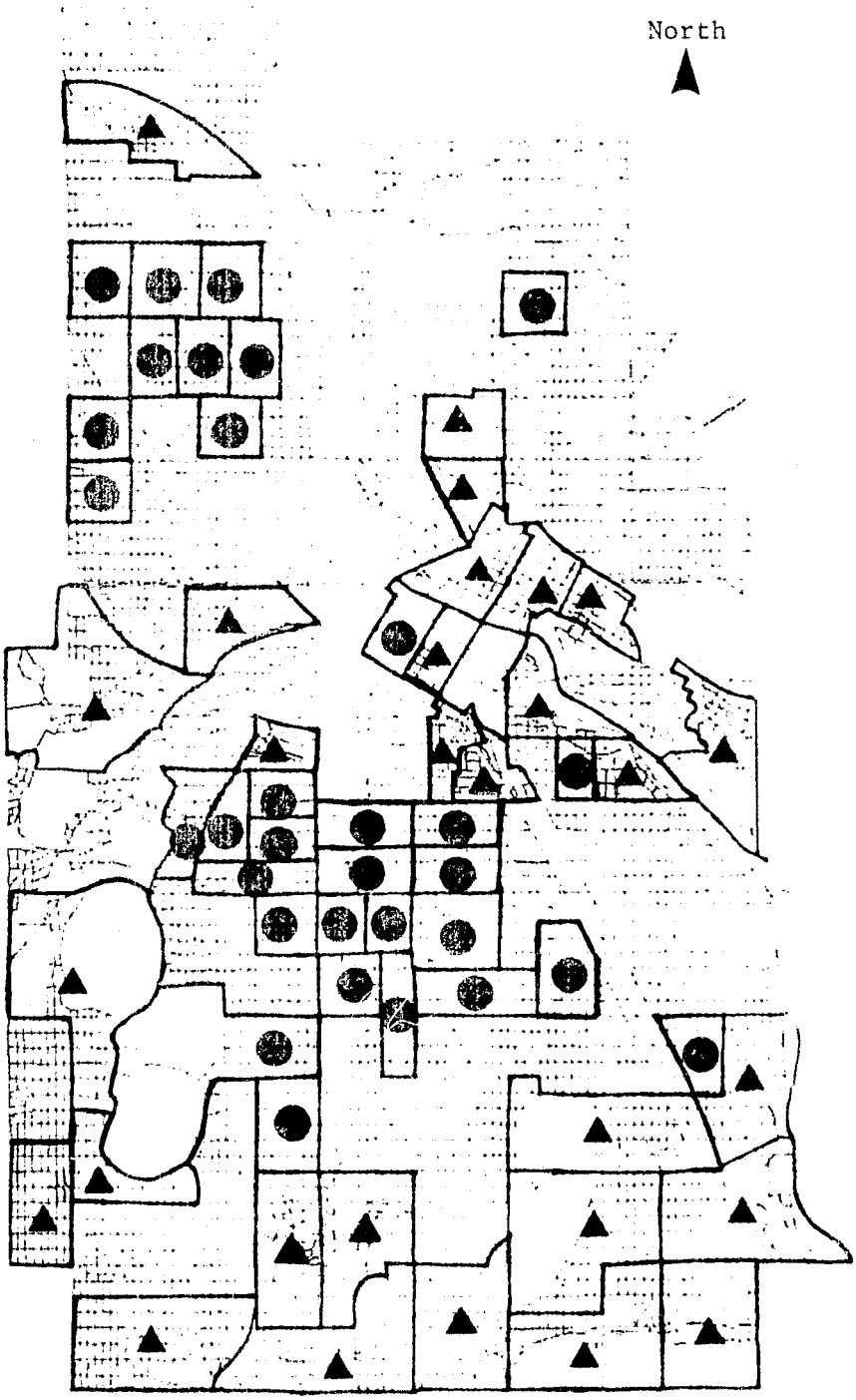
[1] A contribution to R^2 is not considered large enough to be theoretically relevant unless it is at least 0.050. Although the choice of a cutoff point is always somewhat arbitrary, some researchers recommend that 0.050 be used when situationally specific guidelines are absent. See, for example, K. C. Land, "Principles of Path Analysis," *Sociological Methodology*, 1969, E. F. Borgatta, ed., (San Francisco: Jossey-Bass).

[2] The two formulas are:

Estimate without Beta = 31.3 + .7 Poor Juveniles + 3.9 Nearby Poor Juveniles + .9 Blacks - .7 Nearby Blacks, and
Estimate with Beta = -44.4 + .6 Poor Juveniles + 3.8 Nearby Poor Juveniles + .8 Blacks - .6 Nearby Blacks + 37.8 Beta.

Figure 4. Minneapolis Tracts for which Beta Improves Estimation of Residential Burglary Rates



Tracts Where Estimation Improved

Burglary rate and beta both above average (rate > 44 burglaries per 1,000 residences and beta > 2) (n = 32)

Burglary rate and beta both at or below average (n = 29)

Not Shown Other combinations of burglary rate and beta (n = 5)

Tracts Where Estimation Not Improved

Not Shown (n = 61)

0 1
Mile

Even in those tracts where the theorized burglary and beta relationship does apply, it does not explain all of the residential burglaries. When the regression analysis was repeated just for those tracts where the expected relationship fits, beta, entered after the social variables, explains 32 percent of the variation in burglary rates. The social variables explain another 48 percent. About 20 percent was unexplained by either beta or the social variables.

When the regression was repeated for just those tracts where the theorized burglary and beta relationship does not apply, it was expected that the repeated regression would find no relationship between burglary rates and beta. However, a negative relationship was found--low betas unexpectedly coincide with high burglary rates in some of these tracts.[1]

Further examination indicated that limited access blocks causing the low beta values are along tract boundaries farthest from areas of Minneapolis where most burglary suspects live.[2] Traffic coming from where most suspects live would not be detoured from its intended path until deep within the tracts. Suspects could thus be familiar with most of the residences in these tracts, despite the low beta values. Nonlocal traffic could be sufficiently heavy that proprietorship and

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Improvement in estimation is calculated by subtracting (1) the absolute value of the difference between the actual burglary rate and the rate estimated with beta from (2) the absolute value of the difference between the actual burglary rate and the rate estimated without beta. If this number exceeds zero, then considering beta improves the accuracy of the estimated burglary rate.

The formulas seem stable. Formulas almost identical to those above were produced by (1) repetition of the analysis while excluding tracts most deviating from main trends and (2) repetition of the analysis separately for two randomly selected samples, each consisting of half the tracts.

[1]This unexpected relationship is not as strong (contribution to R^2 = .15) as the one found for the regression with just those tracts where the expected relationship fit (contribution to R^2 = .32). Consequently, the expected relationship predominates in the regression applied to all the tracts.

[2]Op. cit., *Crime in Minneapolis*, p. 85.

surveillance on the part of tract residents are not as strong as they might otherwise be.

The results of the census tract phase, up to this point, do not support possibilities mentioned earlier. Burglaries do not seem to merely displace from less accessible to more accessible blocks within the same tract. The relationship observed between burglaries and street layouts does not disappear when traditional social variables are considered.

A third possibility mentioned earlier--street layouts not favorable for committing residential burglary may be favorable for committing other crimes--is also not supported (Table 4). Contrary to this proposition, there are no sizable, negative relationships between beta and the other crime rates.

TABLE 4

REGRESSION RESULTS BY CRIME TYPE

DEPENDENT VARIABLES	CONTRIBUTION TO R^2 BY: SOCIAL VARIABLES (Entered first into formulas)	BETA (Entered last into formulas)
Residential Burglary		
All tracts	.42	.06
Tracts where relationship with beta is:		
As expected	.48	.32
Not as expected	.67	.15
Commercial Burglary	.07	NM
Commercial Robbery	NM	NM
Resident Street Robbery	.39	NM
Resident Assault by Strangers	.09	NM
Resident Rape by Strangers	NM	NM

NM = Not meaningful. The increment to R Square is not considered theoretically relevant unless it is 0.050 or larger.

There are also no sizable, positive relationships of beta with crime rates other than residential burglary. This may mean that offenders in these other crimes, if they are at all affected by street structure, are concerned with aspects not measured by beta.[1]

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[1]See, for instance, Dennis C. Duffala, "Convenience Stores, Armed Robbery, and Physical Environmental Features" in *Criminal Behavior and the Physical Environment*, C. Ray Jeffery, ed., special issue of *American Behavioral Scientist*, 1976.

CONCLUSIONS AND RECOMMENDATIONS

From the block and tract analyses of street layouts and residential burglary rates, these conclusions can be drawn for Minneapolis:

* *Inaccessible street layouts are associated with low residential burglary rates.*

* *The relationship is not uniform across all relatively inaccessible types of layouts. It seems true of dead end, cul-de-sac and L-type blocks, but not of T-type blocks.*

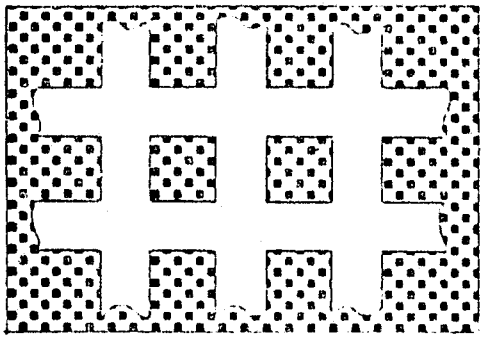
* *Low residential burglary rates along less accessible streets do not seem countered by displacement of burglaries to more accessible streets in the same tract.*

* *The relationship between street layout and residential burglary cannot be dismissed by considering traditional social variables.*

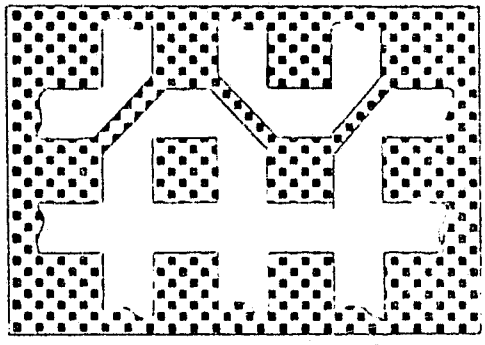
* *Street layouts ill-suited for residential burglaries do not seem conducive to other crimes.*

Replacing through and T-type streets with dead end, cul-de-sac or L-type streets consequently appears a more promising strategy to prevent residential burglary than it would be if the conclusions of this study were different. Figure 5 shows how alternate placements of traffic diverters (for instance, bituminous curbs, post-and-chain combinations, wood fences) create less accessible layouts from gridiron street plans.

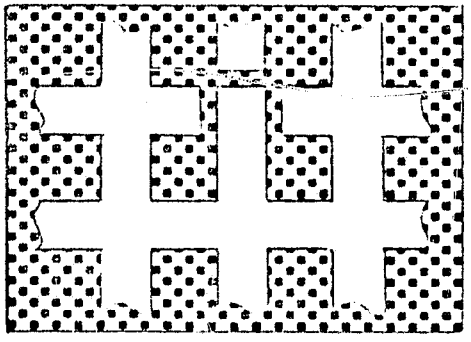
Figure 5. Placement of Traffic Diverters to Reduce Layout Permeability



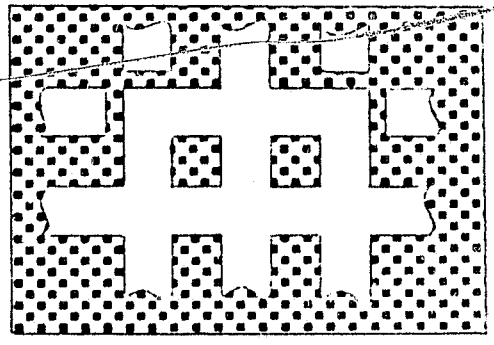
Gridiron Layout
Before Diverters



Diagonal Diverters
Creating
L-type Blocks



Regular Diverters
Creating
Dead End Blocks



Regular Diverters
Creating Dead End
and L-Type Blocks

Recommendation of street layout changes as a strategy to prevent residential burglary, however, must be qualified.

* *The strategy should not be assumed promising for places other than Minneapolis on the basis of this analysis alone.* The generalizability of a strategy is strengthened only with repeated testing producing similar results.

* *Implementation of the strategy in Minneapolis should be selective and experimental.* To avoid undue interference with fire trucks and other legitimate traffic, implementation should be limited to tracts (1) with high rates of residential burglary, (2) with street layouts that are at present highly permeable, (3) for which considering layout permeability improves estimation of the burglary rate and (4) for which the estimated benefits justify the estimated costs (Figure 4, Tables 5 and 6).

  With analyses like those conducted for this paper, it is always possible that some variable causing the relationship between the independent variable and the dependent variable has not been included among criteria used to match study and control subjects or among independent variables entered earlier into the regression equation. The analyses here, however, do suggest that expensive, true experiments are a worthwhile next step.[1]

* *The strategy should be implemented so as to interrupt the travel patterns of mobile burglars.* Traffic diverters should be placed along the tract side which most nonresident burglars cross to enter the tract. Police opinion or suspect flow data could be used to select the appropriate side.[2]

---

[1]True experiment, as used here, would mean random assignment of the tracts in Table 5 to approximately equal-sized treatment, placebo treatment and no treatment groups, with residential burglary rates being measured before and after the treatment (changes in the street layout). If the treatment changes residential burglary rates in the expected direction, extending the treatment to tracts in the placebo and no treatment groups is more warranted than it would otherwise be.

Since the theory of how street layout influences residential burglary emphasizes proprietorship, surveillance and travel behaviors as mechanisms for the influence, the experiment should be performed over a sufficiently long time period to allow behavior changes to develop. Also, the experiment should be monitored for displacement of burglaries from treatment tracts to other tracts nearby.

[2]For an example of how to portray flows from residences of suspects to their burglary targets, see *Crime in Minneapolis*, op. cit., p. 88.

TABLE 5

MINNEAPOLIS TRACTS RECOMMENDED FOR STREET LAYOUT EXPERIMENTATION
(In descending order of estimated effectiveness of layout changes. See Table 6 for formulas)

TRACT[a]	ESTIMATED DIVERTERS NEEDED[b]	ESTIMATED 10-YEAR BENEFITS PER DIVERTER (Value of property otherwise lost to burglary)[c]
68	1	$21,000
70	6	19,000
67	6	18,000
71	3	14,000
82	7	11,000
85	2	10,000
72	5	10,000
66	4	10,000
78	3	10,000
83	4	9,000
84	5	9,000
95	6	8,000
16	2	8,000
11	1	8,000
9	7	7,000
108	8	7,000
97	7	$ 7,000
14	5	7,000
94	3	7,000
27	3	7,000
79	4	7,000
15	6	7,000
8	3	6,000
22	3	6,000
7	5	6,000
104	5	6,000
63	2	6,000
87	4	6,000
77	4	5,000
99	4	5,000
20	3	4,000
46.01	1	Minimal
TOTAL OR AVERAGE (n = 32)	132	$ 9,000

[a]The 32 tracts satisfy each of these criteria for the July, 1974-June, 1975, study period:

- More than 44 burglaries per 1,000 residences
- Beta greater than 2
- Regression equation containing only social variables did not estimate the actual burglary rate as closely as did the equation also containing beta.

City officials should estimate 10-year construction and maintenance costs per diverter in study-year dollars. Tracts for which the estimated cost of a diverter exceeds the estimated dollar benefits would be removed from the list of recommended tracts.

[b]The estimated needs apply to the study period. If diverters have been added to tracts since then, the estimated needs should be adjusted downward.

[c]The benefits are very conservatively estimated. Figures are not adjusted upward to account for future inflation. Also, residential burglaries not reported to the police (almost 50 percent of the total according to victimization surveys) are excluded from the figures. Unreported burglaries probably result in less property loss than do reported burglaries, but by an unknown amount. U.S. Department of Justice, *Criminal Victimization in 13 American Cities* (Washington, D.C., 1975) p. 134.

TABLE 6

FORMULAS FOR TABLE 5 TERMS

TERM	FORMULA
Estimated[a] Diverters Needed	$\frac{v^2 i}{eb - vi}$
Estimated 10-Year Benefits Per Diverter	$\frac{irt \cdot 10}{\text{Estimated Diverters Needed}}$

[a]Adding a diverter to a layout is analogous to adding an intersection. The formula, correspondingly, calculates

- the number of vertices that must be added
- to reduce beta to the level it would be
- if the residential burglary rate were reduced
- by the amount by which beta improves estimation of the burglary rate.

DEFINITIONS

These vary by tract:

- e = edges
- v = vertices
- i = improvement in estimating burglaries with beta (p. 17), expressed per 1,000 residences
- r = residences, expressed in thousands

These are the same for each tract:

- i = the regression coefficient for beta in the equation estimating burglary rates by using social variables and beta (37.791 for Minneapolis)
- t = typical property loss recorded by police for burglaries reported to them ($400 for Minneapolis, a figure midway between the median and the mean)

Knowing that beta = $\frac{e}{v}$, that the number of vertices to be added = v_a, and that the reduction in beta necessary to reduce the burglary rate by i is $\frac{i}{b}$, the formula is calculated like this:

- Beta $-\frac{i}{b} = \frac{e}{v + v_a}$
- $\frac{e}{v} - \frac{i}{b} = \frac{e}{v + v_a}$
- $\frac{eb - vi}{vb} = \frac{e}{v + v_a}$
- $\frac{vb}{eb - vi} = \frac{v + v_a}{e}$
- $\frac{evb}{eb - vi} = v + v_a$
- $\frac{evb}{eb - vi} - v = v_a$
- $\frac{evb}{eb - vi} - v\frac{(eb - vi)}{eb - vi} = v_a$
- $\frac{evb - v(eb - vi)}{eb - vi} = v_a$
- $\frac{evb - evb + v^2 i}{eb - vi} = v_a$
- $\frac{v^2 i}{eb - vi} = v_a$

APPENDIX A

THE SOCIAL VARIABLES

Traditional social causes of crime are incorporated into this study via four variables: poor juveniles, nearby poor juveniles, blacks and nearby blacks. The following statistics for Minneapolis indicate the importance of including these variables in an analysis of residential burglary rates. Whereas juveniles comprise only 27 percent of the population, they comprise 47 percent of the residential burglary suspects in Minneapolis. The three poorest sections in the city contain 36 percent of the population, but 68 percent of the residential burglary suspects. And finally, less than 5 percent of the population in the city is black; yet, 35 percent of the residential burglary suspects are black.[1]

Numerous theories suggest why poor juveniles and minorities may be more inclined to commit profitable property crimes than are other groups not similarly situated. One broad-based cultural theory is the theory of anomie proposed by Robert Merton. Merton maintains that a stressful situation exists when society instills goals in its members that are not legitimately attainable by all of its members.[2] This society instills the goal of material success in its citizens. Poor juveniles and blacks may not have as many legitimate opportunities to obtain material status as others do. Some poor juveniles and blacks may resolve the stress by resorting to illegitimate opportunities like residential burglary.

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[1] Op. Cit. *Crime in Minneapolis*, pp. 84, 85 and 145.

[2] Robert Merton, *Social Theory and Social Structure*, (rev. ed., New York: Free Press), 1957, pp. 131-169.

In particular, juveniles frequently do not qualify for well-paying jobs, merely by virtue of being young, inexperienced and relatively uneducated. Child labor laws and school attendance requirements further limit job opportunities for juveniles. Restricted employment possibilities would present more of a problem to poor juveniles than to other juveniles, since the latter can usually obtain possessions and spending money from their parents.

Racial discrimination, by limiting learning experiences and career opportunities for blacks, can cause economic deprivation. Or it may contribute to crime in noneconomic ways, such as by encouraging disregard of property laws perceived as institutions of the majority race. This consequence of racial discrimination is supported by Albert Cohen, creator of a theory similar to that of Merton. Cohen proposes that people who are unable to obtain status in society, such as poor juveniles or blacks, will seek status in a subculture that has values opposite to values of the larger society.[1]

The differential association theory of Edwin Sutherland suggests that criminal behavior is learned through associations with others who define criminality favorably rather than with those who define it unfavorably. Cloward and Ohlin link the theories of Sutherland and Merton. Following Merton, they believe that delinquency is caused by a lack of legitimate means to achieve success goals. However, following Sutherland, they believe the form of delinquency depends on the illegitimate means available, that is, the learning process potential delinquents experience through their differential associations.[2]

---

[1]The theories of Cohen, Sutherland, and Cloward and Ohlin are summarized in: Silverman, Robert A. and Teevan, James J., Jr., *Crime in Canadian Society*, (Toronto: Butterworth and Co. Ltd.), 1975, pp. 147-162.

[2]Ibid.

The greater is the geographic concentration of groups particularly motivated to commit crimes (theorized as poor juveniles and blacks), the more likely it is that any individual in one of the groups will learn criminality through differential associations. Therefore, in this study, the social variables are measured as percentages rather than as simple numbers. A tract may, for instance, contain a large number of poor juveniles. But if the poor juveniles are an extremely small percentage of the total population, the chances that any one poor juvenile will frequently associate with other poor juveniles may be small.

The social variables--poor juveniles, nearby poor juveniles, blacks, and nearby blacks--are correlated (r^2 = .19 to .71). When independent variables are correlated, the earlier any one enters the regression equation, the larger its contribution to R^2 will generally be. Hence, good reasons must exist for entering some variables earlier than others are entered.

The poor juveniles variables precede the racial variables in the regression equation in this analysis. The racial variables, entered after the economic ones, estimate subcultural contributions of racial discrimination to residential burglary rates after economic contributions have been filtered out of the racial variables.

The poor juvenile and racial measures for tracts enter before the nearby tract measures do. Traditionally, studies of the social causes of crime have focused more on site (the census tract itself) than on situation (the ties between the tract and its surroundings). Entering site characteristics first allows estimating whether the less traditional, situational variables contribute anything to understanding residential burglary rates that is not achieved with site variables alone.

Results of simple and multiple regressions are in Appendix C. Theoretically relevant contributions by social variables to the explanation of crime rates are all

positively signed, as might be expected.[1] The poor juvenile variables together explain over 35 percent of the variance in residential burglary rates and, again, in street robbery rates. The poor juvenile variables do not contribute meaningfully to the other crime types. This accords with suspect statistics for Minneapolis. Juveniles are more common among residential burglary and street robbery suspects but less common among other suspects than expected from the percentage of the Minneapolis population that is less than 18 years old.[2]

Juvenile criminals are probably less skilled and experienced than are adult criminals. Residential burglary and street robbery require less skill and experience than required by commercial burglary and robbery, due to the presence of guards or sophisticated security devices in commercial establishments.

If limited access to cars causes poor juveniles to operate in their own census tracts, then little correlation between juvenile poverty and resident assault and rape by strangers is to be expected. Assailants in resident rape or resident assault may more often be strangers to their victims when the assailants live outside the tract than when they live inside the tract in which the crime occurs.

---

[1] Increments to R^2 that are .050 or greater are considered large enough to be theoretically relevant.

[2] Op. cit., *Crime in Minneapolis*, pp. 85, 111, 130, 162, 182:

	PERCENTAGE UNDER 18
Suspects in	
Residential burglary	47
Resident and nonresident street robbery	46
Commercial burglary	25
Resident and nonresident assault by strangers	17
Commercial robbery	1
Resident and nonresident rape by strangers	1
Minneapolis population	27

The racial variables, blacks and nearby blacks, when each enters the independent side of the regression equation alone, respectively explain 31 and 27 percent of the variance in residential burglary rates. That their contributions shrink considerably when the racial variables enter with other independent variables implies the first two variables entered, poor juveniles and nearby poor juveniles, account for much of the high simple correlations between the racial variables and residential burglary rates. Theories attributing the disproportionately high number of blacks among residential burglary suspects to economic deprivation are thus supported more than theories of subcultural disregard for mainstream values are supported. The same seems true for street robbery.

The racial variables do not contribute meaningfully in simple or multiple regression equations to the explanations of crime types other than residential burglary, despite statistics for Minneapolis showing disproportionate numbers of suspects in these crimes are black.[1] The nonmeaningful contributions may mean that black offenders travel more than one mile to commit these crimes, perhaps because particularly good targets are not available locally or because witnesses in faraway places would not recognize the offenders. Since there are two geographically distinct concentrations of blacks in Minneapolis, black offenders

---

[1] Ibid., pp. 84, 111, 130, 161, 182, 189:

	PERCENTAGE BLACK
Suspects in	
Resident and nonresident street robbery	54
Commercial robbery	47
Resident and nonresident rape by strangers	46
Residential burglary	35
Resident and nonresident assault by strangers	34
Commercial burglary	18
Minneapolis population	5

can operate away from home neighborhoods without operating in white neighborhoods, where they might feel uncomfortable.

Finally, the situational variables seem almost as important in explaining crime as the site variables seem. The poor juveniles variable explains 21 percent of the variation in residential burglary rates and 19 percent of the variation in street robbery rates. The nearby poor juveniles variable, entered after the poor juveniles variable, explains 15 percent and 18 percent of the variation in the respective crime rates.

APPENDIX B

CHOOSING AMONG BETA, GAMMA AND ALPHA

Clues in the classic geographic literature as to which measure--beta, gamma or alpha--should be used are sometimes missing or misleading. Kansky merely treats the measures as sufficiently similar to be grouped together.[1] Chorley and Haggett claim alpha is more useful than beta is.[2] Garrison and Marble say that alpha measures "redundancy" among paths, while gamma measures "connectivity" of points.[3] Nevertheless, it can be shown, mathematically, that beta, gamma and alpha measure different aspects of graph permeability only when there are fewer than 10 vertices per graph.

If e equals the number of edges and v equals the number of vertices in a two dimensional graph:

$$beta = \frac{e}{v},$$

$$gamma = \frac{100e}{3v-2} \text{ and}$$

$$alpha = \frac{100(e - v)}{2v - 5}.$$

Substituting $(beta \cdot v)$ for e in the gamma and alpha equations and then

---

[1] Op. cit., Kansky, p. 13.

[2] Peter Haggett and Richard J. Chorley, *Network Analysis in Geography*, (London: Edward Arnold), 1969, pp. 33-35.

[3] W. L. Garrison and D. F. Marble, "Graph Theoretic Concepts" in *Transportation Geography*, Michael E. Eliot Hurst, ed., (New York: McGraw-Hill Book Company), 1974, pp. 64-65.

reducing the equations to simpler forms produces:

$$gamma = \frac{beta}{.03 - \frac{.02}{v}}, \text{ which rounds to } \frac{beta}{.03} \text{ when } v \text{ is 4 or more, and}$$

$$alpha = \frac{beta - 1}{.02 - \frac{.05}{v}}, \text{ which rounds to } \frac{beta - 1}{.02} \text{ when } v \text{ is 10 or more.}$$

If y and x are variables, a and b are constants and y equals $a + bx$, then the correlation between y and x is 1.0. When v is 4 or more for gamma and 10 or more for alpha, the relationship of gamma and alpha with beta can be stated in the form of $y = a + bx$:

$$gamma = \frac{beta}{.03} = 0 + 33\ beta \text{ and}$$

$$alpha = \frac{beta - 1}{.02} = -50 + 50\ beta.$$

Consequently, when v is sufficiently large, the correlation between *gamma* and *beta* will round to 1.0, as will the correlation between *alpha* and *beta*. *Beta*, then, measures the same aspects of graph structure as *alpha* and *gamma* do when there are 10 or more vertices per graph. There are at least 30 vertices in the layout of each census tract in Minneapolis. Therefore, beta, the simplest of the permeability measures, is used.

APPENDIX C

TABLE C-1

SIMPLE CORRELATION COEFFICIENTS

(r^2 *in italics*, r in regular type)

N = 127		V9	V10	V11	STROB	ASALT	RAPE	PORYNG	NRPRYG	V16	NRBLAK	BETA
Residential Burglary	(V9)	*X*	*.16*	*.18*	*.10*	*.01*	*.05*	*.21*	*.30*	*.31*	*.27*	*.10*
Commercial Burglary	(V10)	.40	*X*	*.07*	*.00*	*.01*	*.00*	*.03*	*.06*	*.02*	*.03*	*.00*
Commercial Robbery	(V11)	.43	.27	*X*	*.00*	*.00*	*.00*	*.01*	*.02*	*.02*	*.03*	*.01*
Resident Street Robbery	(STROB)	.32	-.02	.02	*X*	*.31*	*.00*	*.13*	*.32*	*.08*	*.23*	*.05*
Resident Assault by Strangers	(ASALT)	.11	-.10	.02	.56	*X*	*.00*	*.01*	*.06*	*.01*	*.01*	*.02*
Resident Rape by Strangers	(RAPE)	-.13	.02	-.06	-.04	-.03	*X*	*.00*	*.00*	*.00*	*.00*	*.02*
Poor Juveniles	(PORYNG)	.46	.17	.10	.44	.11	-.06	*X*	*.13*	*.31*	*.24*	*.01*
Nearby Poor Juveniles	(NRPRYG)	.55	.25	.15	.57	.24	-.03	.44	*X*	*.31*	*.71*	*.00*
Blacks	(V16)	.56	.14	.15	.28	.10	-.03	.56	.56	*X*	*.55*	*.00*
Nearby Blacks	(NRBLAK)	.52	.18	.16	.48	.11	-.04	.49	.84	.74	*X*	*.00*
Beta	(BETA)	.31	-.04	.09	.22	.14	-.13	.09	.04	.06	.03	*X*

TABLE C-2

MULTIPLE REGRESSION RESULTS[1]

Dependent Variable	Independent Variables in Order of Entry	Individual Contribution to R Square	Cumulative R Square	b	a
RESIDENTIAL BURGLARY	Poor Juveniles	.207	.207	.574	
	Nearby Poor Juveniles	.154	.361	3.774	
N = 127	Blacks	.051	.413	0.829	
	Nearby Blacks	.009	.421	-.660	
	Beta	.064	.486	37.791	-44.406
COMMERCIAL BURGLARY	Poor Juveniles	.026	.026	1.951	
	Nearby Poor Juveniles	.040	.065	15.164	
N = 127	Blacks	.000	.066	0.522	
	Nearby Blacks	.005	.071	-3.090	
	Beta	.003	.074	-41.441	260.477
COMMERCIAL ROBBERY	Poor Juveniles	.008	.008	-.232	
	Nearby Poor Juveniles	.013	.021	1.130	
N = 127	Blacks	.009	.029	0.601	
	Nearby Blacks	.000	.029	0.259	
	Beta	.007	.036	29.497	15.064
RESIDENT STREET ROBBERY	Poor Juveniles	.191	.191	.628	
	Nearby Poor Juveniles	.175	.366	.188	
N = 127	Blacks	.022	.387	-.238	
	Nearby Blacks	.001	.389	.154	
	Beta	.033	.422	1.226	-2.341
RESIDENT ASSAULT BY STRANGERS	Poor Juveniles	.013	.013	.532	
	Nearby Poor Juveniles	.047	.059	.210	
N = 127	Blacks	.003	.063	.781	
	Nearby Blacks	.030	.093	-.632	
	Beta	.015	.108	.878	-1.299
RESIDENT RAPE BY STRANGERS	Poor Juveniles	.003	.003	-.690	
	Nearby Poor Juveniles	.000	.003	.567	
N = 127	Blacks	.000	.003	.207	
	Nearby Blacks	.000	.004	-.533	
	Beta	.015	.018	-55.825	123.024

[1]For each offense, the entire population of police records in Minneapolis from July, 1974, through June, 1975, was studied. For the counts of residents, housing units and commercial units used to calculate crime rates, and also for the social variables, population rather than sample data were used. Consequently, F, t and other measures signifying whether sample results would be replicated, had the entire population been studied instead of a random sample from it, are technically inappropriate and not cited here. See Denton E. Morrison and Ramon E. Henkel, eds., *The Significance Test Controversy*, (Chicago: Aldine), 1970, especially pp. xiii, 305 and 306.

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Minnesota Crime Prevention Center

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PHONE: (612) 870-0780

November 3, 1978

Ms. Georgette Lemick
Project Manager, NCJRS
Acquisition Report Department
Box 6000
Rockville, MD 20850

Dear Ms. Lemick:

Enclosed you will find a gratis copy of Changing Street Layouts to Reduce Residential Burglary which you requested. I have also enclosed an abstract and price list of other publications available from the Minnesota Crime Prevention Center. The price list includes the price which is regularly charged for the enclosed paper. If Changing Street Layouts to Reduce Residential Burglary is included in the database, we would appreciate it if database users could be informed of the charge for the publication.

Minnesota Crime Prevention Center, formerly the Community Crime Prevention project of Minnesota's Crime Control Planning Board, has changed its address. The new address is reflected in the letterhead.

I am sorry for the delay in responding to your request. I hope you will find the paper useful.

Sincerely,

Jan Ydstie

Jan Ydstie
Librarian

JY/mk

Enclosures

END