A STUDY OF LAG AND
GAP ACCEPTANCES AT
STOP-CONTROLLED
INTERSECTIONS

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by

P. SOLBERG

Joint
Highway
Research
Project

PURDUE UNIVERSITY
LAFAYETTE INDIANA

A STUDY OF LAG AND GAP ACCEPTANCES AT STOP-CONTROLLED INTERSECTIONS

TO: K. B. Woods, Director
Joint Highway Research Project

June 19, 1964

FROM: H. L. Michael, Associate Director
Joint Highway Research Project

File: 8-4-28
Project: C-36-17BB

The report attached is titled "A Study of Lag and Gap Acceptances at Stop-Controlled Intersections". It is the Final Report on research project C-36-17BB which was approved by the Advisory Board on May 8, 1963. The report has been prepared and the research was conducted by Mr. Per Solberg, Graduate Assistant on our staff under the direction of Professor J. C. Oppenlander.

The report presents the relationships found between acceptance of a time interval and the length of the time interval for drivers who stop at a through street. This information is necessary in the simulation of traffic at an intersection and is useful in the development of warrants for stop sign and traffic signal controls at intersections.

The report is presented for the record. The acceptance of this report will terminate the research on this project.

Respectfully submitted,

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Harold L. Michael, Secretary

HIM:bc

Attachment

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Final Report

A STUDY OF LAG AND GAP ACCEPTANCES
AT STOP-CONTROLLED INTERSECTIONS

by

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Project: C-36-17BB

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ABSTRACT

Solberg, Per, MSCE, Purdue University, June 1964. A Study of Lag and Gap Acceptances at Stop-Controlled Intersections. Major Professor: J. C. Oppenlander.

The purpose of this research study was to investigate the lag and gap acceptances for drivers entering and crossing a major roadway from a stopped position. The driver-behavior evaluation included a determination of a lag-and-gap acceptance distribution for the side-street drivers, consideration of community influence on this distribution, and comparisons of driver time-interval acceptance for through, left-turn, and right-turn movements. The study was performed at right-angled intersections formed by two-way, two-lane urban streets.

Four sites, selected in Lafayette and Indianapolis, were as identical as possible regarding geometry and adjacent land use. The data were collected at each of the four sites by means of a motion picture camera. The technique of probit analysis was employed in the statistical treatment of the observations. In addition to probit analysis, two other methods, one developed by Raff and the other by Bissell, were considered in this study of driver behavior.

The analysis indicated that the acceptance distributions were well described by a linear relationship between the probit of acceptance and the logarithm of acceptance time. There were no significant differences between the median lag-acceptance and the median gap-

acceptance times at the four intersections. Significant variations were found between right- and left-turning drivers and between drivers proceeding through the intersection and those making left turns. Right-turning drivers and those crossing the intersection were found to have statistically equal median acceptance times. Community size apparently has little effect on driver acceptance of time gaps. A general agreement was found to exist between the three methods of analysis investigated.

INTRODUCTION

The intersection of streets at grade in urban areas is a primary location of traffic accidents and a point of congestion and delay. One-half of all urban traffic accidents and more than three-fourths of all vehicular delays experienced in dense urban areas occur at these locations. (12)* The intersection is a critical element because vehicles arriving from different directions converge on this small area. The efficiency and capacity of the entire street system is generally dependent upon the characteristics of the intersections in the system.

The safety of the individual driver is related to the intersectional characteristics of the street system. The type of traffic control used at intersections influences the frequency and severity of traffic accidents. Because traffic volume represents exposure to potential accident situations, traffic-control devices, such as "Yield" and "Stop" signs and traffic signals, are used only at relatively high-volume intersections.

In determining controls for intersectional traffic, it is particularly desirable that numerical methods be used rather than casual observations of the many related factors. Quantitative measurements and their analysis are essential to ascertain the proper traffic-control devices and their influence on traffic characteristics. The

*Numbers in parentheses refer to entries in the Bibliography.

control of traffic is difficult because of the inability to predict the exact movements of vehicle streams. This variation results from the abilities, habits, and desires of individual drivers. Because of this dependence upon the driver's perception, judgment, and action, it is difficult to express any theory of traffic flow in exact mathematical terms.

The principle that a majority takes precedence applies in the field of traffic engineering when two traffic streams of unequal volumes come into conflict. The movement with the greater volume is usually less likely to respect the rights of the minor stream. The traffic engineer recognized this principle when he found it necessary to stop the minor stream by placing "Stop" signs at the intersection. Whenever a gap in the major flow is equal to or greater than some acceptable value, one or more vehicles in the minor flow merge with or cross the major stream. In this problem of selecting acceptable gaps, attention must be focused on the distribution of large openings in the primary traffic stream.

The traffic engineer desires to minimize vehicular delay in regulating the flow of traffic. In the case of an intersection, warrants for a traffic signal could be based on the lack of a sufficient number of acceptable minimum gaps occurring in the major traffic flow.

The purpose of this research study was to investigate the gap and lag acceptances for drivers entering and crossing a major roadway from a stopped position. This driver-behavior evaluation was subdivided into the following main categories:

•

1. Determination of a lag-and-gap distribution for side-street traffic that is controlled by a "Stop" sign;
2. Consideration of community influence on these distributions;
and
3. Comparison of driver time interval acceptance for through, left-turn, and right-turn movements.

For each of the above items various statistical tests were employed to evaluate the significance of the findings.

Simulation methods are presently being developed to analyze traffic flow and its characteristics at intersections and at ramp entrances on freeways. However, simulation techniques are dependent on field investigations of traffic-flow performance. The results of driver-behavior studies are required to construct realistic mathematical models which can be used to simulate traffic situations in computer analyses. In addition, time-acceptance distributions provide fundamental information for the development of warrants for "Stop" and "Yield" signs and traffic signals and for the determination of intersection capacities.

PREVIOUS INVESTIGATIONS

Several research projects have been conducted to study the traffic characteristics of at-grade intersections. In these investigations various techniques were used to analyze intersectional flow patterns under different roadway and traffic conditions. In 1933 B. D. Greenshields introduced the photographic method of studying traffic behavior by using a 16-mm Simplex movie camera to study vehicle speeds and spacings. Later Greenshields employed time-motion pictures to study the time intervals accepted by drivers when crossing another traffic stream. Both controlled and uncontrolled intersections were studied, and, in particular, "Stop"-controlled intersections were included in these investigations. The average minimum acceptable time gap was defined as that value which is accepted by more than 50 percent of the drivers. This descriptive time interval was 6.1 sec for the intersected traffic.

A few years later a similar study was made with a 20-pen graphic recorder by M. S. Raff. In this investigation the concept of a time lag was introduced and evaluated. Raff maintained that:

... if all lags and gaps are counted equally in tabulating the numbers of accepted and rejected intervals, then the percentage of intervals accepted for a particular size will not be a true measure of the percentage of drivers who find such an interval acceptable ... this is so because each driver who accepts an interval of a certain size accepts only one of them, while the driver who rejects this interval may reject a number of them. (10)

•

Instead of Greenshields' definition of an average minimum time gap, Raff developed the "critical lag", which is defined as the median length of time lag. That is, the number of accepted lags shorter than the critical time lag is equal to the number of rejected lags longer than this specific value. In this study the critical lags were not constant but varied from intersection to intersection. Critical lags were influenced by sight obstructions, main-street speeds, main-street width, and the patterns of traffic flow on the side street. However, traffic volumes on the main street did not significantly modify the critical-lag value. Turning movements, which probably affect the amount of delay to the side-street vehicles, received little attention in that study.

In comparing the critical lag with Greenshields' time gap, Raff noted that this gap averaged about 0.2 sec greater than the critical lag. Critical-lag values of 4.6 and 4.7 sec were determined for one pair of similar intersections. A comparison of another similar pair produced critical lags of 5.9 and 6.0 sec. According to Raff, the principal use of the critical lag is to simplify the computation of the number of delayed cars by making the assumption that all lags shorter than the critical value are rejected and all lags longer than this quantity are accepted. The critical lag is considered the most appropriate quantity to use because a balance exists between accepted lags longer than the critical lag and rejected lags shorter than this value. The volume warrant suggested by Raff for a "Stop" sign is:

A Stop sign is warranted, under the criterion of percent delayed, if an average day contains eight hours during which the volumes are such as to delay at least fifty percent of the side-street cars.

Based on the assumptions that vehicles on both streets arrive randomly at the intersection and that every side-street vehicle is a "first-position car", this warrant is expressed as the following formula for the percentage of side-street cars delayed:

$$P = 100 \left[1 - \frac{e^{-2.5N_s} e^{-2NL}}{1 - e^{-2.5N_s} (1 - e^{-NL})} \right]$$

where P = percentage of side-street cars delayed,

N = main-street volume; in cars per second,

N_s = side-street volume; in cars per second,

L = critical lag; in seconds, and

e = base of natural logarithms (10)

While most projects were limited to the consideration of vehicular delay and speed-change performance, H. H. Bissell considered vehicular movements through the intersection as through, left turn, and right turn. A 20-pen graphic recorder was used to obtain the necessary data for two intersections within the same urban area. In the analysis of the data it was determined that the acceptance of lags was not significantly different from the acceptance of gaps. This homogeneity of lags and gaps was demonstrated by the overlapping of the confidence intervals determined for a confidence coefficient of 80 percent. A mathematical formula of the accumulative logarithmic normal distribution for pooled lags and gaps was devised to describe the human judgment for accepting or rejecting the main-street traffic gaps that are offered to drivers stopped on the side street. Although the lane position (near or far) of the main-street traffic did not influence the gap acceptance for the traffic entering from the side street, the

type of entering maneuver produced different gap acceptance distributions. (2)

These findings were used by J. H. Kell in developing a computer simulation of traffic flow at an intersection regulated by a "Stop" sign. The modified formula for the simulation study was:

$$p(t) = \frac{1}{S\sqrt{2\pi}} \int_1^{\ln t} \frac{1}{t} \cdot e^{-\frac{(\ln t - \ln \bar{t})^2}{2S^2}} dt$$

where $p(t)$ = the probability of accepting a time lag or gap of seconds

S = standard deviation of the distribution

$\ln t$ = natural logarithm of the accepted time lag or time gap t

$\ln \bar{t}$ = natural logarithm of the average acceptance time (9)

The studies by Greenshields and Raff were both conducted in New Haven, Conn., and Bissell investigated one intersection in Richmond and the other in Oakland, Calif. Bissell suggested that many at-grade intersections should be studied in various locations to account for any variations in driver behavior for different sized cities and regions of the country.

As a general comparison of the three studies, Greenshields, Raff and Bissell reported, respectively, a mean gap acceptance of 6.1 sec, a mean lag acceptance of 5.9 sec, and a mean lag-and-gap acceptance of 5.8 sec.

PROCEDURE

To establish the acceptance distribution for lags and gaps it was necessary to observe driver behavior at selected intersection locations. Statistical estimations and various tests of hypothesis were used, respectively, to develop functional relationships and to appraise the significance of the findings.

Site Selection

The selection of suitable study sites involved the consideration of several factors. To obtain a representative sample of drivers, two at-grade intersections were chosen in each of two cities. Short pilot studies were first conducted to investigate the suitability of the various sites. Lafayette and Indianapolis, Indiana, were selected as typical of small- and medium-sized standard metropolitan areas. These communities permitted a comparison of driving habits as related to city size. The data obtained were random and representative samples of a particular intersection type and of the traffic passing through it. The following limitations were imposed on the final selection of the study locations to control several roadway and traffic variables which could influence the study results:

1. The four intersections were located in residential sections of an urban area.

2. Commercial roadside development near the intersection, such as service stations, laundries, ice-cream stands, etc. were not considered objectionable if the rest of the immediate area was residential.
3. To obtain a random sample of gaps in the main traffic stream, the intersections were located at least 0.25 mile from any traffic-control device on the main street.
4. Traffic volumes on both the main and side streets were in excess of 250 and 60 vph. These limits were established during the conduct of the pilot study to provide for the collection of data within a reasonable amount of time. Also, the range of gaps presented to the side-street drivers is a function of the volume on the main street. A wide range of gap and lag sizes was desired in this field investigation.
5. The intersections studied were very similar in regard to their geometry. These intersections consist of two, two-way streets crossing each other at right angles. Sight-distance conditions were about equal on all approaches, and the main street width was approximately the same at all intersections.
6. Posted speed limits on the main street were 30 mph.

A brief description of each intersection location is given in Table 1. Photographs and plan diagrams of these intersections are shown in Figures 1 to 8.

TABLE I
SUMMARY OF STUDY LOCATIONS

CITY	INTER-SECTION	MAJOR STREET	COMMERCIAL DEVELOPMENT AT INTERSECTION	GRADE AT INTER-SECTION	DEVELOPMENT ALONG STREETS	SIGHT CONDITIONS	POSTED SPEED LIMIT	AVERAGE MAJOR ST. VOLUME	AVERAGE MINOR ST. VOLUME
LAFAYETTE	A	N 14 ST.	SOME	LEVEL	RESIDENTIAL	ADEQUATE	25MPH	420 VPH	65 VPH
	B	KOSSUTH ST.	NONE	MOSTLY LEVEL	RESIDENTIAL	ADEQUATE	30MPH	330 VPH	65 VPH
INDIANA-POLIS	C	N. ILLINOIS ST.	NONE	MOSTLY LEVEL	RESIDENTIAL	ADEQUATE	30 MPH	460 VPH	65 VPH
	D	N. COLLEGE ST.	SOME	LEVEL	RESIDENTIAL	ADEQUATE	30 MPH	590 VPH	65 VPH

FIGURE 1 INTERSECTION A - LAFAYETTE

FIGURE 2 GEOMETRICS OF INTERSECTION A

FIGURE 3 INTERSECTION B- LAFAYETTE

FIGURE 4 GEOMETRICS OF INTERSECTION B

FIGURE 5 INTERSECTION C - INDIANAPOLIS

FIGURE 6 GEOMETRICS OF INTERSECTION C

FIGURE 7 INTERSECTION D - INDIANAPOLIS

FIGURE 8 GEOMETRICS OF INTERSECTION D

Equipment

The three methods generally available to record field data for traffic studies are personal observation, traffic-actuated recording devices, and photographic techniques. The use of time-motion pictures was chosen in this investigation as the best means of securing data on traffic flow at intersections. Former studies have demonstrated the simplicity and sufficient accuracy of this technique. (5, 6) Time-motion pictures provide a complete and permanent record of the traffic-movements within the field of view of the camera. Thus, it is possible to study the traffic patterns in detail and with relative ease at a later time.

The camera used was a 16-mm Eastman Cine Kodak Special with a wide-angle lens. A spring motor drove the camera at the rate of 8 frames per sec. Therefore, elapsed time intervals were measured to the nearest 0.125 sec. This degree of precision was considered sufficient for the purposes of measuring lag and gap times. If a vehicle is traveling at 30 mph, approximately 1.0 sec is required for the vehicle to pass through an average intersection. About 8 pictures of this vehicle are recorded on the movie film.

Data Collection

Data collection was performed with the same procedure at all study sites. At each intersection the camera was mounted on a tripod at some vantage point located near the side-street approach. The camera was positioned about 30 ft from the main street to view the entire intersection area. A typical field installation is shown in

FIGURE 9 TYPICAL FIELD SETUP

Figure 9. The positioning of the camera was relatively inconspicuous to the passing traffic.

Data were collected on Monday, Wednesday, and Friday in the morning and afternoon off-peak periods. Approximately five days were spent at each site to obtain a wide range of traffic-volume levels. Field studies were performed only when the weather was clear and the pavements were dry. The speed of the camera was frequently calibrated with a stopwatch.

The camera was started whenever a side-street vehicle approached the intersection and stopped for the "Stop" sign. After the side-street driver had accepted a time gap, the camera was stopped. The maximum time gap considered in this investigation was 15 sec, and the camera was stopped if the time interval accepted was larger than this limiting value. Only passenger cars and light commercial vehicles with passenger-car operating characteristics were considered in this field investigation.

The developed film was viewed by a time-motion study projector. The projector has a frame counter, and the film can be advanced or reversed one frame at a time. The pictures were projected onto a screen with grid lines drawn to define the collision points. The locations of the possible collision points are illustrated in Figure 10.

A stopped vehicle either proceeded straight through the intersection, turned right, or turned left. If a driver went straight through, the path of movement intersected that of vehicles from both the right and the left. When a right turn was made, the movement merged with traffic coming from the left and did not conflict with traffic from the right. On a left turn the path of a main-street

**FIGURE 10 TYPICAL COLLISION POINTS
CONSIDERED FOR SIDE STREET
TRAFFIC**

vehicle approaching from the left was crossed, and the maneuver merged with the major stream coming from the right.

The frame number in which the vehicle stopped at or crossed the property line was recorded. When the next opposing vehicle crossed the collision point, the frame number was again noted. The difference between these two frame numbers was divided by the film speed of 8 frames per sec to produce the available time lag in seconds. If a driver on the Stop-signed street proceeded across the intersection in front of the opposing vehicle, the time interval was considered as accepted. Otherwise, the time opportunity was rejected. A gap-time interval was recorded as the difference in frame numbers between two successive main-street vehicles, point divided by 8 frames per sec.

Data Analysis

The statistical analysis was designed to investigate the significance of the differences in median acceptance times for the following categories:

1. Lag-acceptance time and gap-acceptance time,
2. Acceptance times for right turns, left turns, and through movements, and
3. Acceptance times in one community as compared with those in the other community.

A technique called probit analysis was applied to test these differences statistically. This method is explained in detail in the book Probit Analysis, A Statistical Treatment of the Sigmoid Response Curve, by D. J. Finney and is especially used in biological

research. However, Finney describes its application in other fields:

The term biological assay in its widest sense should be understood to mean the measurement of the potency of any stimulus, physical, chemical or biological, physiological or psychological, by means of the reactions which it produces in living matter ...

One type of assay which has been found valuable in many different fields ... is that dependent upon the quantal, all or nothing response. Though quantitative measurement of a response is always to be preferred when available, there are certain responses which permit no graduation and which can only be expressed as "occurring" and "not-occurring." ... The statistical treatment of quantal assay data has been much aided by the development of probit analysis. This method which is usually attributed to Gaddum (1933) and Bliss (1934) has now been widely adopted as the standard method of reducing the data to simple terms.

The acceptance or rejection of a time gap is an all or nothing, or binomial, response and is dependent on the size of the gap. The minimum time gap that a driver accepts is defined as the tolerance level. The driver is assumed to reject all smaller time gaps and to accept all greater time gaps. This tolerance may be a fixed quantity for a subject, or it may vary with time.

A variation in the tolerance value exists from one member to another of the population. For quantal response data it is necessary to consider the distribution of tolerances over the population studied. The assumption of a normal distribution for the common logarithm of the tolerances suggests the application of the probit transformation. This transformation from percentages or proportions to probits forces the normal sigmoid curve of the untransformed data into a linear relationship.

The probit of the proportion (P) is defined as the abscissa which corresponds to a probability of P in a normal distribution having a mean of 5.0 and a variance of 1.0. The probit of P is mathematically

expressed as Y , where

$$P = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{Y-5} e^{-\frac{1}{2}u^2} du$$

and e = base of natural logarithms

u = a random variable

When a normalizing transformation for the time gap is available such that the transformed measure (x) of the time (t) is normally distributed, this distribution of tolerances can be expressed as

$$dP = \frac{1}{\sigma\sqrt{2\pi}} \cdot e^{-\frac{1}{2\sigma^2}(x-\mu)^2} dx$$

where μ is the mean of the distribution, and

σ is the variance

The normalizing function was assumed to be logarithmic; in this investigation of driver acceptance times, that is, $x = \log t$. The expected proportion of drivers accepting a time gap of x_0 is:

$$P = \frac{1}{\sigma\sqrt{2\pi}} \int_{-\infty}^{x_0} e^{-\frac{1}{2\sigma^2}(x-\mu)^2} dx$$

A comparison of the two formulas for P shows that the probit of the expected proportion accepting a time gap is related to the time gap by the linear equation:

$$Y = 5 + \frac{1}{\sigma}(x - \mu)$$

By means of the probit transformation the study data were used to obtain an estimate of this equation. The parameters of the tolerance distribution, mean and variance, were also determined. In particular, median gap and lag acceptance times were estimated as that value of x when $Y = 5$.

Initially the data were tabulated into groups at 1-sec intervals as shown in Tables 14 to 21, Appendix A. The observed data are binomial in nature, and within each time interval driver responses are binomially distributed. If a driver, selected at random from a population is exposed to a time interval of (t) sec, the probability of acceptance is P , and the probability of rejection is $Q = 1 - P$. The probability of exactly (r) accepting from a total of (n) drivers is:

$$pr(r) = \left[\frac{n!}{r! (n-r)!} \right] \cdot P^r \cdot Q^{n-r}$$

The average number accepting is nP , and the average number rejecting is nQ .

The purpose of observing a group of drivers in each interval in the time series was to obtain an estimate of the proportion, (p) , of drivers accepting this interval. Each value of the sample proportion p is an estimate of the corresponding proportion in the population (P) from which the sample was drawn.

When experimental data on the relationship between time and acceptance have been obtained, either a graphical or an arithmetical procedure can be used to estimate the slope (b) , of the regression line, which is an estimate of the reciprocal of the standard deviation, and the logarithm of the median acceptance time (m) at which $Y = 5$. The

arithmetical analysis is necessary when an accurate assessment of the precision of the estimates is desired.

To determine either type of estimate, the percentage of acceptance observed for each time gap was first calculated and converted to probits by means of Table 22, Appendix B. The probits were then plotted as a function of the logarithm of time (x), and a straight line was visually fitted to these points. Only the vertical deviations of the points were considered in drawing the line. Very extreme probits outside the range of 2.5 to 7.5 are relatively unimportant and can be disregarded. However, these extreme values should be included in the analysis when more drivers are observed in these ranges than in the groups giving intermediate probit values. This regression line is an approximation of the functional relationship between the gap-acceptance probit and the logarithm of time. This relation was used to initiate the arithmetic process of estimating a better-fitting regression line. The mathematical basis for the method of estimating the probit regression equation by a process of successive approximations is given by Finney. (4)

The linear regression equation of the working probits as a function of the logarithm of time is an improved estimate of the time-response relationship. Finney states:

If it differs markedly from the provisional line drawn by eye, it may itself be used as a new provisional line and the process repeated. The maximum likelihood estimate is, in fact, the limit to which these estimates tend as the cycle of determining a new line with the aid of that last calculated is indefinitely repeated. (4)

The statistical comparison of acceptance times is based on the assumption that the variances for the tolerance distributions are

equal. This fact is demonstrated in the probit analysis by the parallelism of the regression lines. If two series of quantal response data yield parallel probit regression lines, then a constant difference exists between the time gaps for all corresponding proportions of responding subjects.

This constant time difference is denoted by M which is equal to the difference between the common logarithms of the median acceptance times. Thus, the amount by which a time interval in the first series is less than a time interval with the same percentage of acceptance in the second series is expressed as:

$$\begin{aligned} M_{12} &= m_2 - m_1 \\ &= \bar{x}_2 - \bar{x}_1 - (\bar{y}_2 - \bar{y}_1)/b \end{aligned}$$

where m and x are expressed in common logarithms, y is the probit and b is the common slope of the two regression lines.

The relative acceptance of a time interval is expressed as:

$$R = 10^{M_{12}}$$

which is the relative difference between the time intervals with the same percentage of acceptance. The various steps followed in estimating the probit regression line are outlined in Appendix C.

A test of parallelism of two or more regression lines was performed by comparing the sum of the individual chi-square values for the series with that for the total sums of squares and products.

The methods employed by Raff and Bissell in their analyses were applied on the original data collected in this study to make a comparison with the results obtained with the probit method. Raff

determined the critical lag by plotting two cumulative distribution curves on the same graph. One curve describes the accepted number of lags shorter than a time interval (t) and the other shows the number of lags longer than (t). The value of the critical lag was determined as the value of time at which the two curves intersected. This method is illustrated in Figures 11 to 14 and in Table 2.

Bissell acknowledged the binomial character of the acceptance data and determined the equation for the probability of accepting a gap of size t as:

$$p(t) = \frac{1}{\sqrt{2\pi}} \int_0^t \frac{1}{t} \cdot e^{-\frac{(\log t - \log \bar{t})^2}{2s^2}} dt$$

where the logarithm of the time was considered as normally distributed and where

$p(t)$ = the probability of accepting a time lag or gap of t seconds

s = standard deviation of the distribution

$\log t$ = common logarithms of the accepted time lag or time gap t

$\log \bar{t}$ = common logarithm of the average acceptance time

e = base of natural logarithms

(2)

This equation was later modified by J. H. Kell. (9)

The standard deviation(s) is determined directly from the plot assuming that the mean time gap is the median value of the acceptance time (t) in seconds, that is the value of t when the acceptance is 50 percent. The standard deviation was then determined as the

difference between the median acceptance value and the time interval corresponding to an acceptance of 15.9 percent.

The data were plotted on log-probability paper, and a straight line was visually fitted to these points. The lines representing lags and gaps were drawn with equal slope for right turns, left turns and through movements in each comparison of varying conditions. However, the slopes were different from one set of comparisons to the next. Sample graphs are shown in Figures 15 to 17.

FIGURE II DISTRIBUTION OF ACCEPTED AND REJECTED LAGS AND GAPS AT INTERSECTION (A AND B). ALL MOVEMENTS.

FIGURE 12 DISTRIBUTION OF ACCEPTED AND REJECTED LAGS AND GAPS AT INTERSECTION (A AND B). RIGHT TURNS.

FIGURE 13 DISTRIBUTION OF ACCEPTED AND REJECTED LAGS AND GAPS AT INTERSECTION (A AND B). LEFT TURNS.

FIGURE 14 DISTRIBUTION OF ACCEPTED AND REJECTED LAGS AND GAPS AT INTERSECTION (A AND B). THROUGH MOVEMENTS.

Table 2
Accepted and Rejected Lags and Gaps at
Intersections A and B

All Movements

Time Interval Seconds	Number Accepted	Number Rejected	Cumulative No Accepted	Cumulative No. Rejected
0 - 0.9		44		1390
1 - 1.9		226		1346
2 - 2.9	1	289	1	1120
3 - 3.9	5	265	6	831
4 - 4.9	4	172	10	566
5 - 5.9	15	141	25	394
6 - 6.9	47	92	72	253
7 - 7.9	70	60	142	161
8 - 8.9	85	54	227	101
9 - 9.9	97	23	324	47
10 - 10.9	107	16	431	24
11 - 11.9	74	7	505	8
12 - 12.9	86	1	591	1
13 - 13.9	92		683	
14 - 14.9	72		755	
Over 15	1252			

Right Turns

Time Interval Seconds	Number Accepted	Number Rejected	Cumulative No Accepted	Cumulative No Rejected
0 - 0.9		6		100
1 - 1.9		16		94
2 - 2.9		19		78
3 - 3.9		18		59
4 - 4.9		10		41
5 - 5.9	4	8	4	31
6 - 6.9	5	8	9	23
7 - 7.9	5	4	14	15
8 - 8.9	10	4	24	11
9 - 9.9	12	4	36	7
10 - 10.9	8	2	44	3
11 - 11.9	9	1	53	1
12 - 12.9	3		56	
13 - 13.9	5		61	
14 - 14.9	6		67	
Over 15	275			

Table 2, cont.

Left Turns

Time Interval Seconds	Number Accepted	Number Rejected	Cumulative No Accepted	Cumulative No Rejected
0 - 0.9		20		713
1 - 1.9		122		693
2 - 2.9		132		571
3 - 3.9	2	112	2	439
4 - 4.9	1	101	3	327
5 - 5.9	5	81	8	226
6 - 6.9	25	55	33	145
7 - 7.9	40	37	73	90
8 - 8.9	36	29	109	53
9 - 9.9	48	11	157	24
10 - 10.9	56	8	213	13
11 - 11.9	41	5	254	5
12 - 12.9	44		298	
13 - 13.9	51		349	
14 - 14.9	36		385	
Over 15	562		947	

Through Movements

Time Interval Seconds	Number Accepted	Number Rejected	Cumulative No Accepted	Cumulative No Rejected
0 - 0.9		18		577
1 - 1.9		88		559
2 - 2.9	1	138	1	471
3 - 3.9	3	135	4	333
4 - 4.9	3	61	7	198
5 - 5.9	6	52	13	137
6 - 6.9	15	29	28	85
7 - 7.9	25	19	53	56
8 - 8.9	39	21	92	37
9 - 9.9	37	8	129	16
10 - 10.9	43	6	172	8
11 - 11.9	24	1	196	2
12 - 12.9	39	1	235	1
13 - 13.9	36		271	
14 - 14.9	28		299	
Over 15	398		597

FIGURE 15 LAG-AND-GAP DISTRIBUTION FOR RIGHT TURNS IN LAFAYETTE AND INDIANAPOLIS

FIGURE 16 LAG- AND-GAP DISTRIBUTION FOR LEFT TURNS IN LAFAYETTE AND INDIANAPOLIS

FIGURE 17 LAG-AND-GAP DISTRIBUTION FOR THROUGH MOVEMENTS IN LAFAYETTE AND INDIANAPOLIS.

RESULTS

Various methods have been developed to determine the time interval that an average driver accepts in crossing a traffic stream from a stopped position. Drivers were observed at four different inter-sections, and the time interval required by each driver to enter or cross the opposing traffic stream was recorded. The technique of probit analysis was employed in the statistical treatment of the observations. In addition to probit analysis, two other methods, one developed by Raff and the other by Bissell, were considered in this study of driver behavior. A comparative analysis was performed on the median time acceptances developed from the three analytical techniques.

Probit Method

Probit analysis is based on the assumption that a particular transformation of a quantal response is normally distributed. In the problem of determining drivers' lag- and gap-acceptance times, previous studies have indicated that the logarithms of the acceptance times are normally distributed. Thus, when the percentages of drivers accepting particular time intervals are converted to probits, a linear relationship exists between the probit of the percent acceptance and the logarithms of the acceptance time.

The relationships between lag acceptance and time and between gap acceptance and time are shown in Figures 18 to 19. Similar relations between lag- and-gap acceptance and time intervals for different

FIGURE 18 PROBIT REGRESSION LINES FOR ESTIMATION OF THE DIFFERENCE OF LAG ACCEPTANCE TIME AND GAP ACCEPTANCE TIME IN LAFAYETTE.

FIGURE 19 PROBIT REGRESSION LINES FOR ESTIMATION OF THE DIFFERENCE IN LAG ACCEPTANCE TIME AND GAP ACCEPTANCE TIME IN INDIANAPOLIS.

FIGURE 20 PROBIT REGRESSION LINES FOR ESTIMATION OF THE DIFFERENCE IN ACCEPTANCE TIME FOR VARIOUS MOVEMENTS AT INTERSECTIONS IN LAFAYETTE. (LAGS AND GAPS POOLED)

FIGURE 21 PROBIT REGRESSION LINES FOR ESTIMATION OF THE DIFFERENCE IN ACCEPTANCE TIME FOR VARIOUS MOVEMENTS AT INTERSECTIONS IN INDIANAPOLIS (LAGS AND GAPS POOLED)

FIGURE 22 PROBIT REGRESSION LINES FOR ESTIMATION OF THE DIFFERENCE IN ACCEPTANCE TIME FOR INTERSECTIONS IN LAFAYETTE AND INDIANAPOLIS. (LAGS AND GAPS POOLED, ALL MOVEMENTS POOLED RESPECTIVELY)

FIGURE 23 PROBIT REGRESSION LINES FOR ESTIMATION OF THE DIFFERENCE IN ACCEPTANCE TIME FOR VARIOUS MOVEMENTS AT INTERSECTIONS IN LAFAYETTE AND INDIANAPOLIS. (INTERSECTIONS POOLED, LAGS AND GAPS POOLED.)

movements and at different locations are illustrated in Figures 20 to 23. Each regression line represents the best fit of a straight line to the observed data and was used to estimate median acceptance times. For a 5-percent level of significance the difference in acceptance times was considered as non-significant if the relative acceptance time (R) was equal to or less than 1.10.

In previous studies the precision of the findings was not clearly stated, and no tests were performed to investigate the significance of the results. Greenshields and Bissell computed standard deviations of their acceptance time estimates. Bissell also computed confidence limits and plotted these to indicate the difference in acceptance times. Raff did not evaluate the reliability of the estimated acceptance times. However, confidence limits for median acceptance time, as well as those for the differences between acceptance times, may be calculated with the probit technique. A test for the goodness of fit of the regression line to the data points measures the precision of the time value estimates.

The differences in acceptance times between lags and gaps were first analyzed in this investigation of driver behavior. By pooling the data from the two intersections in Lafayette, the relative acceptance time (R) was contained in the interval of 1.00 to 1.08 for a confidence coefficient of 95 percent. That is, the median gap acceptance time is not expected to exceed 1.08 times the median lag acceptance time. Because the test statistics of 1.08 is less than the critical value of 1.10, the differences between the drivers' lag acceptances and gap acceptances were not considered significant. The

median acceptance times for lags and gaps were, respectively, 7.48 and 7.71 sec. The standard errors of estimate were 0.13 and 0.16 sec, and the confidence-limit ranges were between ± 0.27 and ± 0.33 secs. These findings for the comparison of lags and gaps are illustrated in Table 3.

For the two intersections in Indianapolis, the relative acceptance time (R) was 1.01, with 95 percent confidence limits of 1.00 and 1.05. With a gap acceptance time only 1.05 greater than lag acceptance time, this difference was not large enough to be significant. Median acceptance times for lags and gaps together with standard errors and confidence limits, are shown in Table 4. Because of the small differences that existed between the drivers' lag acceptances and gap acceptances in both Lafayette and Indianapolis, it was assumed that these lags and gaps came from the same population.

After the lags and gaps at the intersections in the city were combined, comparisons were performed among the through, left-turn, and right-turn traffic movements. These results are recorded in Tables 5 to 6. The median acceptance times in Lafayette for right turns, left turns, and through movements were, respectively, 7.26, 7.71, and 7.43 sec. The 95-percent confidence-limit ranges were ± 0.40 , ± 0.29 , and ± 0.30 sec. and standard errors of estimate were 0.22, 0.14, and 0.15 sec. In the comparison between left-turning drivers and right-turning drivers the median acceptance time for left turns was 1.06 times greater than the acceptance time for right turns. The 95-percent confidence limits for the relative acceptance time (R) were 1.02 and 1.08.

The relative acceptance times for the comparisons between left turns and through movements and between through movements and right turns

Table 3

Summary of Results - Testing the Difference Between Median Lag
Acceptance and Median Gap Acceptance at Two Intersections
in Lafayette, Indiana

Summary Statistics	Lags	Gaps
Log of mean acceptance time ($\bar{x}$)	0.893	0.897
Mean probit ($\bar{y}$)	5.15	5.08
Log of median acceptance time (m)	0.874	0.887
Median acceptance time (10^m seconds)	7.48	7.71
Standard error of median acceptance time (seconds)	7.48	7.71
95-percent confidence limits for median median acceptance time (seconds)	7.21; 7.75	7.38; 8.04
Test Statistics	Comparison Between Gaps and Lags	
Difference in m values (M)	0.013	
Relative acceptance time ($R = 10^M$)	1.03	
Standard error of relative acceptance time	0.028	
95-percent confidence limits for relative acceptance time	1.00; 1.08	

Table 4

Summary of Results - Testing the Difference Between Median Lag
Acceptance and Median Gap Acceptance at Two Intersections
in Indianapolis, Indiana

Summary Statistics	Lags	Gaps
Log of mean acceptance time ($\bar{x}$)	0.898	0.866
Mean probit ($\bar{y}$)	5.31	4.99
Log of median acceptance time (m)	0.862	0.867
Median acceptance time (10^m seconds)	7.26	7.36
Standard error of median acceptance time (seconds)	0.13	0.13
95-percent confidence limits for median acceptance time (seconds)	7.03; 7.49	7.11; 7.61
Test Statistics	Comparison Between Gaps and Lags	
Difference in m values (M)	0.005	
Relative acceptance time ($R = 10^M$)	1.01	
Standard error of relative acceptance time	0.024	
95-percent confidence limits for relative acceptance time	1.00; 1.08	

Table 5

Summary of Results - Testing the Difference Between Median Lag-
and-Gap Acceptance for Various Movements at Two Intersections
in Lafayette, Indiana

Summary Statistics	Side-Street Movements		
	Right	Left	Through
Log of mean acceptance time ($\bar{x}$)	0.905	0.904	0.892
Mean probit ($\bar{y}$)	5.33	5.14	5.17
Log of median acceptance time (m)	0.861	0.877	0.871
Median acceptance time (10 ^m seconds)	7.26	7.71	7.43
Standard error of median acceptance time (seconds)	0.22	0.14	0.15
95-percent confidence limits for median acceptance time (seconds)	6.86; 7.66	7.42; 8.00	7.13; 7.73

Test Statistics	Comparison between movements		
	Lt to Rt	Lt to Thru	Rt to Thru
Difference in m values (M)	0.026	0.016	0.010
Relative acceptance time (R = 10 ^M)	1.06	1.04	1.02
Standard error of relative acceptance time	0.024	0.028	0.025
95-percent confidence limits for relative acceptance time	1.02; 1.08	1.00; 1.08	1.00; 1.07

Table 6

Summary of Results - Testing the Difference Between Median Lag-
and-Gap Acceptance for Various Movements at Two Intersections
in Indianapolis, Indiana

Summary Statistics	Side-Street Movements		
	Right	Left	Through
Log of mean acceptance time ($\bar{x}$)	0.871	0.899	0.861
Mean probit ($\bar{y}$)	5.03	4.95	5.11
Log of median acceptance time (m)	0.868	0.904	0.849
Median acceptance time (10 ^m seconds)	7.38	8.02	7.06
Standard error of median acceptance time (seconds)	0.16	0.20	0.13
95-percent confidence limits for median acceptance time (seconds)	7.06; 7.70	7.64; 8.40	6.82; 7.30

Test Statistics	Comparison between movements		
	Lt to Rt	Lt to Thru	Rt to Thru
Difference in m values (M)	0.036	0.055	0.019
Relative acceptance time ($R = 10^M$)	1.09	1.13	1.05
Standard error of relative acceptance time	0.039	0.036	0.028
95-percent confidence limits for relative acceptance time	1.00; 1.18	1.06; 1.20	1.01; 1.09

were 1.04 and 1.02. These values were contained in the interval between 1.00 and 1.08 and between 1.00 and 1.07, respectively, at the 5-percent level of significance. That is, left-turning drivers did not require a time interval longer than 1.08 times the interval required by drivers moving straight through the intersection. Drivers crossing the intersection did not require time interval longer than 1.07 times the interval for right-turning drivers. According to the criterion that relative acceptance times greater than 1.10 are significant, the differences in acceptance times between the various movements were not significant in Lafayette.

Similar comparisons were performed for the data obtained at the two intersections in Indianapolis. A significant difference was observed between the median acceptance times of left turns and right turns and of left turns and through movements. However, the difference between right turns and through movements was not significant. The median acceptance times were 7.38, 8.02 and 7.06 sec for right turns, left turns and through movements. The 95-percent confidence-limit intervals were ± 0.32 , ± 0.38 , and ± 0.24 sec, and the standard errors were 0.16, 0.20, and 0.13 secs. Drivers turning left had a median acceptance time 1.09 times greater than the median acceptance time for right turns, and 1.13 times greater than that for through movements. The upper 95-percent confidence limits for these relative acceptance-time values were 1.18 and 1.20. Right-turning drivers has 1.05 times greater median acceptance time than those performing through movements. This relative acceptance value did not exceed 1.09 at a 5-percent significance level. Thus, there existed a significant difference

between the median acceptance times for left turns and right turns and between left turns and through movements, at the 5-percent significance level.

The corresponding acceptance-times for the various traffic movements were different in the two communities studied. However, no significant difference existed in the median lag and gap acceptances for the combined movements in the two cities. The median acceptance time was 7.79 sec in Lafayette and 7.36 sec in Indianapolis. The 95-percent confidence limits for the acceptance times, illustrated in Table 7, were 7.76 and 7.82 sec in Lafayette and 7.34 and 7.38 sec in Indianapolis. The standard errors of the medians were 0.09 sec for both cities. The upper 95-percent confidence limit for the relative acceptance time (R) was 1.10. That is, the median acceptance time in Lafayette was not more than 1.10 times greater than that in Indianapolis at a 5-percent level of significance. Because this difference was not significant, the lag-and-gap acceptance distributions were combined for the intersections in Lafayette and Indianapolis.

A comparison of lag and gap acceptances performed between the different movements is summarized in Table 8. Left-turning drivers have 1.06 and 1.09 times greater median lag-and-gap acceptance times than drivers turning right or proceeding straight through, respectively. A significant difference existed between these movements, at the 5-percent significance level, because the upper confidence limit for the relative acceptance time (R) was 1.12 for the first comparison and 1.14 for the second comparison. The right-turning drivers had only 1.03 times greater median acceptance time than those continuing straight

Table 7

Summary of Results - Testing the Median Lag-and-Gap
Acceptance Difference, Combined Movements,
Between Lafayette and Indianapolis, Indiana

Summary Statistics	Lafayette	Indianapolis
Log of mean acceptance time ($\bar{x}$)	0.891	0.876
Mean probit ($\bar{y}$)	5.02	5.09
Log of median acceptance time (m)	0.892	0.867
Median acceptance time (10^m seconds)	7.79	7.36
Standard error of median acceptance time (seconds)	0.09	0.09
95-percent confidence limits for median acceptance time (seconds)	7.76; 7.82	7.34; 7.38
<hr/>		
Test Statistics	Comparison Between Lafayette and Indianapolis	
Difference in m values (M)	0.025	
Relative acceptance time ($R = 10^M$)	1.06	
Standard error of relative acceptance time	0.037	
95-percent confidence limits for relative acceptance time	1.02; 1.10	

Table 8

Summary of Results - Testing the Difference Between Median Lag-
and-Gap Acceptance for Various Movements at Four Intersections
Combined in Lafayette and Indianapolis, Indiana

Summary Statistics	Side-Street Movements		
	Right	Left	Through
Log of mean acceptance time ($\bar{x}$)	0.883	0.908	0.865
Mean probit ($\bar{y}$)	5.14	5.14	5.08
Log of median acceptance time (m)	0.867	0.893	0.856
Median acceptance time (10^m seconds)	7.36	7.82	7.18
Standard error of median acceptance time (seconds)	0.14	0.11	0.09
95-percent confidence limits for median acceptance time (seconds)	7.10; 7.62	7.60; 8.04	7.00; 7.36

Test Statistics	Comparison between movements		
	Lt to Rt	Lt to Thru	Rt to Thru
Difference in m values (M)	0.026	0.037	0.011
Relative acceptance time ($R = 10^M$)	1.06	1.09	1.03
Standard error of relative acceptance time	0.026	0.023	0.024
95-percent confidence limits for relative acceptance time	1.00; 1.12	1.05; 1.13	1.00; 1.07

through, and the median acceptance times for the two movements were therefore considered equal at the 5-percent significance level.

Raff Method

The results obtained by using the Raff method depend largely on the manner in which the curves are fitted to the data points. No test is presently available to check the precision of this visual fitting technique. The results are relatively accurate if the curve follows the points closely. However, even if the fit was good, a variation of 0.20 sec was evidenced in the estimation of the median acceptance time.

The procedure developed by Raff for the determination of the median acceptance time is briefly described in "Data Analysis." It is illustrated in Figures 11 to 14 and Table 2. The final results are given in Table 9.

In the investigation of median acceptance times for lags and gaps with the combined data for the two intersections in Lafayette, acceptance time for lags was 7.60 sec and that for gaps was 7.75 sec, or 0.15 sec longer. The median acceptance times for lags and for gaps were found to be equal to 7.35 sec for the two intersections in Indianapolis.

The corresponding median acceptance-time values as determined by the probit, Raff, and Bissell methods of analysis are compared in Tables 11 to 13. A reasonable agreement is evident between the Raff-method and the probit-method values for Lafayette. In Lafayette the drivers' median lag-and-gap acceptance time for right turns was 7.55

Table 9
Median Acceptance Times at Study Locations

Raff Method					
Location	Combined Lags and Gaps Seconds			Combined Movements Seconds	
	Right Turns	Left Turns	Through Movements	Lags	Gaps
Lafayette	7.55	7.80	7.60	7.60	7.75
Indianapolis	7.30	7.95	7.10	7.35	7.35
Lafayette and Indianapolis	7.45	7.85	7.35		

sec, or 0.05 sec shorter than the corresponding value for through movements. The value for left turns was 7.80 sec, or 0.20 sec greater than for through movements.

Greater differences were evident in Indianapolis for certain traffic movements. The median acceptance times were 7.30 sec for right turns, 7.95 sec for left turns, and 7.10 sec for through movements, as shown in Table 9. Drivers moving straight through the intersection had the lowest median acceptance time, although this value was only 0.20 sec shorter than that for drivers turning right. The left-turning drivers required a considerably longer median acceptance time than these former two classifications.

When data in Lafayette and Indianapolis were grouped together, the median acceptance time for through movements was 7.35 sec, or only 0.10 sec lower than that for right turns. The value of the median lag-and-gap acceptance time for the left-turning drivers was greater than that of the drivers turning right or moving straight through. These summary statistics are illustrated in Table 9.

These findings are generally similar to the results obtained by the probit method of analyzing the driver acceptance of lags and gaps occurring in the main flow of traffic.

Raff computed values varying from 4.6 to 6.0 sec for the median values of driver lag-acceptance time for the intersections studied. These median times are approximately from 2.0 to 2.5 sec shorter than those measured in the present investigation. Raff found that 2.0 percent accepted in the time interval less than 1.0 sec and up to 7.0 percent in the interval between 1.0 and 2.0 sec. This acceptance of

extremely short time lags may account for his lower median acceptance-times. It also suggests that some of these drivers' acceptance times were "forced," because the average starting reaction time of a driver is approximately 1.0 sec and another 1.5 sec elapses before the vehicle clears the intersection. Consequently, a time interval less than 2.5 sec would not be adequate for the side-street driver to enter the intersection without interfering with the main-traffic stream.

Lags were measured using the near curb line as the reference point in Raff's study. In the present study lags were referred to the collision points. The use of the longer approach path in the latter case may account for part of the difference between median acceptance times.

Bissell Method

The method used by Bissell to estimate median acceptance times and their distribution has been briefly described and is illustrated in Figures 15 to 17 in "Data Analysis". The resulting median acceptance times observed in this study are given in Table 10.

The results obtained are predicated on the accuracy of fitting a line to the observed data. Although median values were estimated to the nearest 0.05 sec, precision of this visual fit cannot be described in numerical terms. The lines were drawn parallel to each other so that homogeneity of variance was obtained. A standard deviation of 1.31 sec was determined for all intersections and movement comparisons.

The drivers' median acceptance times for lags and for gaps in Lafayette and in Indianapolis had an equal difference of 0.10 sec.

Table 10
Median Acceptance Times at Study Locations

Bissel Method					
Location	Combined Lags and Gaps Seconds			Combined Movements Seconds	
	Right Turns	Left Turns	Through Movements	Lags	Gaps
Lafayette	7.30	7.50	7.10	7.40	7.50
Indianapolis	7.35	7.65	7.05	7.20	7.30
Lafayette and Indianapolis	7.35	7.65	7.10		

Table 11
Median Acceptance Times in Lafayette as Determined
by Different Methods

Method	Combined Lags and Gaps Seconds			Combined Movements Seconds	
	Right Turns	Left Turns	Through Movements	Lags	Gaps
Probit	7.26	7.71	7.43	7.48	7.71
Raff	7.55	7.80	7.60	7.60	7.75
Bissell	7.30	7.50	7.10	7.40	7.50

Table 12
 Median Acceptance Times in Indianapolis as
 Determined by Different Methods

Method	Combined Lags and Gaps Seconds			Combined Movements Seconds	
	Right Turns	Left Turns	Through Movements	Lags	Gaps
Probit	7.38	8.02	7.06	7.26	7.36
Raff	7.30	7.95	7.10	7.35	7.35
Bissell	7.35	7.65	7.05	7.20	7.30

Table 13

Pooled Median Acceptance Times in Lafayette and Indianapolis
as Determined by Different Methods

Method	Combined Lags and Gaps Seconds		
	Right Turns	Left Turns	Through Movements
Probit	7.36	7.82	7.18
Raff	7.45	7.85	7.35
Bissell	7.35	7.65	7.10

These lag and gap acceptances were respectively, 7.40 and 7.50 sec for Lafayette and 7.20 and 7.30 sec for Indianapolis. Comparisons of corresponding median acceptance time values as determined by the probit, Raff, and Bissell methods of analysis are illustrated in Tables 11 to 13. The values obtained by the Bissell and the probit methods were relatively equal.

Median acceptance times varied only slightly for the two intersections in Lafayette. The single exception was the comparison of the median acceptance times for the through movements and left turns. Drivers performing a left turn required on the average 0.40 sec longer than those passing straight through the intersection. Drivers turning right had a median lag-and-gap acceptance value of 7.30 sec. Left-turning drivers and those proceeding straight through the intersection had median acceptance times of 7.50 and 7.10 sec, respectively.

For the Indianapolis intersections the differences in lag-and-gap acceptance times for the various movements were found to be greater than the corresponding values in Lafayette. The only exception was the through movements, for which the different acceptance times are shown in Table 10. Left-turning drivers had a median lag-and-gap acceptance time of 7.35 sec, which was 0.30 sec longer than that for right-turning drivers and 0.60 sec longer than that for drivers moving straight through the intersection.

Acceptance times for the drivers in Lafayette and Indianapolis combined are recorded in Table 10. Right-turning and left-turning drivers had median acceptance times of 7.35 and 7.65 sec, respectively. Drivers moving straight through the intersection had a median lag-and-gap acceptance time of 7.10 sec.

When the intersections were pooled for Lafayette and Indianapolis, a greater number of observations were included in the estimation of median acceptance times. Therefore, the line in the log-normal probability plot can be fitted with greater precision. This combination of the four intersections afforded the best conformance between the probit method and the Bissell method for median lag-and gap acceptance times. As indicated by the summary data in Tables 11 to 13, the Bissell values are generally lower than the probit values, except for the median acceptance time for right-turning drivers in Lafayette.

Bissell obtained the following median lag-and-gap acceptance times for right turns, left turns, and through movements, respectively, as 5.25, 6.25, and 5.80 sec. The corresponding values from the combined intersections in the present investigation are 7.36, 7.82, and 7.18 sec. The difference of 2.11 sec between right turns was the greatest variation encountered in the comparison of the two studies.

The discrepancies in the acceptance times are probably largely due to a different population of drivers. However, the volumes on the side street and on the main street were larger in the Bissell investigation, and this might have forced drivers to accept smaller time intervals. Though, Raff disproved the significance of main-street traffic volumes on driver gap and lag acceptances. The "forced" gap acceptance was indicated by Bissell when during peak hours side-street drivers forced themselves into the main traffic stream when adequate gaps were not actually available. Bissell also found that many drivers "cruised" by the "Stop" sign without stopping. This fact was particularly true for right-turning drivers and may account for

the differences between the right turns and the other movements in that study and the right turns in this investigation.

SUMMARY OF RESULTS AND CONCLUSIONS

The results inferred from this field investigation are representative of right-angle intersections formed by two-way, two-lane urban streets. Two intersections in Lafayette and two in Indianapolis were investigated to determine the median acceptance times for side-street traffic crossing a major traffic stream. These locations have similar geometric characteristics. Lag and gap acceptance distributions were developed for the side-street traffic, and the influence of community differences on these distributions was evaluated. A comparison of driver acceptance times for through, right-turn, and left-turn movements was also performed.

1. No drivers accepted any time interval less than 2.0 sec, and only one driver was observed accepting an interval less than 3.0 sec.
2. The overall median acceptance times for right turn, left turn, and through movements were 7.36, 7.82, and 7.18 sec, respectively.
3. There were no significant differences between the median lag-acceptance and the median gap-acceptance times at the four intersections.
4. In Lafayette the gap-and-lag acceptance times for the right turn, left turn, and through movements were statistically equal.

5. Significant variations were found between right- and left-turning drivers and between drivers proceeding through and those making left turns for the intersections in Indianapolis. Through-movement and right-turn acceptance times differed only slightly.
6. When the intersections in Lafayette were combined with those in Indianapolis, a difference in acceptance times was found between drivers making left turns and right turns and between those performing through movements and left turns. However, no significant difference existed between right-turning drivers and the drivers moving straight through the intersection.
7. Lag- and gap acceptances for combined movements in Lafayette and Indianapolis were not significantly different. Community size apparently has little effect on driver acceptance of time gaps.
8. Because the regression lines developed in the probit analysis can be tested for goodness of fit, this technique is more reliable and valuable for the determination of median acceptance times than the Raff and the Bissell procedures.
9. Except for the median acceptance times for right turns and left turns in Indianapolis, the values obtained by the probit method were within the values determined by the other methods. The results from Bissell's method were generally in better agreement with the probit values than were the results from Raff's method. This is demonstrated in the Tables 11 to 13.

10. Only two of the drivers' median acceptance time values as determined from the Raff and Bissell methods were outside the 95-percent confidence limits for the corresponding values obtained by the probit analysis. These measures were for through movements in Indianapolis and Lafayette. Thus, a general agreement exists between the results from the three methods investigated.
11. In previous investigations the median acceptance times varied from 5.8 sec in Bissell's study to 6.1 sec in a study by Greenshields. The overall lag- and gap-acceptance times for Lafayette and Indianapolis were 7.79 and 7.36 sec, respectively, and are between 1.5 and 2.5 sec longer than the values observed in these former studies.

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APPENDIX

APPENDIX A

SUMMARY DATA

Table 14
Accepted and Rejected Lags at Intersection A

All Movements

Length of Lag in Seconds	Number Accepted	Number Rejected	Total Number	Percent Accepted
0 - 0.9		15	15	
1 - 1.9		70	70	
2 - 2.9		82	82	0.0
3 - 3.9	1	67	68	1.5
4 - 4.9	2	41	43	4.8
5 - 5.9	4	30	34	11.8
6 - 6.9	11	21	33	33.3
7 - 7.9	20	16	36	55.5
8 - 8.9	25	16	41	61.0
9 - 9.9	25	3	28	89.5
10 - 10.9	34	3	37	91.9
11 - 11.9	28	1	29	96.5
12 - 12.9	27		27	100.0
13 - 13.9	32		32	
14 - 14.9	21		21	
Over 15	389		389	

Right Turns

Length of Lag in Seconds	Number Accepted	Number Rejected	Total Number	Percent Accepted
0 - 0.9		4	4	
1 - 1.9		11	11	
2 - 2.9		11	11	
3 - 3.9		7	7	
4 - 4.9		6	6	0.0
5 - 5.9	2	2	4	50.0
6 - 6.9	2	4	6	33.3
7 - 7.9	3	1	4	75.0
8 - 8.9	9	2	11	81.9
9 - 9.9	5	1	6	83.2
10 - 10.9	4	1	5	79.9
11 - 11.9	5	1	6	83.2
12 - 12.9	2		2	100.0
13 - 13.9	3		3	
14 - 14.9	3		3	
Over 15	147		147	

Table 14, cont.

Left Turns

Length of Lag in Seconds	Number Accepted	Number Rejected	Total Number	Percent Accepted
0 - 0.9		4	4	
1 - 1.9		29	29	
2 - 2.9		30	30	
3 - 3.9		23	23	0.0
4 - 4.9	1	16	17	5.9
5 - 5.9	1	9	10	10.0
6 - 6.9	5	10	15	30.0
7 - 7.9	10	8	18	55.5
8 - 8.9	5	5	10	50.0
9 - 9.9	10	1	11	90.9
10 - 10.9	15	1	16	93.8
11 - 11.9	10		10	100.0
12 - 12.9	11		11	
13 - 13.9	19		19	
14 - 14.9	10		10	
Over 15	107		107	

Through Movements

Length of Lag in Seconds	Number Accepted	Number Rejected	Total Number	Percent Accepted
0 - 0.9		7	7	
1 - 1.9		30	30	
2 - 2.9		41	41	0.0
3 - 3.9	1	37	38	2.6
4 - 4.9	1	19	20	5.0
5 - 5.9	1	19	20	5.0
6 - 6.9	4	7	11	36.4
7 - 7.9	7	7	14	50.0
8 - 8.9	11	9	20	55.0
9 - 9.9	10	1	11	90.9
10 - 10.9	15	1	16	93.8
11 - 11.9	13		13	100.0
12 - 12.9	14		14	
13 - 13.9	10		10	
14 - 14.9	8		8	
Over 15	135		135	

Table 15
Accepted and Rejected Lags at Intersection B

All Movements				
Length of Lag in Seconds.	Number Accepted	Number Rejected	Total Number	Percent Accepted
0 - 0.9		21	21	
1 - 1.9		59	59	
2 - 2.9		54	54	
3 - 3.9		54	54	
4 - 4.9		43	43	0.0
5 - 5.9	7	47	54	13.0
6 - 6.9	15	34	49	30.6
7 - 7.9	22	16	38	58.0
8 - 8.9	22	11	33	66.7
9 - 9.9	32	9	41	78.0
10 - 10.9	36	7	43	83.5
11 - 11.9	24	3	27	88.9
12 - 12.9	21		21	100.0
13 - 13.9	34		34	
14 - 14.9	24		24	
Over 15	455		455	

Right turns				
Length of Lag in Seconds	Number Accepted	Number Rejected	Total Number	Percent Accepted
0 - 0.9		1	1	
1 - 1.9		4	4	
2 - 2.9		3	3	
3 - 3.9		4	4	
4 - 4.9		3	3	0.0
5 - 5.9	1	4	5	20.0
6 - 6.9	0	1	1	0.0
7 - 7.9	1	1	2	50.0
8 - 8.9	1	0	1	100.0
9 - 9.9	2	2	4	50.0
10 - 10.9	4	1	5	80.0
11 - 11.9	4		4	100.0
12 - 12.9	0		0	
13 - 13.9	1		1	
14 - 14.9	3		3	
Over 15	65		65	

Table 15, cont.

Left turns

Length of Lag in Seconds	Number Accepted	Number Rejected	Total Number	Percent Accepted
0 - 0.9		14	14	
1 - 1.9		37	37	
2 - 2.9		30	30	
3 - 3.9		27	27	
4 - 4.9		26	26	0.0
5 - 5.9	2	28	30	6.7
6 - 6.9	12	23	35	34.3
7 - 7.9	16	11	27	59.2
8 - 8.9	14	7	21	66.5
9 - 9.9	20	5	25	80.0
10 - 10.9	22	3	25	88.0
11 - 11.9	16	3	19	84.0
12 - 12.9	13		13	100.0
13 - 13.9	21		21	
14 - 14.9	14		14	
Over 15	265		265	

Through Movements

Length of Lag in Seconds	Number Accepted	Number Rejected	Total Number	Percent Accepted
0 - 0.9		6	6	
1 - 1.9		18	18	
2 - 2.9		21	21	
3 - 3.9		23	23	
4 - 4.9		14	14	0.0
5 - 5.9	4	15	19	21.1
6 - 6.9	3	10	13	23.1
7 - 7.9	5	4	9	55.5
8 - 8.9	7	4	11	63.5
9 - 9.9	10	2	12	83.3
10 - 10.9	10	3	13	77.0
11 - 11.9	4		4	100.0
12 - 12.9	8		8	
13 - 13.9	12		12	
14 - 14.9	7		7	
Over 15	108		108	

Table 16
Accepted and Rejected Lags at Intersection C

All Movements				
Length of Lag in Seconds	Number Accepted	Number Rejected	Total Number	Percent Accepted
0 - 0.9		46	46	
1 - 1.9		110	110	
2 - 2.9		68	68	
3 - 3.9		65	65	
4 - 4.9		59	59	0.0
5 - 5.9	4	35	39	10.3
6 - 6.9	14	23	37	37.8
7 - 7.9	25	13	38	66.0
8 - 8.9	32	10	42	76.0
9 - 9.9	27	5	32	84.2
10 - 10.9	30	2	32	93.6
11 - 11.9	32	1	33	97.0
12 - 12.9	43	1	44	97.5
13 - 13.9	26		26	100.0
14 - 14.9	24		24	
Over 15	344		344	

Right Turns				
Length of Lag in Seconds	Number Accepted	Number Rejected	Total Number	Percent Accepted
0 - 0.9		8	8	
1 - 1.9		22	22	
2 - 2.9		13	13	
3 - 3.9		15	15	
4 - 4.9		12	12	
5 - 5.9		8	8	0.0
6 - 6.9	1	3	4	25.0
7 - 7.9	2	4	6	33.3
8 - 8.9	4	1	5	80.0
9 - 9.9	8		8	100.0
10 - 10.9	10		10	
11 - 11.9	5		5	
12 - 12.9	9		9	
13 - 13.9	4		4	
14 - 14.9	6		6	
Over 15	142		142	

Table 16, cont.

Left Turns

Length of Lag in Seconds	Number Accepted	Number Rejected	Total Number	Percent Accepted
0 - 0.9		10	10	
1 - 1.9		17	17	
2 - 2.9		9	9	
3 - 3.9		7	7	
4 - 4.9		9	9	0.0
5 - 5.9	1	7	8	12.5
6 - 6.9	1	8	9	11.1
7 - 7.9	4	5	9	44.4
8 - 8.9	6	3	9	66.8
9 - 9.9	2	3	5	40.0
10 - 10.9	6		6	100.0
11 - 11.9	6		6	
12 - 12.9	9		9	
13 - 13.9	4		4	
14 - 14.9	0		0	
Over 15	49		49	

Through Movements

Length of Lag in Seconds	Number Accepted	Number Rejected	Total Number	Percent Accepted
0 - 0.9		28	28	
1 - 1.9		71	71	
2 - 2.9		46	46	
3 - 3.9		43	43	
4 - 4.9		38	38	0.0
5 - 5.9	3	20	23	13.1
6 - 6.9	12	12	24	50.0
7 - 7.9	19	4	23	82.5
8 - 8.9	22	6	28	78.5
9 - 9.9	17	2	19	89.5
10 - 10.9	14	2	16	87.5
11 - 11.9	21	1	22	95.5
12 - 12.9	25	1	26	96.0
13 - 13.9	18		18	100.0
14 - 14.9	18		18	
Over 15	153		153	

Table 17
Accepted and Rejected Lags at Intersection D

All Movements				
Length of Lag in Seconds	Number Accepted	Number Rejected	Total Number	Percent Accepted
0 - 0.9		19	19	
1 - 1.9		71	71	
2 - 2.9		70	70	
3 - 3.9		44	44	0.0
4 - 4.9	1	46	47	2.1
5 - 5.9	8	37	45	17.8
6 - 6.9	6	36	42	14.3
7 - 7.9	19	13	32	59.4
8 - 8.9	32	16	48	66.7
9 - 9.9	27	4	31	87.2
10 - 10.9	35	2	37	94.6
11 - 11.9	23		23	100.0
12 - 12.9	16		16	
13 - 13.9	20		20	
14 - 14.9	27		27	
Over 15	288		288	

Right Turns				
Length of Lag in Seconds	Number Accepted	Number Rejected	Total Number	Percent Accepted
0 - 0.9		6	6	
1 - 1.9		28	28	
2 - 2.9		29	29	
3 - 3.9		24	24	0.0
4 - 4.9	1	17	18	55.5
5 - 5.9	5	20	25	20.0
6 - 6.9	4	15	19	21.1
7 - 7.9	13	12	25	52.0
8 - 8.9	17	8	25	68.0
9 - 9.9	14	2	16	87.5
10 - 10.9	13	2	15	86.8
11 - 11.9	15		15	100.0
12 - 12.9	9		9	
13 - 13.9	12		12	
14 - 14.9	21		21	
Over 15	234		234	

Table 17, cont.

Left Turns

Length of Lag in Seconds	Number Accepted	Number Rejected	Total Number	Percent Accepted
0 - 0.9		7	7	
1 - 1.9		22	22	
2 - 2.9		21	21	
3 - 3.9		8	8	
4 - 4.9		10	10	0.0
5 - 5.9	1	11	12	8.3
6 - 6.9	0	14	14	0.0
7 - 7.9	1	0	1	100.0
8 - 8.9	9	4	13	69.2
9 - 9.9	6	1	7	85.8
10 - 10.9	9		9	100.0
11 - 11.9	6		6	
12 - 12.9	4		4	
13 - 13.9	2		2	
14 - 14.9	4		4	
Over 15	38		38	

Through Movements

Length of Lag in Seconds	Number Accepted	Number Rejected	Total Number	Percent Accepted
0 - 0.9		6	6	
1 - 1.9		21	21	
2 - 2.9		20	20	
3 - 3.9		12	12	
4 - 4.9		19	19	0.0
5 - 5.9	2	6	8	25.0
6 - 6.9	2	7	9	22.2
7 - 7.9	5	1	6	83.4
8 - 8.9	6	4	10	60.0
9 - 9.9	7	1	8	87.5
10 - 10.9	13		13	100.0
11 - 11.9	2		2	
12 - 12.9	3		3	
13 - 13.9	6		6	
14 - 14.9	2		2	
Over 15	16		16	

Table 18
Accepted and Rejected Gaps at Intersection A

All Movements				
Length of Gap in Seconds	Number Accepted	Number Rejected	Total Number	Percent Accepted
0 - 0.9		5	5	
1 - 1.9		56	56	
2 - 2.9		102	102	0.0
3 - 3.9	2	102	104	1.9
4 - 4.9	2	51	53	3.8
5 - 5.9	2	36	38	5.3
6 - 6.9	10	28	38	26.3
7 - 7.9	14	19	33	42.4
8 - 8.9	17	12	29	58.6
9 - 9.9	28	6	34	82.2
10 - 10.9	16	2	18	88.9
11 - 11.9	8	1	9	89.0
12 - 12.9	17		17	100.0
13 - 13.9	10		10	
14 - 14.9	13		13	
Over 15	200		200	

Right Turns				
Length of Gap in Seconds	Number Accepted	Number Rejected	Total Number	Percent Accepted
0 - 0.9		1	1	
1 - 1.9		1	1	
2 - 2.9		3	3	
3 - 3.9		6	6	
4 - 4.9		1	1	0.0
5 - 5.9	1	1	2	50.0
6 - 6.9	3	3	6	50.0
7 - 7.9	1	2	3	33.3
8 - 8.9	0	1	1	0.0
9 - 9.9	3		3	100.0
10 - 10.9	0		0	
11 - 11.9	0		0	
12 - 12.9	1		1	
13 - 13.9	1		1	
14 - 14.9	0		0	
Over 15	40		40	

Table 18, cont.

Left Turns

Length of Gap in Seconds	Number Accepted	Number Rejected	Total Number	Percent Accepted
0 - 0.9		1	1	
1 - 1.9		34	34	
2 - 2.9		37	37	0.0
3 - 3.9	2	39	41	4.9
4 - 4.9	0	33	33	0.0
5 - 5.9	0	25	25	0.0
6 - 6.9	3	18	21	14.3
7 - 7.9	6	12	18	33.4
8 - 8.9	4	7	11	36.4
9 - 9.9	9	4	13	69.2
10 - 10.9	7	1	8	87.5
11 - 11.9	4	1	5	80.0
12 - 12.9	5		5	100.0
13 - 13.9	2		2	
14 - 14.9	4		4	
Over 15	64		64	

Through Movements

Length of Gap in Seconds	Number Accepted	Number Rejected	Total Number	Percent Accepted
0 - 0.9		3	3	
1 - 1.9		21	21	
2 - 2.9		62	62	
3 - 3.9		57	57	0.0
4 - 4.9	2	17	19	10.5
5 - 5.9	1	10	11	9.1
6 - 6.9	4	7	11	36.4
7 - 7.9	7	5	12	58.2
8 - 8.9	13	4	17	76.5
9 - 9.9	16	2	18	88.5
10 - 10.9	9	1	10	90.0
11 - 11.9	4		4	100.0
12 - 12.9	11		11	
13 - 13.9	7		7	
14 - 14.9	9		9	
Over 15	96		96	

Table 19
Accepted and Rejected Gaps at Intersection B

All Movements				
Length of Gap in Seconds	Number Accepted	Number Rejected	Total Number	Percent Accepted
0 - 0.9		3	3	
1 - 1.9		41	41	0.0
2 - 2.9	1	51	52	1.9
3 - 3.9	2	42	44	4.5
4 - 4.9	0	37	37	0.0
5 - 5.9	2	28	30	6.7
6 - 6.9	11	9	20	55.0
7 - 7.9	14	9	23	60.9
8 - 8.9	21	15	37	56.8
9 - 9.9	12	5	17	70.5
10 - 10.9	21	4	25	84.0
11 - 11.9	14	2	16	87.5
12 - 12.9	21	1	22	95.5
13 - 13.9	16		16	100.0
14 - 14.9	12		12	
Over 15	208		208	

Right Turns				
Length of Gap in Seconds	Number Accepted	Number Rejected	Total Number	Percent Accepted
0 - 0.9				
1 - 1.9				
2 - 2.9		2	2	
3 - 3.9		1	1	
4 - 4.9		0	0	
5 - 5.9		1	1	
6 - 6.9		0	0	
7 - 7.9		0	0	
8 - 8.9		1	1	0.0
9 - 9.9	2	1	3	66.7
10 - 10.9				
11 - 11.9				
12 - 12.9				
13 - 13.9				
14 - 14.9				
Over 15	23		23	

Table 19, cont.

Left Turns

Length of Gap in Seconds	Number Accepted	Number Rejected	Total Number	Percent Accepted
0 - 0.9		1	1	
1 - 1.9		22	22	
2 - 2.9		35	35	
3 - 3.9		23	23	
4 - 4.9		26	26	0.0
5 - 5.9	2	19	21	9.5
6 - 6.9	5	4	9	55.5
7 - 7.9	8	6	14	57.2
8 - 8.9	13	10	23	56.5
9 - 9.9	9	1	10	90.0
10 - 10.9	12	3	15	80.0
11 - 11.9	11	1	12	91.5
12 - 12.9	15		15	100.0
13 - 13.9	9		9	
14 - 14.9	8		8	
Over 15	126		126	

Through Movements

Length of Gap in Seconds	Number Accepted	Number Rejected	Total Number	Percent Accepted
0 - 0.9		2	2	
1 - 1.9		19	19	0.0
2 - 2.9	1	14	15	6.7
3 - 3.9	2	18	20	10.0
4 - 4.9	0	11	11	0.0
5 - 5.9	0	8	8	0.0
6 - 6.9	6	5	11	54.5
7 - 7.9	6	3	9	66.5
8 - 8.9	8	4	12	66.5
9 - 9.9	1	3	4	25.0
10 - 10.9	9	1	10	90.0
11 - 11.9	3	1	4	75.0
12 - 12.9	6	1	7	86.0
13 - 13.9	7		7	100.0
14 - 14.9	4		4	
Over 15	59		59	

Table 20
Accepted and Rejected Gaps at Intersection C

All Movements				
Length of Gap in Seconds	Number Accepted	Number Rejected	Total Number	Percent Accepted
0 - 0.9		21	21	
1 - 1.9		112	112	
2 - 2.9		106	106	0.0
3 - 3.9	1	82	83	1.2
4 - 4.9	3	62	65	4.6
5 - 5.9	15	38	53	26.5
6 - 6.9	10	25	35	28.5
7 - 7.9	23	19	42	54.8
8 - 8.9	21	12	33	63.5
9 - 9.9	35	5	40	87.5
10 - 10.9	27	3	30	90.0
11 - 11.9	24	1	25	96.0
12 - 12.9	33	1	34	97.0
13 - 13.9	19		19	100.0
14 - 14.9	19		19	
Over 15	207		207	

Right Turns				
Length of Gap in Seconds	Number Accepted	Number Rejected	Total Number	Percent Accepted
0 - 0.9				
1 - 1.9		17	17	
2 - 2.9		11	11	
3 - 3.9		9	9	
4 - 4.9		6	6	0.0
5 - 5.9	1	6	7	14.3
6 - 6.9	4	5	9	44.5
7 - 7.9	2	2	4	50.0
8 - 8.9	2	1	3	66.7
9 - 9.9	2	1	3	66.7
10 - 10.9	6	1	7	85.9
11 - 11.9	3		3	100.0
12 - 12.9	5		5	
13 - 13.9	3		3	
14 - 14.9	1		1	
Over 15	57		57	

Table 20, cont.

Left Turns

Length of Gap in Seconds	Number Accepted	Number Rejected	Total Number	Percent Accepted
0 - 0.9		4	4	
1 - 1.9		23	23	
2 - 2.9		14	14	
3 - 3.9		17	17	
4 - 4.9		13	13	0.0
5 - 5.9	2	10	12	16.7
6 - 6.9	1	4	5	20.0
7 - 7.9	6	5	11	54.5
8 - 8.9	2	1	3	66.7
9 - 9.9	5	3	8	62.5
10 - 10.9	2	2	4	50.0
11 - 11.9	5		5	100.0
12 - 12.9	7		7	
13 - 13.9	4		4	
14 - 14.9	3		3	
Over 15	43		43	

Through Movements

Length of Gap in Seconds	Number Accepted	Number Rejected	Total Number	Percent Accepted
0 - 0.9		17	17	
1 - 1.9		72	72	
2 - 2.9		81	81	0.0
3 - 3.9	1	56	57	1.8
4 - 4.9	3	43	46	6.5
5 - 5.9	12	22	34	35.3
6 - 6.9	5	16	21	23.8
7 - 7.9	15	12	27	55.5
8 - 8.9	17	10	27	63.0
9 - 9.9	28	1	29	96.5
10 - 10.9	19	0	19	100.0
11 - 11.9	16	1	17	94.0
12 - 12.9	21		21	100.0
13 - 13.9	12		12	
14 - 14.9	15		15	
Over 15	107		107	

Table 21
Accepted and Rejected Gaps at Intersection D

All Movements				
Length of Gap in Seconds	Number Accepted	Number Rejected	Total Number	Percent Accepted
0 - 0.9		6	6	
1 - 1.9		107	107	
2 - 2.9		173	173	0.0
3 - 3.9	1	96	97	1.0
4 - 4.9	3	83	86	3.5
5 - 5.9	11	40	51	21.6
6 - 6.9	14	33	47	29.8
7 - 7.9	15	16	31	48.4
8 - 8.9	13	14	27	48.2
9 - 9.9	8	5	13	61.6
10 - 10.9	16	2	18	89.0
11 - 11.9	16		16	100.0
12 - 12.9	23		23	
13 - 13.9	21		21	
14 - 14.9	20		20	
Over 15	194		194	

Right Turns				
Length of Gap in Seconds	Number Accepted	Number Rejected	Total Number	Percent Accepted
0 - 0.9		1	1	
1 - 1.9		32	32	
2 - 2.9		53	53	
3 - 3.9		30	30	0.0
4 - 4.9	1	23	24	4.2
5 - 5.9	4	13	17	23.5
6 - 6.9	8	8	16	50.0
7 - 7.9	3	5	8	37.5
8 - 8.9	4	4	8	50.0
9 - 9.9	0	2	2	0.0
10 - 10.9	6		6	100.0
11 - 11.9	4		4	
12 - 12.9	13		13	
13 - 13.9	4		4	
14 - 14.9	8		8	
Over 15	109		109	

Table 21, cont.

Left Turns

Length of Gap in Seconds	Number Accepted	Number Rejected	Total Number	Percent Accepted
0 - 0.9		4	4	
1 - 1.9		39	39	
2 - 2.9		76	76	
3 - 3.9		32	32	0.0
4 - 4.9	1	30	31	3.2
5 - 5.9	1	10	11	9.1
6 - 6.9	2	10	12	16.7
7 - 7.9	4	7	11	36.3
8 - 8.9	4	6	10	40.0
9 - 9.9	4	2	6	66.7
10 - 10.9	5	1	6	83.4
11 - 11.9	7		7	100.0
12 - 12.9	7		7	
13 - 13.9	10		10	
14 - 14.9	6		6	
Over 15	40		40	

Through Movements

Length of Gap in Seconds	Number Accepted	Number Rejected	Total Number	Percent Accepted
0 - 0.9		1	1	
1 - 1.9		36	36	
2 - 2.9		44	44	0.0
3 - 3.9	1	34	35	2.9
4 - 4.9	1	30	31	3.2
5 - 5.9	6	17	23	26.1
6 - 6.9	4	15	19	21.1
7 - 7.9	8	4	12	66.7
8 - 8.9	5	4	9	55.6
9 - 9.9	4	1	5	80.0
10 - 10.9	5	1	6	83.4
11 - 11.9	5		5	100.0
12 - 12.9	3		3	
13 - 13.9	7		7	
14 - 14.9	6		6	
Over 15	45		45	

APPENDIX B
PROBIT ANALYSIS TABLES

Reprinted from Tables I, II and IV of D. J. Finney's
"Probit Analysis, A Statistical Treatment of the
Sigmoid Response Curve" published by the Cambridge
University Press, Cambridge, England 1947, by kind
permission of the publishers.

TABLE 22. Transformation of Percentages to Probits

%	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	2	3	4	5
0	—	1.9098	2.1218	2.2522	2.3479	2.4242	2.4879	2.5427	2.5911	2.6344	For more detail see values for 95-100				
1	2.6737	2.7096	2.7429	2.7738	2.8027	2.8299	2.8556	2.8799	2.9031	2.9251					
2	2.9463	2.9665	2.9859	3.0046	3.0226	3.0400	3.0569	3.0732	3.0890	3.1043					
3	3.1192	3.1337	3.1478	3.1616	3.1750	3.1881	3.2009	3.2134	3.2256	3.2376					
4	3.2493	3.2608	3.2721	3.2831	3.2940	3.3046	3.3151	3.3253	3.3354	3.3454	For more detail see values for 95-100				
5	3.3551	3.3648	3.3742	3.3836	3.3928	3.4018	3.4107	3.4195	3.4282	3.4368					
6	3.4452	3.4536	3.4618	3.4699	3.4780	3.4859	3.4937	3.5015	3.5091	3.5167					
7	3.5242	3.5316	3.5389	3.5462	3.5534	3.5605	3.5675	3.5745	3.5813	3.5882					
8	3.5949	3.6016	3.6083	3.6148	3.6213	3.6278	3.6342	3.6405	3.6468	3.6531	For more detail see values for 95-100				
9	3.6592	3.6654	3.6715	3.6775	3.6835	3.6894	3.6953	3.7012	3.7070	3.7127					
10	3.7184	3.7241	3.7298	3.7354	3.7409	3.7464	3.7519	3.7574	3.7628	3.7681					
11	3.7735	3.7788	3.7840	3.7893	3.7945	3.7996	3.8048	3.8099	3.8150	3.8200	For more detail see values for 95-100				
12	3.8250	3.8300	3.8350	3.8399	3.8448	3.8497	3.8545	3.8593	3.8641	3.8689					
13	3.8736	3.8783	3.8830	3.8877	3.8923	3.8969	3.9015	3.9061	3.9107	3.9152					
14	3.9197	3.9242	3.9286	3.9331	3.9375	3.9419	3.9463	3.9506	3.9550	3.9593					
15	3.9636	3.9678	3.9721	3.9763	3.9806	3.9848	3.9890	3.9931	3.9973	4.0014	For more detail see values for 95-100				
16	4.0055	4.0096	4.0137	4.0178	4.0218	4.0259	4.0299	4.0339	4.0379	4.0419					
17	4.0458	4.0498	4.0537	4.0576	4.0615	4.0654	4.0693	4.0731	4.0770	4.0808					
18	4.0846	4.0884	4.0922	4.0960	4.0998	4.1035	4.1073	4.1110	4.1147	4.1184					
19	4.1221	4.1258	4.1295	4.1331	4.1367	4.1404	4.1440	4.1476	4.1512	4.1548	For more detail see values for 95-100				
20	4.1584	4.1619	4.1655	4.1690	4.1726	4.1761	4.1796	4.1831	4.1866	4.1901					
21	4.1936	4.1970	4.2005	4.2039	4.2074	4.2108	4.2142	4.2176	4.2210	4.2244					
22	4.2278	4.2312	4.2345	4.2379	4.2412	4.2446	4.2479	4.2512	4.2546	4.2579					
23	4.2612	4.2644	4.2677	4.2710	4.2743	4.2775	4.2808	4.2840	4.2872	4.2905	For more detail see values for 95-100				
24	4.2937	4.2969	4.3001	4.3033	4.3065	4.3097	4.3129	4.3160	4.3192	4.3224					
25	4.3255	4.3287	4.3318	4.3349	4.3380	4.3412	4.3443	4.3474	4.3505	4.3536					
26	4.3567	4.3597	4.3628	4.3659	4.3689	4.3720	4.3750	4.3781	4.3811	4.3842	For more detail see values for 95-100				
27	4.3872	4.3902	4.3932	4.3962	4.3992	4.4022	4.4052	4.4082	4.4112	4.4142					
28	4.4172	4.4201	4.4231	4.4260	4.4290	4.4319	4.4349	4.4378	4.4408	4.4437					
29	4.4466	4.4495	4.4524	4.4554	4.4583	4.4612	4.4641	4.4670	4.4698	4.4727					

TABLE 22. (cont.)

%	0-0	0-1	0-2	0-3	0-4	0-5	0-6	0-7	0-8	0-9	1	2	3	4	5
30	4-4756	4-4785	4-4813	4-4842	4-4871	4-4899	4-4928	4-4956	4-4985	4-5013	3	6	9	11	14
31	4-5041	4-5070	4-5098	4-5126	4-5155	4-5183	4-5211	4-5239	4-5267	4-5295	3	6	8	11	14
32	4-5323	4-5351	4-5379	4-5407	4-5435	4-5462	4-5490	4-5518	4-5546	4-5573	3	6	8	11	14
33	4-5601	4-5628	4-5656	4-5684	4-5711	4-5739	4-5766	4-5793	4-5821	4-5848	3	5	8	11	14
34	4-5875	4-5903	4-5930	4-5958	4-5984	4-6011	4-6039	4-6066	4-6093	4-6120	3	5	8	11	14
35	4-6147	4-6174	4-6201	4-6228	4-6255	4-6281	4-6308	4-6335	4-6362	4-6389	3	5	8	11	13
36	4-6415	4-6442	4-6469	4-6495	4-6522	4-6549	4-6575	4-6602	4-6628	4-6655	3	5	8	11	13
37	4-6681	4-6708	4-6734	4-6761	4-6787	4-6814	4-6840	4-6866	4-6893	4-6919	3	5	8	11	13
38	4-6945	4-6971	4-6998	4-7024	4-7050	4-7076	4-7102	4-7129	4-7155	4-7181	3	5	8	10	13
39	4-7207	4-7233	4-7259	4-7285	4-7311	4-7337	4-7363	4-7389	4-7415	4-7441	3	5	8	10	13
40	4-7467	4-7492	4-7518	4-7544	4-7570	4-7596	4-7622	4-7647	4-7673	4-7699	3	5	8	10	13
41	4-7725	4-7750	4-7776	4-7802	4-7827	4-7853	4-7879	4-7904	4-7930	4-7955	3	5	8	10	13
42	4-7981	4-8007	4-8032	4-8058	4-8083	4-8109	4-8134	4-8160	4-8185	4-8211	3	5	8	10	13
43	4-8236	4-8262	4-8287	4-8313	4-8338	4-8363	4-8389	4-8414	4-8440	4-8465	3	5	8	10	13
44	4-8490	4-8516	4-8541	4-8566	4-8592	4-8617	4-8642	4-8668	4-8693	4-8718	3	5	8	10	13
45	4-8743	4-8769	4-8794	4-8819	4-8844	4-8870	4-8895	4-8920	4-8945	4-8970	3	5	8	10	13
46	4-8996	4-9021	4-9046	4-9071	4-9096	4-9122	4-9147	4-9172	4-9197	4-9222	3	5	8	10	13
47	4-9247	4-9272	4-9298	4-9323	4-9348	4-9373	4-9398	4-9423	4-9448	4-9473	3	5	8	10	13
48	4-9498	4-9524	4-9549	4-9574	4-9599	4-9624	4-9649	4-9674	4-9699	4-9724	3	5	8	10	13
49	4-9749	4-9774	4-9799	4-9825	4-9850	4-9875	4-9900	4-9925	4-9950	4-9975	3	5	8	10	13
50	5-0000	5-0025	5-0050	5-0075	5-0100	5-0125	5-0150	5-0175	5-0201	5-0226	3	5	8	10	13
51	5-0251	5-0276	5-0301	5-0326	5-0351	5-0376	5-0401	5-0426	5-0451	5-0476	3	5	8	10	13
52	5-0502	5-0527	5-0552	5-0577	5-0602	5-0627	5-0652	5-0677	5-0702	5-0728	3	5	8	10	13
53	5-0753	5-0778	5-0803	5-0828	5-0853	5-0878	5-0904	5-0929	5-0954	5-0979	3	5	8	10	13
54	5-1004	5-1030	5-1055	5-1080	5-1105	5-1130	5-1156	5-1181	5-1206	5-1231	3	5	8	10	13
55	5-1257	5-1282	5-1307	5-1332	5-1358	5-1383	5-1408	5-1434	5-1459	5-1484	3	5	8	10	13
56	5-1510	5-1535	5-1560	5-1586	5-1611	5-1637	5-1662	5-1687	5-1713	5-1738	3	5	8	10	13
57	5-1764	5-1789	5-1815	5-1840	5-1866	5-1891	5-1917	5-1942	5-1968	5-1993	3	5	8	10	13
58	5-2019	5-2045	5-2070	5-2096	5-2121	5-2147	5-2173	5-2198	5-2224	5-2250	3	5	8	10	13
59	5-2275	5-2301	5-2327	5-2353	5-2378	5-2404	5-2430	5-2456	5-2482	5-2508	3	5	8	10	13

TABLE 22. (cont.)

%	0-0	0-1	0-2	0-3	0-4	0-5	0-6	0-7	0-8	0-9	1	2	3	4	5
60	5-2533	5-2559	5-2585	5-2611	5-2637	5-2663	5-2689	5-2715	5-2741	5-2767	3	5	8	10	13
61	5-2793	5-2819	5-2845	5-2871	5-2898	5-2924	5-2950	5-2976	5-3002	5-3029	3	5	8	10	13
62	5-3055	5-3081	5-3107	5-3134	5-3160	5-3186	5-3213	5-3239	5-3266	5-3292	3	5	8	11	13
63	5-3319	5-3345	5-3372	5-3398	5-3425	5-3451	5-3478	5-3505	5-3531	5-3558	3	5	8	11	13
64	5-3585	5-3611	5-3638	5-3665	5-3692	5-3719	5-3745	5-3772	5-3799	5-3826	3	5	8	11	13
65	5-3853	5-3880	5-3907	5-3934	5-3961	5-3989	5-4016	5-4043	5-4070	5-4097	3	5	8	11	14
66	5-4125	5-4152	5-4179	5-4207	5-4234	5-4261	5-4289	5-4316	5-4344	5-4372	3	5	8	11	14
67	5-4399	5-4427	5-4454	5-4482	5-4510	5-4538	5-4565	5-4593	5-4621	5-4649	3	6	8	11	14
68	5-4677	5-4705	5-4733	5-4761	5-4789	5-4817	5-4845	5-4874	5-4902	5-4930	3	6	8	11	14
69	5-4959	5-4987	5-5015	5-5044	5-5072	5-5101	5-5129	5-5158	5-5187	5-5215	3	6	9	11	14
70	5-5244	5-5273	5-5302	5-5330	5-5359	5-5388	5-5417	5-5446	5-5476	5-5505	3	6	9	12	14
71	5-5534	5-5563	5-5592	5-5622	5-5651	5-5681	5-5710	5-5740	5-5769	5-5799	3	6	9	12	15
72	5-5828	5-5858	5-5888	5-5918	5-5948	5-5978	5-6008	5-6038	5-6068	5-6098	3	6	9	12	15
73	5-6128	5-6158	5-6189	5-6219	5-6250	5-6280	5-6311	5-6341	5-6372	5-6403	3	6	9	12	15
74	5-6433	5-6464	5-6495	5-6526	5-6557	5-6588	5-6620	5-6651	5-6682	5-6713	3	6	9	12	16
75	5-6745	5-6776	5-6808	5-6840	5-6871	5-6903	5-6935	5-6967	5-6999	5-7031	3	6	10	13	16
76	5-7063	5-7095	5-7128	5-7160	5-7192	5-7225	5-7257	5-7290	5-7323	5-7356	3	7	10	13	16
77	5-7388	5-7421	5-7454	5-7488	5-7521	5-7554	5-7588	5-7621	5-7655	5-7688	3	7	10	13	17
78	5-7722	5-7756	5-7790	5-7824	5-7858	5-7892	5-7926	5-7961	5-7995	5-8030	3	7	10	14	17
79	5-8064	5-8099	5-8134	5-8169	5-8204	5-8239	5-8274	5-8310	5-8345	5-8381	4	7	11	14	18
80	5-8416	5-8452	5-8488	5-8524	5-8560	5-8596	5-8633	5-8669	5-8705	5-8742	4	7	11	14	18
81	5-8779	5-8816	5-8853	5-8890	5-8927	5-8965	5-9002	5-9040	5-9078	5-9116	4	7	11	15	19
82	5-9154	5-9192	5-9230	5-9269	5-9307	5-9346	5-9385	5-9424	5-9463	5-9502	4	8	12	15	19
83	5-9542	5-9581	5-9621	5-9661	5-9701	5-9741	5-9782	5-9822	5-9863	5-9904	4	8	12	16	20
84	5-9945	5-9986	6-0027	6-0069	6-0110	6-0152	6-0194	6-0237	6-0279	6-0322	4	8	13	17	21
85	6-0364	6-0407	6-0450	6-0494	6-0537	6-0581	6-0625	6-0669	6-0714	6-0758	4	9	13	18	22
86	6-0803	6-0848	6-0893	6-0939	6-0985	6-1031	6-1077	6-1123	6-1170	6-1217	5	9	14	18	23
87	6-1264	6-1311	6-1359	6-1407	6-1455	6-1503	6-1552	6-1601	6-1650	6-1700	5	10	15	19	24
88	6-1750	6-1800	6-1850	6-1901	6-1952	6-2004	6-2055	6-2107	6-2160	6-2212	5	10	15	21	26
89	6-2265	6-2319	6-2372	6-2426	6-2481	6-2536	6-2591	6-2646	6-2702	6-2759	5	11	16	22	27

TABLE 22 (cont.)

%	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	2	3	4	5
90	6.2816	6.2873	6.2930	6.2988	6.3047	6.3106	6.3165	6.3225	6.3285	6.3346	6	12	18	24	29
91	6.3408	6.3469	6.3532	6.3595	6.3658	6.3722	6.3787	6.3852	6.3917	6.3984	6	13	19	26	32
92	6.4051	6.4118	6.4187	6.4255	6.4325	6.4395	6.4466	6.4538	6.4611	6.4684	7	14	21	28	35
93	6.4758	6.4833	6.4909	6.4985	6.5063	6.5141	6.5220	6.5301	6.5382	6.5464	8	16	24	31	39
94	6.5548	6.5632	6.5718	6.5805	6.5893	6.5982	6.6072	6.6164	6.6258	6.6352	9	18	27	36	45
95	6.6449	6.6546	6.6646	6.6747	6.6849	6.6954	6.7060	6.7169	6.7279	6.7392					
96	6.7507	6.7624	6.7744	6.7866	6.7991	6.8119	6.8250	6.8384	6.8522	6.8663					
117	120	122	125	128	131	134	138	141	145	149					
97	6.8808	6.8957	6.9110	6.9268	6.9431	6.9600	6.9774	6.9954	7.0141	7.0335					
149	153	158	163	169	174	180	187	194	202						
%	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	1	2	3	4	5
98.0	7.0537	7.0558	7.0579	7.0600	7.0621	7.0642	7.0663	7.0684	7.0706	7.0727	2	4	6	8	11
98.1	7.0749	7.0770	7.0792	7.0814	7.0836	7.0858	7.0880	7.0902	7.0924	7.0947	2	4	7	9	11
98.2	7.0969	7.0992	7.1015	7.1038	7.1061	7.1084	7.1107	7.1130	7.1154	7.1177	2	5	7	9	12
98.3	7.1201	7.1224	7.1248	7.1272	7.1297	7.1321	7.1345	7.1370	7.1394	7.1419	2	5	7	10	12
98.4	7.1444	7.1469	7.1494	7.1520	7.1545	7.1571	7.1596	7.1622	7.1648	7.1675	3	5	8	10	13
98.5	7.1701	7.1727	7.1754	7.1781	7.1808	7.1835	7.1862	7.1890	7.1917	7.1945	3	5	8	11	14
98.6	7.1973	7.2001	7.2029	7.2058	7.2086	7.2115	7.2144	7.2173	7.2203	7.2232	3	6	9	12	14
98.7	7.2262	7.2292	7.2322	7.2353	7.2383	7.2414	7.2445	7.2476	7.2508	7.2539	3	6	9	12	15
98.8	7.2571	7.2603	7.2636	7.2668	7.2701	7.2734	7.2768	7.2801	7.2835	7.2869	3	7	10	13	17
98.9	7.2904	7.2938	7.2973	7.3009	7.3044	7.3080	7.3116	7.3152	7.3189	7.3226	4	7	11	14	18
99.0	7.3263	7.3301	7.3339	7.3378	7.3416	7.3455	7.3495	7.3535	7.3575	7.3615	4	8	12	16	20
99.1	7.3656	7.3698	7.3739	7.3781	7.3824	7.3867	7.3911	7.3954	7.3999	7.4044	4	9	13	17	22
99.2	7.4089	7.4135	7.4181	7.4228	7.4276	7.4324	7.4372	7.4421	7.4471	7.4522	5	10	14	19	24
99.3	7.4573	7.4624	7.4677	7.4730	7.4783	7.4838	7.4893	7.4949	7.5006	7.5063	5	11	16	22	27
99.4	7.5121	7.5181	7.5241	7.5302	7.5364	7.5427	7.5491	7.5556	7.5622	7.5690	6	13	19	25	32
99.5	7.5758	7.5828	7.5899	7.5972	7.6045	7.6121	7.6197	7.6276	7.6356	7.6437					
99.6	7.6521	7.6606	7.6693	7.6783	7.6874	7.6968	7.7065	7.7164	7.7266	7.7370					
99.7	7.7478	7.7589	7.7703	7.7822	7.7944	7.8070	7.8202	7.8338	7.8480	7.8627					
99.8	7.8782	7.8943	7.9112	7.9290	7.9478	7.9677	7.9889	8.0115	8.0357	8.0618					
99.9	8.0902	8.1214	8.1559	8.1947	8.2389	8.2905	8.3528	8.4316	8.5401	8.7190					

I am indebted to Professor R. A. Fisher and Dr F. Yates, and also to Messrs Oliver and Boyd, Ltd. of Edinburgh, for permission to reprint Table I from Table IX of their book *Statistical Tables for Biological, Agricultural and Medical Research*.

TABLE 23. The Weighting Coefficient and Q/Z
Percentage natural mortality, C

Y	Q/Z	0	1	2	3	4	5	6	7	8	9	10
1-1	5034	-00082	—	—	—	—	—	—	—	—	—	—
1-2	3425	-00118	-00001	—	—	—	—	—	—	—	—	—
1-3	2354	-00167	-00002	-00001	-00001	-00001	-00001	-00001	-00001	-00001	-00001	-00001
1-4	1634	-00235	-00004	-00002	-00001	-00001	-00001	-00001	-00001	-00001	-00001	-00001
1-5	1146	-00327	-00007	-00004	-00002	-00002	-00001	-00001	-00001	-00001	-00001	-00001
1-6	811.2	-00451	-00015	-00007	-00005	-00004	-00003	-00002	-00002	-00002	-00002	-00001
1-7	580.2	-00614	-00028	-00014	-00009	-00007	-00006	-00005	-00004	-00003	-00003	-00003
1-8	419.1	-00828	-00053	-00027	-00018	-00013	-00011	-00009	-00007	-00006	-00006	-00005
1-9	305.8	-01105	-00097	-00050	-00034	-00025	-00020	-00017	-00014	-00012	-00011	-00010
2-0	225.3	-01457	-00172	-00090	-00061	-00046	-00036	-00030	-00026	-00022	-00020	-00017
2-1	167.69	-01903	-00297	-00159	-00108	-00082	-00065	-00054	-00046	-00040	-00035	-00031
2-2	126.02	-02458	-00496	-00274	-00188	-00142	-00114	-00095	-00081	-00070	-00062	-00055
2-3	95.63	-03143	-00803	-00456	-00317	-00241	-00194	-00162	-00138	-00121	-00106	-00095
2-4	73.28	-03977	-01256	-00739	-00521	-00400	-00324	-00271	-00232	-00202	-00179	-00160
2-5	56.70	-04979	-01895	-01161	-00832	-00646	-00525	-00441	-00379	-00332	-00294	-00264
2-6	44.288	-06168	-02763	-01768	-01292	-01014	-00831	-00702	-00606	-00531	-00472	-00424
2-7	34.923	-07563	-03895	-02605	-01947	-01548	-01280	-01088	-00943	-00830	-00740	-00666
2-8	27.797	-09179	-05316	-03719	-02847	-02297	-01918	-01642	-01431	-01265	-01131	-01021
2-9	22.330	-11026	-07044	-05147	-04037	-03309	-02794	-02411	-02115	-01879	-01687	-01527
3-0	18.101	-13112	-09080	-06912	-05557	-04631	-03957	-03445	-03043	-02719	-02452	-02228
3-1	14.802	-15436	-11419	-09023	-07432	-06298	-05449	-04790	-04263	-03832	-03473	-03170
3-2	12.211	-17994	-14046	-11476	-09670	-08332	-07300	-06481	-05814	-05261	-04795	-04397
3-3	10.159	-20773	-16935	-14249	-12263	-10736	-09525	-08541	-07726	-07039	-06453	-05947
3-4	8.521	-23753	-20056	-17308	-15184	-13494	-12116	-10973	-10008	-09182	-08469	-07846
3-5	7.205	-26907	-23373	-20611	-18392	-16571	-15050	-13760	-12652	-11690	-10848	-10103

TABLE 23. (cont.)
percentage natural mortality, C

Y	Q/Z	0	1	2	3	4	5	6	7	8	9	10
3.6	6.1394	.30199	.26842	.24107	.21836	.19921	.18283	.16897	.15631	.14541	.13575	.12711
3.7	5.2705	.33589	.30415	.27741	.25456	.23482	.21759	.20242	.18896	.17694	.16614	.15639
3.8	4.5571	.37031	.34043	.31453	.29186	.27187	.25409	.23819	.22387	.21092	.19915	.18840
3.9	3.9676	.40474	.37669	.35181	.32960	.30964	.29161	.27524	.26031	.24685	.23409	.22230
4.0	3.4770	.43863	.41237	.38864	.36707	.34739	.32937	.31279	.29749	.28334	.27020	.25797
4.1	3.0665	.47144	.44691	.42438	.40362	.38441	.36661	.35005	.33460	.32017	.30666	.29397
4.2	2.7206	.50260	.47973	.45844	.43858	.42000	.40259	.38623	.37085	.35634	.34264	.32969
4.3	2.4276	.53159	.51029	.49024	.47134	.45350	.43662	.42063	.40546	.39105	.37735	.36430
4.4	2.1780	.55786	.53806	.51924	.50134	.48430	.46805	.45255	.43774	.42357	.41002	.39702
4.5	1.9640	.58099	.56257	.54495	.52806	.51187	.49633	.48140	.46705	.45325	.43996	.42716
4.6	1.7797	.60052	.58341	.56694	.55106	.53574	.52095	.50666	.49286	.47951	.46659	.45409
4.7	1.6202	.61609	.60022	.58485	.56996	.55551	.54150	.52790	.51470	.50187	.48941	.47729
4.8	1.4814	.62742	.61271	.59840	.58446	.57089	.55766	.54478	.53221	.51996	.50801	.49635
4.9	1.3599	.63431	.62069	.60737	.59436	.58164	.56921	.55704	.54514	.53350	.52210	.51094
5.0	1.2533	.63662	.62401	.61165	.59953	.58765	.57599	.56455	.55332	.54230	.53149	.52087
5.1	1.1593	.63431	.62266	.61120	.59994	.58886	.57796	.56724	.55689	.54631	.53609	.52604
5.2	1.0759	.62742	.61667	.60607	.59562	.58532	.57516	.56515	.55527	.54553	.53592	.52644
5.3	1.0018	.61609	.60618	.59639	.58672	.57717	.56773	.55841	.54919	.54008	.53108	.52219
5.4	0.9357	.60052	.59140	.58238	.57346	.56462	.55588	.54722	.53866	.53018	.52178	.51347
5.5	0.8764	.58099	.57263	.56434	.55612	.54797	.53990	.53189	.52396	.51609	.50829	.50056
5.6	0.8230	.55788	.55022	.54262	.53507	.52759	.52015	.51278	.50545	.49818	.49097	.48380
5.7	0.7749	.53159	.52460	.51765	.51075	.50389	.49708	.49030	.48357	.47688	.47024	.46363
5.8	0.7313	.50260	.49624	.48992	.48363	.47737	.47114	.46495	.45879	.45266	.44657	.44050
5.9	0.6917	.47144	.46567	.45993	.45422	.44853	.44287	.43723	.43162	.42603	.42047	.41493
6.0	0.6557	.43863	.43343	.42824	.42308	.41793	.41281	.40770	.40261	.39754	.39249	.38746
6.1	0.6227	.40474	.40006	.39540	.39075	.38612	.38150	.37690	.37231	.36774	.36318	.35863
6.2	0.5926	.37031	.36613	.36196	.35781	.35366	.34952	.34540	.34128	.33718	.33308	.32900
6.3	0.5649	.33589	.33218	.32847	.32477	.32108	.31740	.31372	.31006	.30640	.30274	.29910
6.4	0.5394	.30199	.29871	.29543	.29216	.28890	.28564	.28238	.27913	.27589	.27266	.26942
6.5	0.5158	.26907	.26619	.26331	.26044	.25757	.25470	.25184	.24899	.24613	.24329	.24044

TABLE 23. (cont.)

Y	Q/Z	Percentage natural mortality, C										
		0	1	2	3	4	5	6	7	8	9	10
6-6	0-4940	-23753	-23502	-23251	-23001	-22751	-22501	-22251	-22001	-21752	-21503	-21255
6-7	0-4739	-20773	-20556	-20339	-20122	-19905	-19689	-19473	-19256	-19041	-18825	-18609
6-8	0-4551	-17994	-17808	-17621	-17435	-17249	-17063	-16877	-16691	-16506	-16320	-16135
6-9	0-4376	-15436	-15277	-15118	-14960	-14801	-14643	-14484	-14326	-14168	-14010	-13852
7-0	0-4214	-13112	-12977	-12843	-12709	-12575	-12442	-12308	-12174	-12040	-11907	-11773
7-1	0-4062	-11026	-10914	-10802	-10689	-10577	-10465	-10353	-10241	-10129	-10017	-98905
7-2	0-3919	-09179	-09086	-08993	-08900	-08807	-08714	-08621	-08528	-08435	-08342	-08249
7-3	0-3786	-07564	-07487	-07411	-07334	-07258	-07181	-07105	-07029	-06952	-06876	-06800
7-4	0-3661	-06168	-06106	-06044	-05982	-05920	-05858	-05795	-05733	-05671	-05609	-05547
7-5	0-3543	-04979	-04929	-04879	-04828	-04778	-04728	-04678	-04628	-04578	-04528	-04478
7-6	0-3432	-03977	-03937	-03897	-03857	-03817	-03777	-03737	-03697	-03657	-03617	-03577
7-7	0-3327	-03143	-03112	-03080	-03048	-03017	-02985	-02954	-02922	-02891	-02859	-02828
7-8	0-3228	-02458	-02434	-02409	-02385	-02360	-02335	-02311	-02286	-02261	-02237	-02212
7-9	0-3134	-01993	-01883	-01864	-01845	-01826	-01807	-01788	-01769	-01750	-01731	-01712
8-0	0-3046	-01457	-01442	-01428	-01413	-01399	-01384	-01369	-01355	-01340	-01326	-01311
8-1	0-2962	-01104	-01093	-01082	-01071	-01060	-01049	-01038	-01027	-01016	-01005	-00993
8-2	0-2882	-00828	-00819	-00811	-00803	-00795	-00786	-00778	-00770	-00762	-00753	-00745
8-3	0-2806	-00614	-00608	-00602	-00596	-00590	-00583	-00577	-00571	-00565	-00559	-00553
8-4	0-2734	-00451	-00446	-00442	-00437	-00433	-00428	-00424	-00419	-00415	-00410	-00406
8-5	0-2666	-00327	-00324	-00321	-00318	-00314	-00311	-00308	-00305	-00301	-00298	-00295
8-6	0-2600	-00235	-00233	-00231	-00228	-00226	-00224	-00221	-00219	-00217	-00214	-00212
8-7	0-2538	-00167	-00166	-00164	-00162	-00161	-00159	-00157	-00156	-00154	-00152	-00150
8-8	0-2478	-00117	-00116	-00114	-00114	-00113	-00112	-00111	-00110	-00108	-00107	-00106
8-9	0-2421	-00082	-00081	-00080	-00080	-00079	-00078	-00077	-00076	-00076	-00075	-00074
9-0	0-2367	-00056	-00056	-00055	-00055	-00054	-00054	-00053	-00053	-00052	-00051	-00051

TABLE 24(cont.)

(1° = 3.0-3.9; 0-50% kill)

% kill	Provisional probit, F									
	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9
0	2.579	2.662	2.745	2.826	2.906	2.984	3.061	3.135	3.207	3.277
1	2.764	2.815	2.872	2.932	2.996	3.061	3.127	3.193	3.259	3.323
2	.949	.967	.998	3.039	3.086	.139	.191	.252	.310	.369
3	3.134	3.120	3.125	.145	.176	.216	.261	.310	.362	.415
4	.319	.272	.252	.251	.267	.293	.328	.369	.413	.461
5	.505	.421	.378	.358	.357	.370	.395	.427	.465	.507
6	3.690	3.577	3.505	3.464	3.447	3.417	3.461	3.485	3.516	3.553
7	.875	.729	.632	.570	.537	.525	.528	.514	.568	.599
8	4.060	.882	.758	.677	.627	.602	.595	.602	.619	.645
9	.246	4.034	.885	.783	.717	.679	.662	.660	.671	.690
10	.431	.186	4.012	.889	.808	.756	.728	.719	.722	.736
11	4.616	4.339	4.138	3.996	3.898	3.834	3.795	3.777	3.774	3.782
12	.801	.491	.265	1.102	.988	.911	.862	.835	.825	.828
13	.986	.644	.391	.208	4.078	.988	.929	.894	.877	.874
14	5.172	.796	.518	.315	.168	4.065	.996	.952	.928	.920
15	.357	.948	.645	.421	.258	.112	4.062	4.010	.980	.966
16	5.542	5.101	4.771	4.527	4.348	4.220	4.129	4.069	4.031	4.012
17	.727	.253	.898	.631	.439	.297	.196	.127	.083	.058
18	.913	.406	5.025	.740	.529	.374	.263	.185	.131	.101
19	6.098	.558	.151	.846	.619	.451	.330	.241	.186	.149
20	.283	.710	.278	.953	.709	.528	.396	.302	.237	.195
21	6.468	5.863	5.405	5.059	4.799	4.606	4.463	4.361	4.289	4.241
22	.653	6.015	.531	.165	.889	.683	.530	.419	.310	.287
23	.839	.168	.658	.272	.979	.760	.597	.477	.392	.333
24	7.024	.320	.785	.378	5.070	.837	.664	.536	.413	.379
25	.209	.472	.911	.181	160	.914	.730	.594	.495	.425
26	7.394	6.625	6.038	5.591	5.250	4.992	4.797	4.652	4.546	4.471
27	.580	.777	.165	.697	.340	5.069	.864	.711	.598	.517
28	.765	.930	.291	.803	.430	.146	.931	.769	.619	.563
29	.950	7.082	.418	.910	.520	.223	.997	.827	.701	.608
30	8.135	.234	.545	6.016	.610	.300	5.064	.886	.752	.654
31	8.320	7.387	6.671	6.122	5.701	5.378	5.131	4.944	4.801	4.700
32	.506	.539	.798	.229	.791	.455	.198	5.002	.855	.746
33	.691	.692	.925	.335	.881	.532	.265	.061	.907	.792
34	.876	.844	7.051	.141	.971	.609	.331	.119	.958	.838
35	9.061	.996	.178	.548	6.061	.687	.398	.177	5.010	.884
36	9.247	8.149	7.305	6.654	6.151	5.764	5.465	5.236	5.061	4.930
37	.432	.301	.431	.760	.242	.841	.532	.294	.113	.976
38	.617	.454	.558	.867	.332	.918	.599	.353	.164	5.022
39	.802	.606	.685	.973	.422	.995	.665	.411	.216	.068
40	.987	.758	.811	7.079	.512	6.073	.732	.469	.267	.113
41	—	8.911	7.938	7.186	6.602	6.150	5.799	5.528	5.319	5.159
42	—	9.063	8.065	.292	.692	.227	.866	.586	.370	.205
43	—	.216	.191	.398	.782	.304	.932	.644	.422	.251
44	—	.368	.318	.505	.873	.381	.999	.703	.473	.297
45	—	.520	.445	.611	.963	.459	6.066	.761	.525	.313
46	—	9.673	8.571	7.717	7.053	6.536	6.133	5.819	5.576	5.389
47	—	.825	.698	.824	.143	.613	.200	.878	.628	.435
48	—	.978	.825	.930	.233	.690	.266	.936	.679	.481
49	—	—	.951	8.036	.323	.767	.333	.994	.731	.527
50	—	—	9.078	.143	.414	.845	.400	6.053	.782	.572

TABLE 24(cont.)

(Y = 4.0-4.9; 0-50% kill)

% kill	Provisional probit, Y									
	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9
0	3.344	3.408	3.469	3.525	3.577	3.624	3.664	3.698	3.724	3.741
1	3.386	3.446	3.503	3.557	3.607	3.652	3.691	3.724	3.750	3.766
2	.427	.487	.538	.589	.637	.680	.719	.751	.775	.791
3	.468	.521	.572	.621	.667	.709	.746	.777	.801	.816
4	.510	.559	.607	.653	.697	.737	.773	.803	.826	.841
5	.551	.596	.641	.685	.727	.766	.800	.829	.852	.867
6	3.592	3.634	3.676	3.717	3.757	3.794	3.827	3.856	3.878	3.892
7	.634	.671	.710	.749	.787	.822	.854	.882	.903	.917
8	.675	.709	.745	.781	.817	.851	.882	.908	.929	.942
9	.716	.747	.779	.813	.847	.879	.909	.934	.954	.967
10	.758	.784	.814	.845	.877	.908	.936	.960	.980	.993
11	3.799	3.822	3.848	3.877	3.907	3.936	3.963	3.987	4.005	4.018
12	.840	.859	.883	.909	.937	.964	.990	4.013	.031	.043
13	.882	.897	.917	.941	.967	.993	4.017	.039	.057	.068
14	.923	.931	.952	.973	.997	4.021	.044	.065	.082	.093
15	.964	.972	.986	4.005	4.027	.050	.072	.092	.108	.119
16	4.006	4.010	4.021	4.038	4.057	4.078	4.099	4.118	4.133	4.144
17	.047	.047	.056	.070	.087	.106	.126	.144	.159	.169
18	.088	.085	.090	.102	.117	.135	.153	.170	.184	.194
19	.130	.122	.125	.134	.147	.163	.180	.196	.210	.219
20	.171	.160	.159	.166	.177	.192	.207	.223	.236	.245
21	4.212	4.198	4.194	4.198	4.207	4.220	4.235	4.249	4.261	4.270
22	.253	.235	.228	.230	.237	.248	.262	.275	.287	.295
23	.295	.273	.263	.262	.267	.277	.289	.301	.312	.320
24	.336	.310	.297	.294	.297	.305	.316	.327	.338	.345
25	.377	.348	.332	.326	.327	.334	.343	.354	.363	.370
26	4.419	4.385	4.366	4.358	4.357	4.362	4.370	4.380	4.389	4.396
27	.460	.423	.401	.390	.387	.391	.397	.406	.415	.421
28	.501	.461	.435	.422	.417	.419	.425	.432	.440	.446
29	.543	.498	.470	.454	.447	.447	.452	.459	.466	.471
30	.584	.536	.504	.486	.477	.476	.479	.485	.491	.496
31	4.625	4.573	4.539	4.518	4.507	4.504	4.506	4.511	4.517	4.522
32	.607	.611	.573	.550	.537	.533	.533	.537	.542	.547
33	.708	.649	.608	.582	.567	.561	.560	.563	.568	.572
34	.749	.686	.642	.614	.597	.589	.588	.590	.594	.597
35	.791	.724	.677	.646	.627	.618	.615	.616	.619	.622
36	4.832	4.761	4.711	4.678	4.657	4.646	4.642	4.642	4.645	4.648
37	.873	.799	.746	.710	.687	.675	.669	.668	.670	.673
38	.915	.836	.780	.742	.717	.703	.696	.695	.696	.698
39	.956	.874	.815	.774	.747	.731	.723	.721	.721	.723
40	.997	.912	.849	.806	.777	.760	.750	.747	.747	.748
41	5.039	4.949	4.884	4.838	4.807	4.788	4.778	4.773	4.773	4.774
42	.080	.987	.918	.870	.837	.817	.805	.799	.798	.799
43	.121	5.024	.953	.902	.867	.845	.832	.826	.824	.824
44	.163	.062	.988	.934	.897	.873	.859	.852	.849	.849
45	.204	.899	5.022	.966	.927	.902	.886	.878	.875	.874
46	5.245	5.137	5.057	4.998	4.957	4.930	4.913	4.904	4.900	4.900
47	.287	.175	.091	5.030	.987	.959	.941	.931	.926	.925
48	.328	.212	.126	.062	5.017	.987	.968	.957	.952	.950
49	.369	.250	.160	.094	.047	5.015	.995	.983	.977	.975
50	.411	.287	.195	.126	.078	.044	5.022	5.009	5.003	5.000

TABLE 24 (cont.)

(Y = 5.0-5.9; 0-50% kill)

% kill	Provisional probit, Y									
	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9
0	3.747	3.740	3.719	3.680	3.620	3.536	3.422	3.272	3.079	2.834
1	3.772	3.765	3.744	3.706	3.647	3.564	3.452	3.304	3.114	2.871
2	.797	.790	.770	.732	.675	.593	.482	.336	.148	.909
3	.822	.816	.795	.758	.702	.621	.512	.368	.183	.946
4	.847	.841	.821	.785	.729	.650	.542	.400	.217	.984
5	.872	.866	.846	.811	.756	.678	.572	.433	.252	3.021
6	3.897	3.891	3.872	3.837	3.783	3.706	3.602	3.465	3.287	3.059
7	.922	.916	.898	.863	.810	.735	.632	.497	.321	.097
8	.947	.942	.923	.890	.838	.763	.662	.529	.356	.134
9	.972	.967	.949	.916	.865	.792	.692	.561	.390	.172
10	.997	.992	.974	.942	.892	.820	.722	.593	.425	.209
11	4.022	4.017	4.000	3.968	3.919	3.848	3.752	3.625	3.459	3.247
12	.047	.042	.025	.994	.946	.877	.782	.657	.494	.284
13	.073	.068	.051	4.021	.973	.905	.812	.689	.528	.322
14	.098	.093	.077	.047	4.000	.934	.842	.721	.563	.360
15	.123	.118	.102	.073	.028	.962	.872	.753	.597	.397
16	4.148	4.143	4.128	4.099	4.055	3.990	3.902	3.785	3.632	3.435
17	.173	.168	.153	.126	.082	4.019	.932	.817	.666	.472
18	.198	.194	.179	.152	.109	.047	.962	.849	.701	.510
19	.223	.219	.204	.178	.136	.076	.992	.884	.735	.548
20	.248	.244	.230	.204	.163	.104	4.022	.913	.770	.585
21	4.273	4.269	4.256	4.230	4.191	4.132	4.052	3.945	3.804	3.623
22	.298	.294	.281	.257	.218	.161	.082	.977	.839	.660
23	.323	.320	.307	.283	.245	.189	.112	4.009	.873	.698
24	.348	.345	.332	.309	.272	.218	.142	.041	.908	.735
25	.373	.370	.358	.335	.299	.246	.172	.073	.942	.773
26	4.398	4.395	4.383	4.362	4.326	4.275	4.202	4.105	3.977	3.811
27	.423	.420	.409	.388	.353	.303	.232	.137	4.011	.848
28	.449	.445	.435	.414	.381	.331	.262	.169	.046	.886
29	.474	.471	.460	.440	.408	.360	.292	.201	.080	.923
30	.499	.496	.486	.466	.435	.388	.322	.233	.115	.961
31	4.524	4.521	4.511	4.493	4.462	4.417	4.352	4.265	4.149	3.999
32	.519	.516	.507	.489	.459	.415	.382	.297	.184	4.036
33	.544	.541	.533	.515	.486	.443	.412	.329	.219	.074
34	.569	.567	.558	.541	.514	.482	.442	.361	.253	.111
35	.624	.622	.614	.598	.571	.530	.472	.393	.288	.149
36	4.649	4.647	4.639	4.624	4.598	4.559	4.502	4.425	4.322	4.186
37	.674	.672	.665	.650	.625	.587	.532	.457	.357	.224
38	.699	.697	.690	.676	.652	.615	.562	.489	.391	.262
39	.724	.723	.716	.702	.679	.644	.592	.521	.426	.299
40	.749	.748	.742	.729	.706	.672	.622	.553	.460	.337
41	4.774	4.773	4.767	4.755	4.734	4.701	4.652	4.585	4.495	4.371
42	.799	.798	.793	.781	.761	.729	.682	.617	.529	.412
43	.825	.823	.818	.807	.788	.757	.712	.649	.564	.450
44	.850	.849	.844	.833	.815	.786	.742	.682	.598	.487
45	.875	.874	.869	.860	.842	.814	.772	.714	.633	.525
46	4.900	4.899	4.895	4.886	4.869	4.843	4.802	4.746	4.667	4.562
47	.925	.924	.921	.912	.897	.871	.832	.778	.702	.600
48	.950	.949	.946	.938	.921	.899	.862	.810	.736	.637
49	.975	.975	.972	.965	.951	.928	.892	.842	.771	.675
50	5.000	5.000	.997	.991	.978	.956	.922	.874	.805	.713

TABLE 24(cont.)

(I' = 6.0-6.9; 0-50% kill)

%	Provisional probit, I'									
kill	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9
0	2.523	2.132	1.643	1.030	0.261	—	—	—	—	—
1	2.564	2.178	1.694	1.088	0.327	—	—	—	—	—
2	.606	.224	.746	.146	.394	—	—	—	—	—
3	.647	.270	.797	.205	.461	—	—	—	—	—
4	.688	.316	.849	.263	.528	—	—	—	—	—
5	.730	.362	.900	.321	.595	—	—	—	—	—
6	2.771	2.408	1.952	1.380	0.661	—	—	—	—	—
7	.812	.454	2.003	.438	.728	—	—	—	—	—
8	.854	.500	.055	.496	.795	—	—	—	—	—
9	.895	.546	.106	.555	.862	—	—	—	—	—
10	.936	.591	.158	.613	.928	0.067	—	—	—	—
11	2.978	2.637	2.209	1.671	0.995	0.144	—	—	—	—
12	3.019	.683	.261	.730	1.062	.221	—	—	—	—
13	.060	.729	.312	.788	.129	.299	—	—	—	—
14	.102	.775	.364	.846	.196	.376	—	—	—	—
15	.143	.821	.415	.905	.262	.453	—	—	—	—
16	3.184	2.867	2.467	1.963	1.329	0.530	—	—	—	—
17	.226	.913	.518	2.022	.396	.607	—	—	—	—
18	.267	.959	.570	.080	.463	.685	—	—	—	—
19	.308	3.005	.621	.138	.530	.762	—	—	—	—
20	.350	.050	.673	.197	.596	.839	—	—	—	—
21	3.391	3.096	2.724	2.255	1.663	0.916	—	—	—	—
22	.432	.142	.776	.313	.730	.993	0.062	—	—	—
23	.474	.188	.827	.372	.797	1.071	.152	—	—	—
24	.515	.234	.879	.430	.864	.148	.243	—	—	—
25	.556	.280	.930	.488	.930	.225	.333	—	—	—
26	3.598	3.326	2.982	2.547	1.997	1.302	0.423	—	—	—
27	.639	.372	3.033	.605	2.064	.379	.513	—	—	—
28	.680	.418	.085	.663	.131	.457	.603	—	—	—
29	.721	.464	.136	.722	.197	.534	.693	—	—	—
30	.763	.509	.188	.780	.264	.611	.784	—	—	—
31	3.804	3.555	3.239	2.838	2.331	1.688	0.874	—	—	—
32	.845	.601	.291	.897	.398	.766	.964	—	—	—
33	.887	.617	.312	.955	.465	.843	1.054	0.050	—	—
34	.928	.693	.394	3.014	.531	.920	.144	.156	—	—
35	.969	.739	.445	.072	.598	.997	.234	.262	—	—
36	4.011	3.785	3.497	3.130	2.665	2.074	1.324	0.369	—	—
37	.052	.831	.548	.189	.732	.152	.415	.475	—	—
38	.093	.877	.600	.247	.799	.229	.505	.581	—	—
39	.135	.923	.651	.305	.865	.306	.595	.688	—	—
40	.176	.969	.703	.364	.932	.383	.685	.794	—	—
41	4.217	4.014	3.754	3.422	2.999	2.460	1.775	0.900	—	—
42	.259	.060	.806	.480	3.066	.538	.865	1.007	—	—
43	.300	.106	.857	.539	.132	.615	.955	.113	0.035	—
44	.341	.152	.909	.597	.199	.692	2.046	.219	.162	—
45	.383	.198	.960	.655	.266	.769	.136	.326	.289	—
46	4.424	4.244	4.012	3.714	3.333	2.846	2.226	1.432	0.415	—
47	.465	.290	.063	.772	.400	.924	.316	.538	.542	—
48	.507	.336	.115	.830	.466	3.001	.406	.645	.669	—
49	.548	.382	.166	.889	.533	.078	.496	.751	.795	—
50	.589	.428	.218	.947	.600	.155	.586	.857	.922	—

TABLE 24 (cont.)

(T = 3.0-3.9; 51-100% kill)

%	Provisional probit, T									
kill	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9
51	—	—	9.205	8.249	7.501	6.922	6.467	6.111	5.834	5.618
52	—	—	.331	.355	.591	.999	.534	.170	.885	.664
53	—	—	.458	.462	.681	7.076	.600	.228	.937	.710
54	—	—	.585	.568	.774	.154	.667	.286	.988	.756
55	—	—	.711	.674	.864	.231	.734	.345	6.010	.802
56	—	—	9.838	8.781	7.954	7.308	6.801	6.403	6.091	5.848
57	—	—	.965	.887	8.045	.385	.868	.461	.143	.894
58	—	—	—	.993	.135	.462	.934	.520	.191	.940
59	—	—	—	9.100	.225	.540	7.001	.578	.246	.986
60	—	—	—	.206	.315	.617	.068	.636	.297	6.031
61	—	—	—	9.312	8.405	7.694	7.135	6.695	6.349	6.077
62	—	—	—	.419	.495	.771	.201	.753	.400	.123
63	—	—	—	.525	.585	.818	.268	.811	.452	.169
64	—	—	—	.631	.676	.926	.335	.870	.503	.215
65	—	—	—	.738	.766	8.003	.402	.928	.555	.261
66	—	—	—	9.844	8.856	8.080	7.469	6.986	6.606	6.307
67	—	—	—	.950	.946	.157	.535	7.015	.658	.353
68	—	—	—	—	9.036	.234	.602	.103	.709	.399
69	—	—	—	—	.126	.312	.669	.162	.761	.445
70	—	—	—	—	.216	.389	.736	.220	.812	.191
71	—	—	—	—	9.307	8.466	7.803	7.278	6.864	6.536
72	—	—	—	—	.397	.543	.869	.337	.915	.582
73	—	—	—	—	.487	.621	.936	.395	.967	.628
74	—	—	—	—	.577	.698	8.003	.453	7.018	.674
75	—	—	—	—	.667	.775	.070	.512	.070	.720
76	—	—	—	—	9.757	8.852	8.136	7.570	7.121	6.766
77	—	—	—	—	.848	.929	.203	.628	.173	.812
78	—	—	—	—	.938	9.007	.270	.687	.224	.858
79	—	—	—	—	—	.084	.337	.745	.276	.904
80	—	—	—	—	—	.161	.404	.803	.327	.950
81	—	—	—	—	—	9.238	8.470	7.862	7.379	6.995
82	—	—	—	—	—	.315	.537	.920	.430	7.041
83	—	—	—	—	—	.393	.604	.978	.482	.087
84	—	—	—	—	—	.470	.671	8.037	.533	.133
85	—	—	—	—	—	.547	.738	.095	.585	.179
86	—	—	—	—	—	9.624	8.804	8.154	7.636	7.225
87	—	—	—	—	—	.701	.871	.212	.688	.271
88	—	—	—	—	—	.779	.938	.270	.739	.317
89	—	—	—	—	—	.856	9.005	.329	.791	.363
90	—	—	—	—	—	.933	.072	.387	.842	.409
91	—	—	—	—	—	—	9.138	8.445	7.894	7.454
92	—	—	—	—	—	—	.265	.504	.945	.500
93	—	—	—	—	—	—	.272	.562	.997	.546
94	—	—	—	—	—	—	.339	.620	8.048	.592
95	—	—	—	—	—	—	.405	.679	.100	.638
96	—	—	—	—	—	—	9.472	8.737	8.151	7.684
97	—	—	—	—	—	—	.539	.795	.203	.730
98	—	—	—	—	—	—	.606	.854	.254	.776
99	—	—	—	—	—	—	.673	.912	.306	.822
100	—	—	—	—	—	—	.739	.970	.357	.868

TABLE 24 (cont.)
($Y=4.0-4.9$; 51-100% kill)

kill	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9
51	5.452	5.325	5.229	5.158	5.108	5.072	5.049	5.035	5.028	5.025
52	.493	.363	.264	.190	.138	.101	.076	.062	.054	.051
53	.535	.400	.298	.222	.168	.129	.103	.088	.079	.076
54	.576	.438	.333	.254	.198	.157	.131	.114	.105	.101
55	.617	.475	.367	.286	.228	.186	.158	.140	.131	.126
56	5.659	5.513	5.402	5.318	5.258	5.214	5.185	5.167	5.156	5.151
57	.700	.550	.436	.351	.288	.243	.212	.193	.182	.177
58	.741	.588	.471	.383	.318	.271	.239	.219	.207	.202
59	.783	.626	.505	.415	.348	.299	.266	.245	.233	.227
60	.824	.663	.540	.447	.378	.328	.294	.271	.258	.252
61	5.865	5.701	5.574	5.479	5.408	5.356	5.321	5.298	5.284	5.277
62	.907	.738	.609	.511	.438	.385	.348	.324	.310	.303
63	.948	.776	.643	.543	.468	.413	.375	.350	.335	.328
64	.989	.814	.678	.575	.498	.441	.402	.376	.361	.353
65	6.031	.851	.712	.607	.528	.470	.429	.402	.386	.378
66	6.072	5.889	5.747	5.639	5.558	5.498	5.456	5.429	5.412	5.403
67	.113	.926	.781	.671	.588	.527	.484	.455	.437	.429
68	.155	.964	.816	.703	.618	.555	.511	.481	.463	.454
69	.196	6.001	.851	.735	.648	.583	.538	.507	.489	.479
70	.237	.039	.885	.767	.678	.612	.565	.534	.514	.504
71	6.279	6.077	5.920	5.799	5.708	5.640	5.592	5.560	5.540	5.529
72	.320	.114	.954	.831	.738	.669	.619	.586	.565	.555
73	.361	.152	.989	.863	.768	.697	.647	.612	.591	.580
74	.402	.189	6.023	.895	.798	.725	.674	.638	.617	.605
75	.444	.227	.058	.927	.828	.754	.701	.665	.642	.630
76	6.485	6.265	6.092	5.959	5.858	5.782	5.728	5.691	5.668	5.655
77	.526	.302	.127	.991	.888	.811	.755	.717	.693	.680
78	.568	.340	.161	6.023	.918	.839	.782	.743	.719	.706
79	.609	.377	.196	.055	.948	.868	.809	.770	.744	.731
80	.650	.415	.230	.087	.978	.896	.837	.796	.770	.756
81	6.692	6.452	6.265	6.119	6.008	5.924	5.864	5.822	5.796	5.781
82	.733	.490	.299	.151	.038	.953	.891	.848	.821	.806
83	.774	.528	.334	.183	.068	.981	.918	.874	.847	.832
84	.816	.565	.368	.215	.098	6.010	.945	.901	.872	.857
85	.857	.603	.403	.247	.128	.038	.972	.927	.898	.882
86	6.898	6.640	6.437	6.279	6.158	6.066	6.000	5.953	5.923	5.907
87	.940	.678	.472	.311	.188	.095	.027	.979	.949	.932
88	.981	.716	.506	.343	.218	.123	.054	6.006	.975	.958
89	7.022	.753	.541	.375	.248	.152	.081	.032	6.000	.983
90	.064	.791	.575	.407	.278	.180	.108	.058	.026	6.008
91	7.105	6.828	6.610	6.439	6.308	6.208	6.135	6.084	6.051	6.033
92	.146	.866	.644	.471	.338	.237	.162	.110	.077	.058
93	.188	.903	.679	.503	.368	.265	.190	.137	.102	.081
94	.229	.941	.713	.535	.398	.294	.217	.163	.128	.109
95	.270	.979	.748	.567	.428	.322	.244	.189	.154	.134
96	7.312	7.016	6.783	6.600	6.458	6.350	6.271	6.215	6.179	6.159
97	.353	.054	.817	.632	.488	.379	.298	.242	.205	.184
98	.394	.091	.852	.664	.518	.407	.325	.268	.230	.210
99	.436	.129	.886	.696	.548	.436	.353	.294	.256	.235
100	.477	.166	.921	.728	.578	.464	.380	.320	.281	.260

TABLE 24 (cont.)
($Y = 5.0-5.9; 51-100\%$ kill)

% kill	Provisional probit, Y									
	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9
51	5.025	5.025	5.023	5.017	5.005	4.985	4.953	4.906	4.840	4.750
52	.050	.050	.048	.043	.032	5.013	.983	.938	.874	.788
53	.075	.075	.074	.069	.059	.041	5.013	.970	.909	.825
54	.100	.100	.100	.096	.087	.070	.043	5.002	.943	.863
55	.125	.126	.125	.122	.114	.098	.073	.034	.978	.901
56	5.150	5.151	5.151	5.148	5.141	5.127	5.103	5.066	5.012	4.938
57	.175	.176	.176	.174	.168	.155	.133	.098	.047	.976
58	.201	.201	.202	.201	.195	.183	.163	.130	.082	5.013
59	.226	.226	.227	.227	.222	.212	.193	.162	.116	.051
60	.251	.252	.253	.253	.250	.240	.223	.194	.151	.088
61	5.276	5.277	5.279	5.279	5.277	5.269	5.253	5.226	5.185	5.126
62	.301	.302	.304	.305	.304	.297	.283	.258	.220	.164
63	.326	.327	.330	.332	.331	.325	.313	.290	.254	.201
64	.351	.352	.355	.358	.358	.354	.343	.322	.289	.239
65	.376	.378	.381	.384	.385	.382	.373	.354	.323	.276
66	5.401	5.403	5.406	5.410	5.412	5.411	5.403	5.386	5.358	5.314
67	.426	.428	.432	.437	.440	.439	.433	.418	.392	.351
68	.451	.453	.458	.463	.467	.467	.463	.450	.427	.389
69	.476	.478	.483	.489	.494	.496	.493	.482	.461	.427
70	.501	.504	.509	.515	.521	.524	.523	.514	.496	.464
71	5.526	5.529	5.534	5.541	5.548	5.553	5.553	5.546	5.530	5.502
72	.551	.554	.560	.568	.575	.581	.583	.578	.565	.539
73	.577	.579	.585	.594	.603	.609	.613	.610	.599	.577
74	.602	.604	.611	.620	.630	.638	.643	.642	.634	.615
75	.627	.630	.637	.646	.657	.666	.673	.674	.668	.652
76	5.652	5.655	5.662	5.673	5.684	5.695	5.703	5.706	5.703	5.690
77	.677	.680	.688	.699	.711	.723	.733	.738	.737	.727
78	.702	.705	.713	.725	.738	.752	.763	.770	.772	.765
79	.727	.730	.739	.751	.765	.780	.793	.802	.806	.802
80	.752	.755	.764	.777	.793	.808	.823	.834	.841	.840
81	5.777	5.781	5.790	5.804	5.820	5.837	5.853	5.866	5.875	5.878
82	.802	.806	.816	.830	.847	.865	.883	.898	.910	.915
83	.827	.831	.841	.856	.874	.894	.913	.930	.944	.953
84	.852	.856	.867	.882	.901	.922	.943	.962	.979	.990
85	.877	.881	.892	.908	.928	.950	.973	.995	6.014	6.028
86	5.902	5.907	5.918	5.935	5.956	5.979	6.003	6.027	6.048	6.066
87	.927	.932	.943	.961	.983	6.007	.033	.059	.083	.103
88	.953	.957	.969	.987	6.010	.036	.063	.091	.117	.141
89	.978	.982	.995	6.013	.037	.064	.093	.123	.152	.178
90	6.003	6.007	6.020	.040	.064	.092	.123	.155	.186	.216
91	6.028	6.033	6.046	6.066	6.091	6.121	6.153	6.187	6.221	6.253
92	.053	.058	.071	.092	.118	.149	.183	.219	.255	.291
93	.078	.083	.097	.118	.146	.178	.213	.251	.290	.329
94	.103	.108	.122	.144	.173	.206	.243	.283	.324	.366
95	.128	.133	.148	.171	.200	.234	.273	.315	.359	.404
96	6.153	6.159	6.174	6.197	6.227	6.263	6.303	6.347	6.393	6.441
97	.178	.184	.199	.223	.254	.291	.333	.379	.428	.479
98	.203	.209	.225	.249	.281	.320	.363	.411	.462	.517
99	.228	.234	.250	.276	.309	.348	.393	.443	.497	.554
100	.253	.259	.276	.302	.336	.376	.423	.475	.531	.592

TABLE 24 (cont.)
(Y = 6.0-6.9; 51-100% kill)

% kill	Provisional probit, Y									
	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9
51	4.631	4.473	4.269	4.006	3.667	3.233	2.677	1.964	1.049	—
52	.672	.519	.321	.064	.734	.310	.767	2.070	.175	0.022
53	.713	.565	.372	.122	.800	.387	.857	.176	.302	.175
54	.755	.611	.424	.181	.867	.464	.917	.283	.429	.327
55	.796	.657	.475	.239	.934	.541	3.037	.389	.555	.480
56	4.837	4.703	4.527	4.297	4.001	3.619	3.127	2.495	1.682	0.632
57	.879	.749	.578	.356	.068	.696	.218	.602	.809	.784
58	.920	.795	.630	.414	.134	.773	.308	.708	.935	.937
59	.961	.841	.681	.472	.201	.850	.398	.814	2.062	1.089
60	5.003	.887	.733	.531	.268	.927	.488	.921	.189	.242
61	5.044	4.932	4.784	4.589	4.335	4.005	3.578	3.027	2.315	1.394
62	.085	.978	.836	.647	.401	.082	.668	.133	.442	.546
63	.127	5.024	.887	.706	.468	.159	.758	.240	.569	.699
64	.168	.070	.939	.764	.535	.236	.849	.346	.695	.851
65	.209	.116	.990	.823	.602	.313	.939	.452	.822	2.004
66	5.251	5.162	5.042	4.881	4.669	4.391	4.029	3.559	2.949	2.156
67	.292	.208	.093	.939	.735	.468	.119	.665	3.075	.308
68	.333	.254	.145	.998	.802	.545	.209	.771	.202	.461
69	.375	.300	.196	5.056	.869	.622	.299	.878	.329	.613
70	.416	.346	.248	.114	.936	.700	.390	.984	.455	.766
71	5.457	5.392	5.299	5.173	5.003	4.777	4.480	4.090	3.582	2.918
72	.499	.437	.351	.231	.069	.854	.570	.197	.709	3.070
73	.540	.483	.402	.289	.136	.931	.660	.303	.835	.223
74	.581	.529	.454	.348	.203	5.008	.750	.409	.962	.375
75	.623	.575	.505	.406	.270	.086	.840	.516	4.089	.528
76	5.664	5.621	5.557	5.464	5.336	5.163	4.930	4.622	4.215	3.680
77	.705	.667	.608	.523	.403	.240	5.021	.728	.342	.832
78	.747	.713	.660	.581	.470	.317	.111	.835	.469	.985
79	.788	.759	.711	.639	.537	.394	.201	.941	.595	4.137
80	.829	.805	.763	.698	.604	.472	.291	5.047	.722	.290
81	5.870	5.851	5.814	5.756	5.670	5.549	5.381	5.154	4.849	4.442
82	.912	.896	.866	.815	.737	.626	.471	.260	.975	.594
83	.953	.942	.917	.873	.804	.703	.561	.366	5.102	.747
84	.994	.988	.969	.931	.871	.780	.652	.473	.229	.899
85	6.036	6.034	6.020	.990	.938	.858	.742	.579	.355	5.052
86	6.077	6.080	6.072	6.048	6.004	5.935	5.832	5.685	5.482	5.204
87	.118	.126	.123	.106	.071	6.012	.922	.792	.609	.356
88	.160	.172	.175	.165	.138	.089	6.012	.898	.735	.509
89	.201	.218	.226	.223	.205	.166	.102	6.004	.862	.661
90	.242	.264	.278	.281	.272	.244	.192	.111	.988	.814
91	6.284	6.310	6.329	6.340	6.338	6.321	6.283	6.217	6.115	5.966
92	.325	.355	.381	.398	.405	.398	.373	.323	.242	6.118
93	.366	.401	.432	.456	.472	.475	.463	.430	.368	.271
94	.408	.447	.484	.515	.539	.553	.553	.536	.495	.423
95	.449	.493	.535	.573	.605	.630	.643	.642	.622	.576
96	6.490	6.539	6.587	6.631	6.672	6.707	6.733	6.749	6.748	6.728
97	.532	.585	.638	.690	.739	.784	.824	.855	.875	.880
98	.573	.631	.690	.748	.806	.861	.914	.961	7.002	7.033
99	.614	.677	.741	.807	.873	.939	7.004	7.068	.128	.185
100	.656	.723	.793	.865	.939	7.016	.094	.174	.255	.338

TABLE 24 (cont.)

(Y = 7.0-7.9; 51-100% kill)

%	Provisional probit, Y									
kill	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9
51	—	—	—	—	—	—	—	—	—	—
52	—	—	—	—	—	—	—	—	—	—
53	—	—	—	—	—	—	—	—	—	—
54	—	—	—	—	—	—	—	—	—	—
55	—	—	—	—	—	—	—	—	—	—
56	—	—	—	—	—	—	—	—	—	—
57	—	—	—	—	—	—	—	—	—	—
58	—	—	—	—	—	—	—	—	—	—
59	—	—	—	—	—	—	—	—	—	—
60	0.013	—	—	—	—	—	—	—	—	—
61	0.198	—	—	—	—	—	—	—	—	—
62	.383	—	—	—	—	—	—	—	—	—
63	.568	—	—	—	—	—	—	—	—	—
64	.753	—	—	—	—	—	—	—	—	—
65	.939	—	—	—	—	—	—	—	—	—
66	1.124	—	—	—	—	—	—	—	—	—
67	.309	0.003	—	—	—	—	—	—	—	—
68	.494	.231	—	—	—	—	—	—	—	—
69	.680	.458	—	—	—	—	—	—	—	—
70	.865	.685	—	—	—	—	—	—	—	—
71	2.050	0.913	—	—	—	—	—	—	—	—
72	.235	1.140	—	—	—	—	—	—	—	—
73	.420	.367	—	—	—	—	—	—	—	—
74	.606	.595	0.263	—	—	—	—	—	—	—
75	.791	.822	.515	—	—	—	—	—	—	—
76	2.976	2.050	0.827	—	—	—	—	—	—	—
77	3.161	.277	1.108	—	—	—	—	—	—	—
78	.347	.504	.390	—	—	—	—	—	—	—
79	.532	.732	.672	0.265	—	—	—	—	—	—
80	.717	.959	.954	.618	—	—	—	—	—	—
81	3.902	3.186	2.236	0.971	—	—	—	—	—	—
82	4.087	.414	.518	1.324	—	—	—	—	—	—
83	.273	.641	.800	.677	0.175	—	—	—	—	—
84	.458	.868	3.082	2.030	.621	—	—	—	—	—
85	.643	4.096	.364	.383	1.068	—	—	—	—	—
86	4.828	4.323	3.615	2.736	1.514	—	—	—	—	—
87	5.014	.551	.927	3.089	.961	0.438	—	—	—	—
88	.199	.778	4.209	.412	2.408	1.008	—	—	—	—
89	.384	5.005	.491	.795	.854	.579	—	—	—	—
90	.569	.233	.773	4.118	3.301	2.149	0.581	—	—	—
91	5.754	5.460	5.055	4.501	3.747	2.720	1.317	—	—	—
92	.940	.687	.337	.851	4.194	3.290	2.051	0.356	—	—
93	6.125	.915	.619	5.207	.610	.861	.790	1.316	—	—
94	.310	6.142	.901	.560	5.087	4.431	3.526	2.275	0.542	—
95	.495	.369	6.182	.914	.533	5.002	4.262	3.235	1.806	—
96	6.681	6.597	6.464	6.267	5.980	5.572	4.998	4.194	3.069	1.493
97	.866	.824	.746	.620	6.426	6.143	5.735	5.154	4.333	3.173
98	7.051	7.051	7.028	.973	.873	.713	6.471	6.114	5.596	4.853
99	.236	.279	.310	7.326	7.319	7.284	7.207	7.073	6.859	6.533
100	.421	.506	.592	.679	.766	.854	.943	8.033	8.123	8.213

APPENDIX C

SAMPLE COMPUTATIONAL PROCEDURE FOR THE PROBIT REGRESSION LINE ESTIMATION

APPENDIX C
 SAMPLE COMPUTATIONAL PROCEDURE FOR THE PROBIT
 REGRESSION LINE ESTIMATION

The comparison of median acceptance times for various traffic movements at intersections in Lafayette and Indianapolis, Indiana, is illustrated in the following sample problem. The basic computations for fitting the probit regression equation to the observed data are shown in Tables 25 to 27.

1. In the column headed "t" enter the mid-value for the time-interval group observed in seconds.
2. In column "x" enter logarithm of t.
3. In columns "n" and "a", respectively, enter the total number observed and the number accepted in each time group.
4. In column "p'" enter the percent acceptance, $p' = (100 a) / n$
5. Compute the adjusted acceptance, $p = 100 \left(\frac{p' - 1}{100 - 1} \right)$.
6. Enter the probits of p in the "empirical probit" column. These values are obtained from Table 22, Appendix B.
7. Plot the empirical probits against x, as shown in Figures 18 to 23, and visually draw a provisional line to fit these points.
8. For each mid-value of time obtain the expected probit Y as the ordinate to the provisional line.
9. From Table 23, Appendix B read the weighting coefficient in the column where C = 1 for each Y and multiply this by the corresponding n and enter in column "nw".

10. From Table 24, Appendix B, enter the working probit "y" corresponding to each adjusted acceptance p and each expected probit Y.
11. Multiply each entry in column "nw" with the respective values of x , x^2 , y , y^2 , and xy to obtain the other designated columns.
12. Sum the entries in each column to obtain Snw , $Snwx$, $Snwx^2$, $Snwy$, $Snwy^2$, and $Snwxy$.

<u>Sums</u>	<u>Right Turns</u>	<u>Left Turns</u>	<u>Through Movements</u>
Snw	193.013	354.437	424.526
Snwx	170.341	321.757	367.386
$Snwx^2$	152.978	295.792	324.825
Snwy	992.360	1820.200	2156.488
$Snwy^2$	5284.243	9659.925	11447.752
Snwxy	897.442	1686.121	1923.969

13. Divide the totals $Snwx$ and $Snwy$ by Snw to obtain the arithmetic means $\bar{x}$ and $\bar{y}$.

	<u>Right Turns</u>	<u>Left Turns</u>	<u>Through Movements</u>
$\bar{x} = Snwx/Snw$	0.883	0.908	0.865
$\bar{y} = Snwy/Snw$	5.141	5.136	5.080

14. Reduce the three totals, $Snwx^2$, $Snwxy$, and $Snwy^2$, by $(Snwx)^2/Snw$, $(Snwx)(Snwy)/Snw$ and $(Snwy)^2/Snw$, to obtain the sums of squares and products about the mean.

	<u>Right Turns</u>	<u>Left Turns</u>	<u>Through Movements</u>
$Snwx^2$	152.978	295.792	324.825
$(Snwx)^2/Snw$	<u>150.332</u>	<u>292.093</u>	<u>317.941</u>
Sxx	2.646	3.699	6.884
$Snwxy$	897.442	1686.121	1923.969
$(Snwx)(Snwy)/Snw$	<u>875.794</u>	<u>1652.387</u>	<u>1866.256</u>
Sxy	21.648	33.734	57.713
$Snwy^2$	5284.243	9659.925	11447.752
$(Snwy)^2/Snw$	<u>5102.137</u>	<u>9347.659</u>	<u>10954.578</u>
Syy	182.106	312.266	493.174

The total sums are:

<u>Sxx</u>	<u>Sxy</u>	<u>Syy</u>
2.646	21.648	182.106
3.699	33.734	312.266
<u>6.884</u>	<u>57.713</u>	<u>493.174</u>
$\Sigma Sxx = 13.229$	$\Sigma Sxy = 113.095$	$\Sigma Syy = 978.546$

15. The estimation of the average slope of several parallel regression lines is:

$$\begin{aligned} b &= \Sigma S_{xy} / \Sigma S_{xx} \\ &= 113.095 / 13.229 \\ &= 8.549 \end{aligned}$$

where Σ indicates summation over the several sample series.

16. Test of parallelism of the three regression lines is performed by comparing the respective chi-square values:

$$\text{chi-square} = S_{yy} - (S_{xy})^2 / S_{xx}$$

Chi-square for the totals is given by:

$$978.546 - (113.095)^2 / 13.279 = 20.360$$

Chi-square for right turns

$$182.106 - (21.648)^2 / 2.646 = 4.995$$

Chi-square for left turns

$$312.266 - (33.734)^2 / 3.699 = 5.620$$

Chi-square for through movements

$$493.174 - (57.713)^2 / 6.884 = \underline{9.329}$$

Total 19.944

With a 5-percent level of significance, the chi-square values for a two-tailed test with 22 and 2 degrees of freedom, respectively, are 36.8 and 0.0506. Since the chi-square for heterogeneity is not significant, the sum of squares for parallelism can be evaluated by the chi-square test. This analysis is summarized in Table 28. Since the chi-square value for parallelism is not significant, the hypothesis that the three lines are parallel is accepted.

Table 28

Chi-Square Test

	Degrees of Freedom	Sums of Squares	Chi-Square at 5-Percent Level
<hr/>			
Parallelism of Regressions	2	0.425	0.0506
Residual Heterogeneity	22	19.944	36.8000
Total	24	20.369	

17. The fitted equations are of the form

$$Y = \bar{y} + b(x - \bar{x}) \quad \text{or}$$

$$Y = a + bx.$$

For right turns

$$Y_1 = -2.41 + 8.55x$$

For left turns

$$Y_2 = -2.63 + 8.55x$$

For through movements

$$Y_3 = -2.32 + 8.55x$$

These three lines are illustrated in Figure 23.

18. The variance of b is:

$$\begin{aligned} V(b) &= 1 / \sum Sxx \\ &= 1/6.884 \\ &= 0.145 \end{aligned}$$

19. The median acceptance time (T) is obtained from the equation

$$T = 10^m$$

where m is the value of x for $Y = 5$ in the above regression equation.

$$\text{For right turns} \quad T = 10^{0.867} = 7.36 \text{ sec}$$

$$\text{For left turns} \quad T = 10^{0.893} = 7.82 \text{ sec}$$

$$\text{For through movements} \quad T = 10^{0.856} = 7.18 \text{ sec}$$

20. The relative lag-and-gap acceptance times (R) are obtained by comparing the median value for each movement as follows:

Comparing left turns with right turns

$$\begin{aligned}
 M_{21}^* &= m_2 - m_1 \\
 &= 0.893 - 0.867 \\
 &= 0.026 \\
 R_{21} &= 10^{M_{21}} \\
 &= 1.06
 \end{aligned}$$

where R_{21} indicates that the median acceptance time for left turns is 1.06 times longer than that for right turns.

Similarly, the R values for the comparisons of left turns with through movements and right turns with through movements are 1.09 and 1.03, respectively.

An R value for median acceptance times greater than 1.10 at a 5-percent significance level is considered large enough to reject the hypothesis of equality.

21. The standard error of m is expressed as

$$s_m = \sqrt{1/b \quad 1/S_{nw} + (m - \bar{x})^2 / S_{xx}}$$

For right turns

$$\begin{aligned}
 s_{m1} &= \sqrt{1/8.55 \quad 0.0052 + (0.867 - 0.883)^2 / 2.646} \\
 &= 0.0084
 \end{aligned}$$

*Subscripts 1, 2 and 3 refer to right turns, left turns and through movements, respectively.

Similarly for left turns and through movements

$$s_{m2} = 0.006 \text{ and}$$

$$s_{m3} = 0.006$$

The standard error of the median acceptance time is:

$$S. E. (10^m) = 10^m \log_e 10 \cdot s_m$$

$$\text{For right turns} \quad = 0.142 \text{ sec}$$

$$\text{For left turns} \quad = 0.112 \text{ sec}$$

$$\text{For through movements} \quad = 0.094 \text{ sec}$$

The standard error of M_{21} is expressed as

$$\begin{aligned} S_{M_{21}} &= 1/b \sqrt{(1/S_{nw})_1 + (1/S_{nw})_2 + (\bar{x}_1 - \bar{x}_2 - M_{21})^2 / S_{xx}} \\ &= 1/8.55 \sqrt{0.0052 + 0.0028 + \frac{(0.883 - 0.908 - 0.029)^2}{13.224}} \\ &= 0.011 \end{aligned}$$

Similarly,

$$S_{M_{23}} = 0.009 \text{ and}$$

$$S_{M_{13}} = 0.010$$

The standard error of the relative acceptance time (R) is then

$$S. E. (R_{21}) = 10^{M_{21}} \cdot \log_e 10 \cdot S_{M_{21}} = 0.026$$

$$S. E. (R_{23}) = 0.023$$

$$S. E. (R_{13}) = 0.024$$

Confidence limits for the median acceptance time and the relative acceptance time are determined using the normal deviate, t , at the 5-percent significance level, if the following function

$$g = t^2 V(b)/b^2 = t^2/b^2 S_{xx}$$

is small compared with unity.

$$\text{For right turns } g_1 = (1.96)^2 / (8.55)^2 \cdot 2.65 = 0.020$$

$$\text{Similarly, } g_2 = 0.014 \text{ and } g_3 = 0.008$$

These are all much less than unity; hence,

95-percent confidence limits for median acceptance times are equal to 10^{K_1} and 10^{K_2} where

$$K_1 = m - t \cdot s_m$$

$$K_2 = m + t \cdot s_m$$

$$t = 1.96$$

For right turns

$$K_1 = 0.851$$

$$K_2 = 0.883$$

$$10^{K_1} = 7.10$$

$$10^{K_2} = 7.64$$

There is 95-percent confidence that the median acceptance time for right turns will lie between 7.10 sec and 7.64 sec.

Similarly, confidence limits for left turns and through movements are respectively (7.60, 8.04) sec and (7.00, 7.36) sec.

The 95-percent confidence limits for relative acceptance times (R) are equal to 10^{Z_1} and 10^{Z_2} where

$$Z_1 = M - t \cdot S_M$$

$$Z_2 = M + t \cdot S_M$$

$$t = 1.96$$

Comparing left turns with right turns,

$$Z_1 = 0.008$$

$$Z_2 = 0.050$$

$$10^{Z_1} = 1.02$$

$$10^{Z_2} = 1.12$$

There is 95-percent confidence that the median acceptance time for left turns is in no instance more than 12 percent greater than the median acceptance time for right turns. Similarly for the other comparisons:

$$1.05 < R_{23} < 1.14$$

$$1 < R_{13} < 1.07$$

Thus, the differences in acceptance time between left turns and right turns, and left turns and through movements are significant.

ABRIDGEMENT

Solberg, Per, "A Study of Lag and Gap Acceptances at Stop-Controlled Intersections". MSCE Thesis, Purdue University, June 1964.

Descriptors: driver gap acceptance; driver lag acceptance; intersection control; stop-controlled intersections; Solberg, Per.

The purpose of this study was to investigate the time gap acceptance of drivers entering or crossing a major street from a stopped position. The study was limited to four intersections located in Lafayette and Indianapolis, Indiana. The field data were obtained with a motion picture camera at right-angled intersections formed by two-way, two-lane urban streets. The statistical treatment of the data was performed employing probit analysis. In addition, two methods, one developed by M. S. Raff and the other by H. H. Bissell were appraised in this study of driver behavior.

The author presents graphs demonstrating time-interval acceptance distributions, that is, the relationship between acceptance of a time interval and the length of this time interval. The acceptance distributions were well described by linear relationships

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between the probit of acceptance and the logarithm of acceptance time. Tables show the final results of median acceptance times for right- and left-turning drivers and for drivers proceeding straight through the intersections.