A STUDY OF PEDESTRIAN'S WALKING RATE AND ACCEPTABLE GAP INTERVAL WHEN CROSSING THE STREET

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INTRODUCTION

What is a pedestrian? A pedestrian is anyone afoot. In the context of transportation rather than recreational walking, we give most attention to the person afoot in relation to the motor vehicle. Frequently this is exemplified by the pedestrian-vehicle conflict because an average man of 160 pounds cannot compete with the typical motor vehicle weighing about two tons. There must be separation. Then, too, our greatest concern is with the pedestrian in urban areas; and hopefully, in the years to come, cities will be built with the pedestrian considered as a significant element in all planning and construction. (1)

NEED FOR THE STUDY

As part of an investigation of the behavior of pedestrians at crossings, a Swedish study (2) found that the average adult and elderly person moved at the rate of about 1.4 meters per second, or 4.5 feet per second which is about 3 miles per hour, as shown in Figure 1. However, many elderly walked more rapidly or more slowly than did typical adults. For men walking across street alone, Weiner (3) found an average rate of 4.22 feet per second; for women the rate was 3.70. When walking with others, the rate for men was reduced to 3.83 and for women to 3.63.

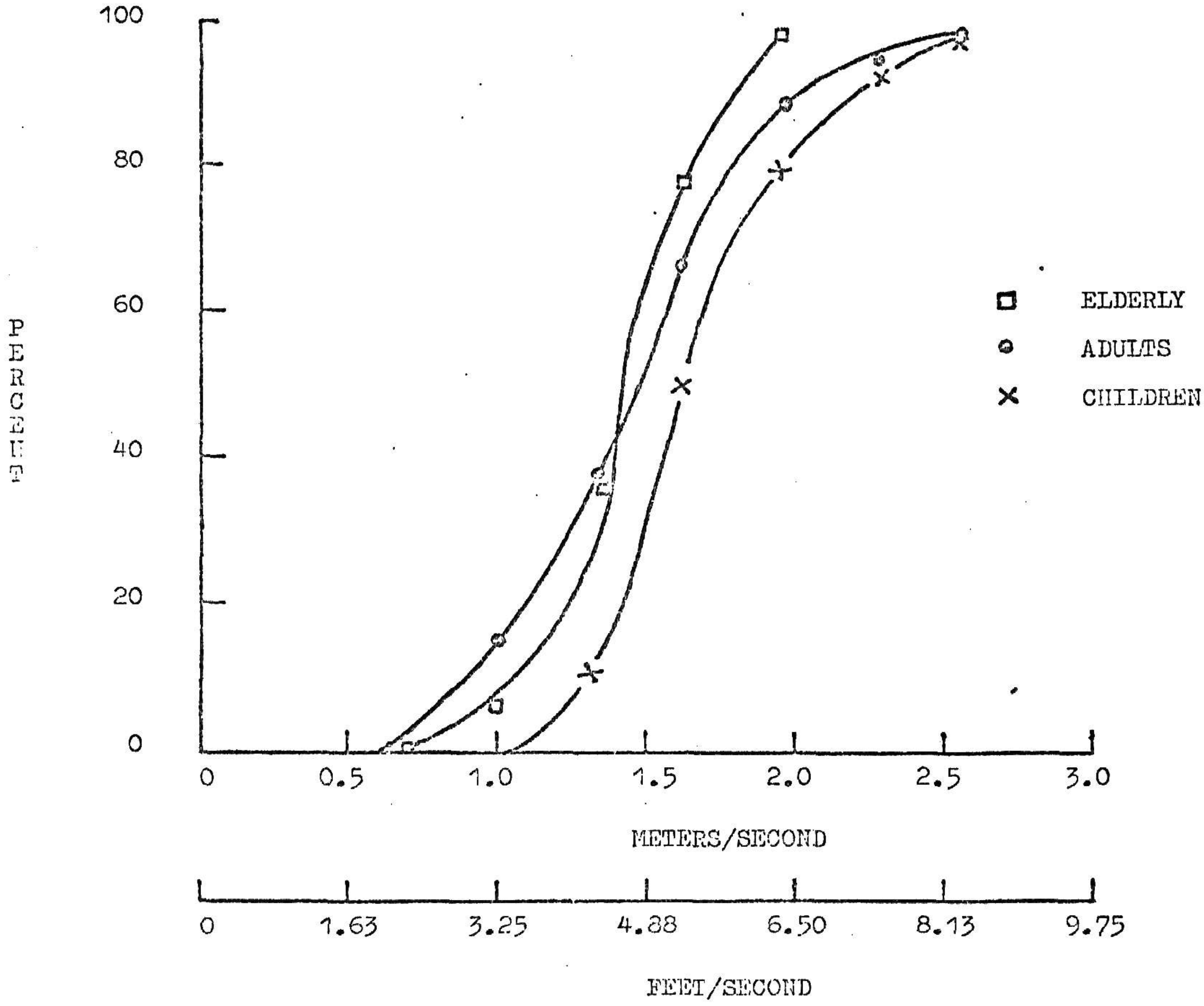

FIGURE 1. TYPICAL SPEED OF PEDESTRIAN MOVEMENT AT CROSSING (1)

The Manual on Uniform Traffic Control Devices (4) assumes a pedestrian walking rate of 4 feet per second for the timing of pedestrian signals. A study has shown that the median acceptable gap for pedestrian crossing a one-way street is 5.7 seconds, and for a two-way street is 7.3 and 7.7 seconds for the near-side and far-side flows, respectively. (5)
It is also shown in a supplementary study (6) that the median acceptable gap will vary according to the width of the street to be crossed, with the two-way street values shown above applicable to a street 44 feet wide.
Another research result (1) has shown that, when driving was at 20 mph in typical lighting in a large city, the so-called threshold gap (defined as the gap accepted by 50 percent of the pedestrians and on the basis of which they crossed the roadway) was 84 feet or 2.8 seconds if expressed in time. The distribution of gaps accepted is shown by the curve in Figure 2.
Although the causes and cures relating to pedestrian casualties are somewhat different in the daylight than night and twilight conditions, the two main factors influencing the visibility of the pedestrian, are the illumination of that pedestrian, and the visual contrast of the pedestrian with his background. The accident rate per million vehicle-miles for fatal and serious accidents is 2½ to 3 times as high during hours of darkness as during hours of daylight. (7) Another study (8)

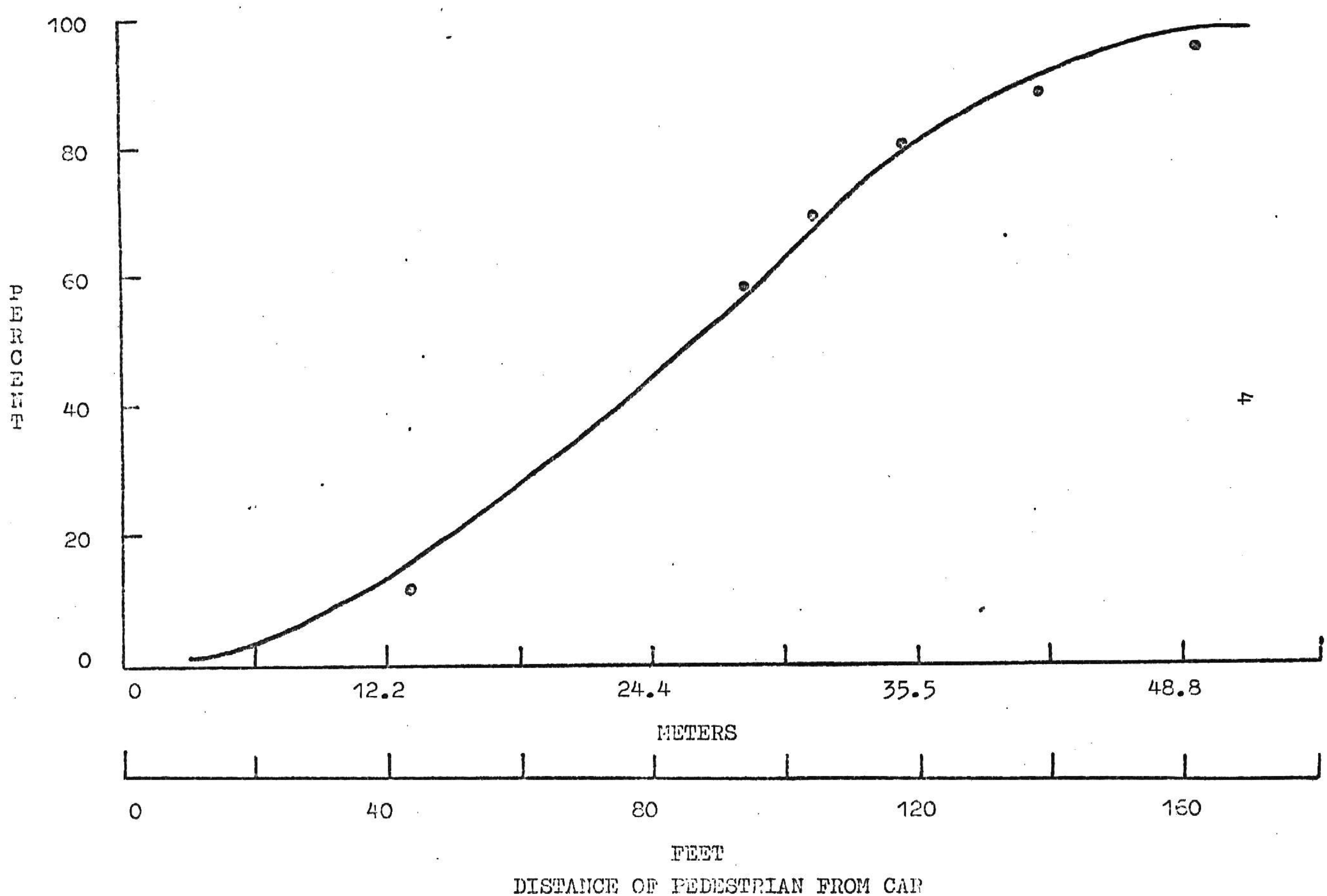

FIGURE 2. PERCENT OF PEDESTRIANS ACCEPTING GAPS IN CROSSING (1)

points out that while overall pedestrian deaths represent slightly less than 20 percent of all motor vehicle fatalities, a three-year study of 12 United States cities with populations of more than 500,000 found that 50 percent of the total nighttime traffic fatalities were pedestrian deaths.

The various research experiments and assumptions previously mentioned, have made important contributions to the field of traffic engineering. It seems, however, that no significant research has been done on the pedestrian's reactions to the approaching vehicles while crossing streets, daytime vs nighttime.

The purpose of this report was to determine the difference between the pedestrian's walking rate and gap interval acceptance distribution when crossing the street during the day and the night. My hypotheses are that the mean value of walking rate at nighttime will be faster than the mean value in the daytime, and that the average acceptable gap at nighttime will be larger than the same value in the daytime. The test was also run between males and females to determine whether a difference existed between them.

METHOD

A particular T type intersection was selected which was located at Anderson Avenue and the non-named drive east of the Student Union parking lot at Kansas State University (the south end of the drive which lies in front of Calvin Hall) in Manhattan, Kansas. It is an intersection with one-way north and four lane, two-way, east-west traffic (See Figure 3). Two white pedestrian markings cross Anderson Avenue and two "Ped Xing" signs, one facing in each direction, have been placed at the location in order to cause the vehicular drivers to yield to those pedestrians who wish to cross the street. Anderson Avenue is a major street in Manhattan and the drive is one of the main exits for students to go back and forth to the campus. In other words, it is a main pedestrian-vehicle conflict point in this college town.

Task

For the walking rate sample, the author simply recorded the time for each individual subject to cross the street.
For the acceptable gap interval experiment, three persons were used. One held two stop watches in order to record the accepted gap interval of the near-side and far-side approaching vehicles as each individual pedestrian crossed the street (the definition of near-side and far-side street is that; for example, in Figure 3,

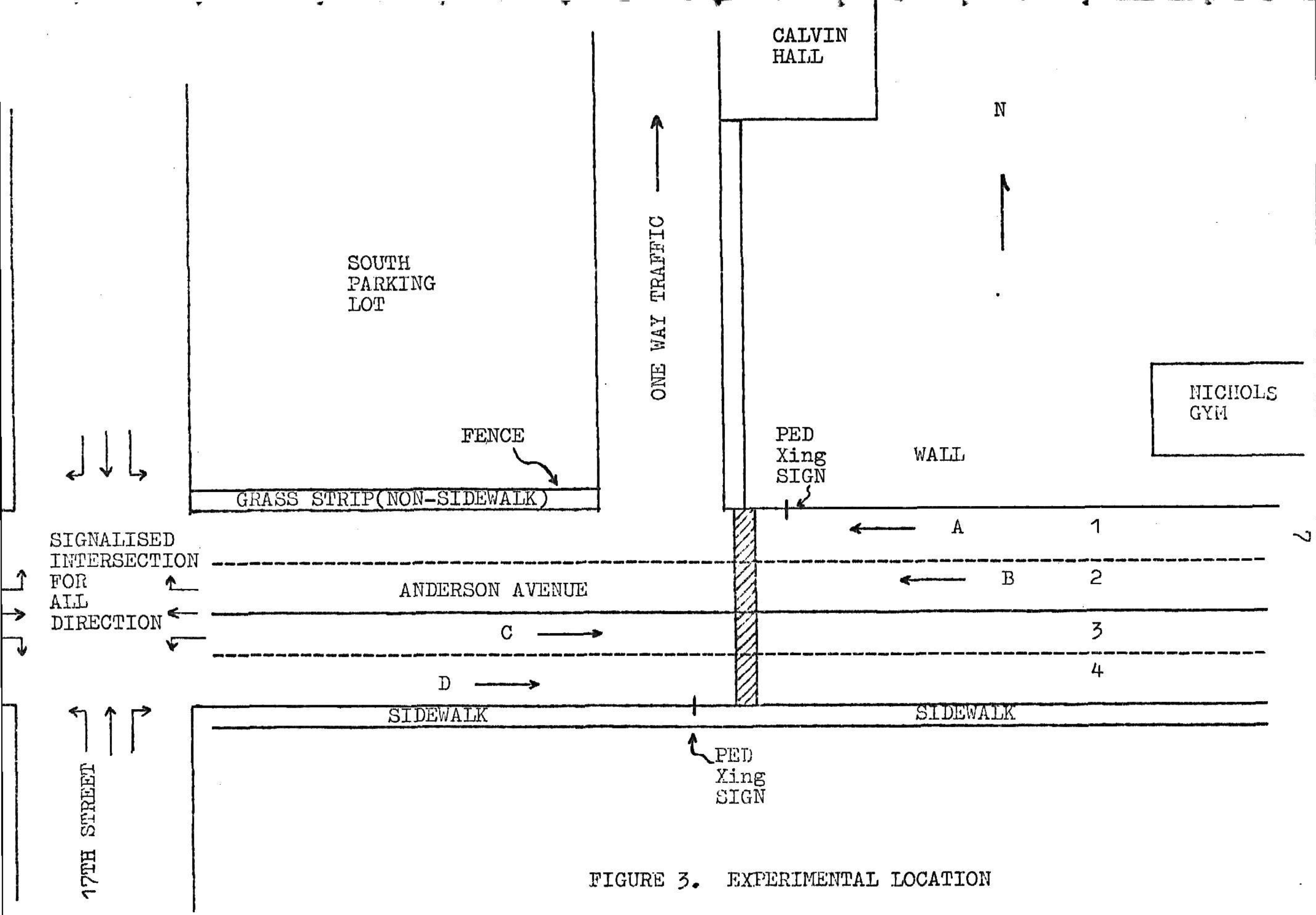

FIGURE 3. EXPERIMENTAL LOCATION

when a pedestrian wants to cross Anderson Avenue from south of the location to the north, lanes 1 and 2 are his far-side streets, lanes 3 and 4 are his near-side streets), the second one then wrote those numbers down, and the third person counted the traffic volume during the same time period. Any vehicle which crossed the measuring line from either direction was included in the traffic count.

WALKING RATE EXPERIMENT

CRITERIA FOR SAMPLE TAKEN

In order to make the experiment more accurate, the included subjects:

1. must cross the street individually
2. must not stop at any point in the street

SUBJECTS

Fifty males and fifty females in the day and fifty males and fifty females at night were picked by random observation.

MEASUREMENT AND INSTRUMENTATION

The observations were taken on:

1. November 27, 1972
   From 11:30 A.M. to 1:17 P.M., 50 males and 50 females were observed. The sky was clear and the sun shining; the pavement was dry.
2. November 27, 1972
   From 5:30 P.M. to 8:07 P.M., 50 males and 50 females were observed. The sky was completely dark; the pavement was dry. The large pole-light in the parking lot to the north and the street lights on both sides resulted

in a poor, unclear visual condition in which the light intensity was approximately 60 footcandles at the location described.

According to the judgement of the author, each subject was marked as old, young or child (the old age group was defined as the age of 50 and over, from 18 to 49 was defined as the young group and under 18 was taken as the child group). However, during the observation there were no child and only three old (two males and one female).

The author started the watch at the time the random subject stepped on the 44 feet wide street from either curb, and stopped the watch at the time when that subject reached the curb at the other side. The obtained data are shown in Appendix 1.

RESULTS

The Student's-t test was used to examine the hypotheses. The first hypothesis, again, was that the mean value of walking rate at nighttime will be faster than the mean value in the daytime. The second was that the mean value of walking rate for females will be faster than for males in both day and night. The test was run between:

1. male vs female in the day
2. male vs female at night
3. male total vs female total
4. male in the day vs male at night

5. female in the day vs female at night

6. total subjects in the day vs total subjects at night

Figure 4 shows the speed of movement distribution with respect to the total male and total female observations, and Figure 5 shows the same distribution with respect to the day total and night total observations. All the data obtained with respect to sex group are shown in Appendix 1, Table 1 & 2 indicate the average walking time in seconds and average walking rate in feet per second for male, female and total subjects to cross the 44 feet street with respect to day, night and their average. The comparison of distribution with respect to male vs female and day vs night are shown in Appendix 2.

TABLE 1. MEAN TIME VALUE OBTAINED FROM EACH GROUP (IN SECONDS)

CONDITION	MALE	FEMALE	MALE AND FEMALE
DAY	8.02	7.96	7.99
NIGHT	6.71	6.38	6.54
DAY AND NIGHT	7.36	7.17	7.27

TABLE 2. MEAN WALKING RATE FOR EACH GROUP (IN FEET PER SECOND)

CONDITION	MALE	FEMALE	MALE AND FEMALE
DAY	5.49	5.53	5.51
NIGHT	6.56	6.90	6.73
DAY AND NIGHT	6.03	6.21	6.12

The necessary preliminary calculations and analysis of the data with respect to the requirement of the Student's-t test are shown in Appendix 3. The results of the two-tail Student's-t test, as shown in Appendix 4, indicate that there was no significant difference between the male and female groups while the difference between day and night (8.02 vs 6.71, 7.96 vs 6.38, and 7.99 vs 6.54) were significant. Thus apparently confirming the hypothesis that the walking rate for pedestrians was faster at night than that in the day.

CONCLUSIONS

For those 200 "young" subjects, the difference between male and female walking rate when crossing the street was not significant in either day or night although the average walking speed for female was slightly faster than that for male. The test also showed that the walking rate for the total subjects at night was significantly faster than that in the day time. Weiner (3) had reported that the average walking rate for men to cross the street was 4.22 feet per second, and for women it was 3.70 feet per second. These figures were based on all ages of pedestrians. This experiment has shown that the average walking rate for men was 6.03 feet per second, and 6.21 feet per second for women. In other words, the average walking rate for women was greater than the average value for men, and both the average rates were much greater than the values Weiner found. The walking speed deviation between Weiner's results and this experiment might be explained by the fact that almost all of the subjects in this experiment were young pedestrians who usually have a faster pace in crossing streets.

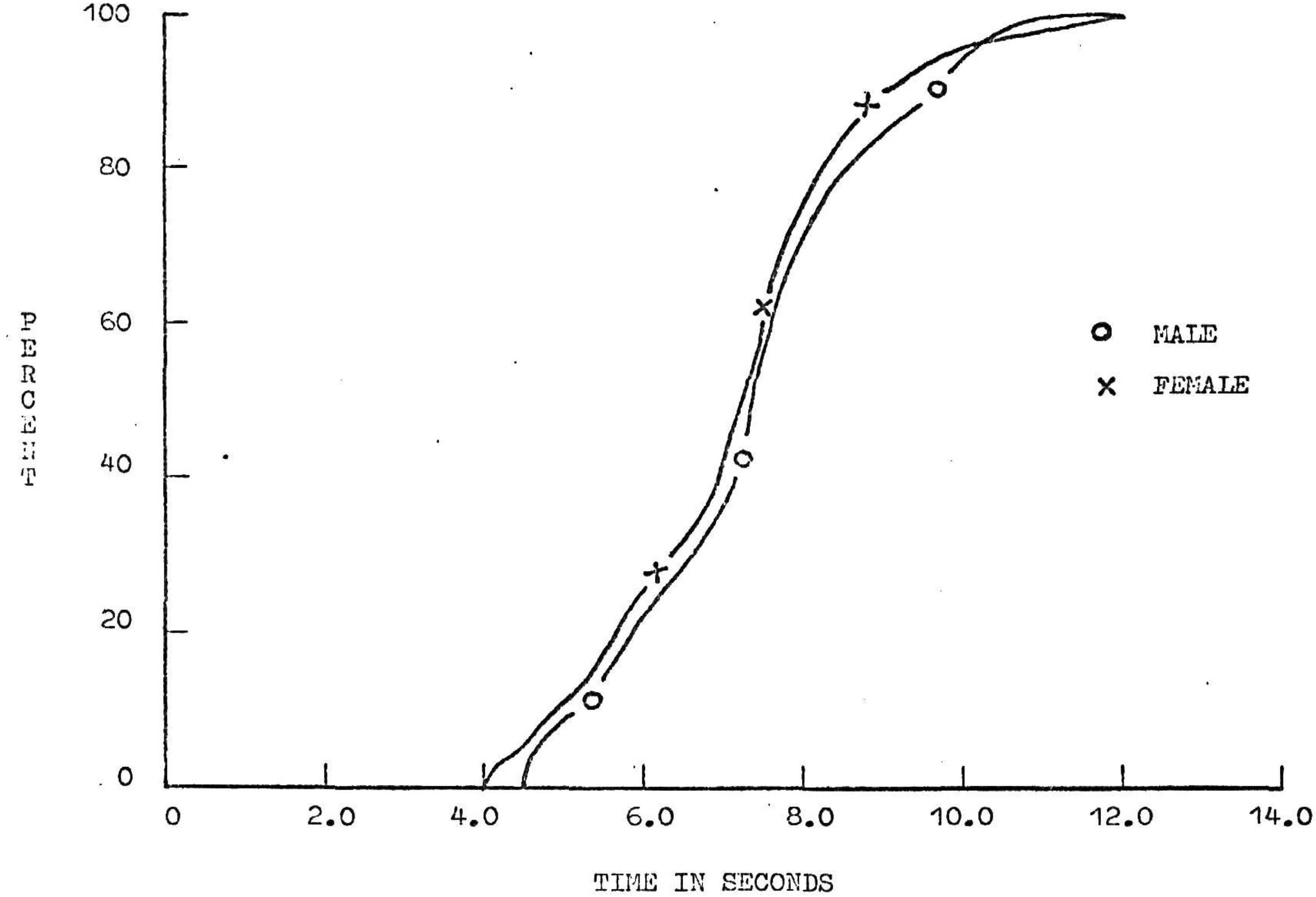

FIGURE 4. SPEED DISTRIBUTION OF PEDESTRIAN MOVEMENT(MALE vs FEMALE)

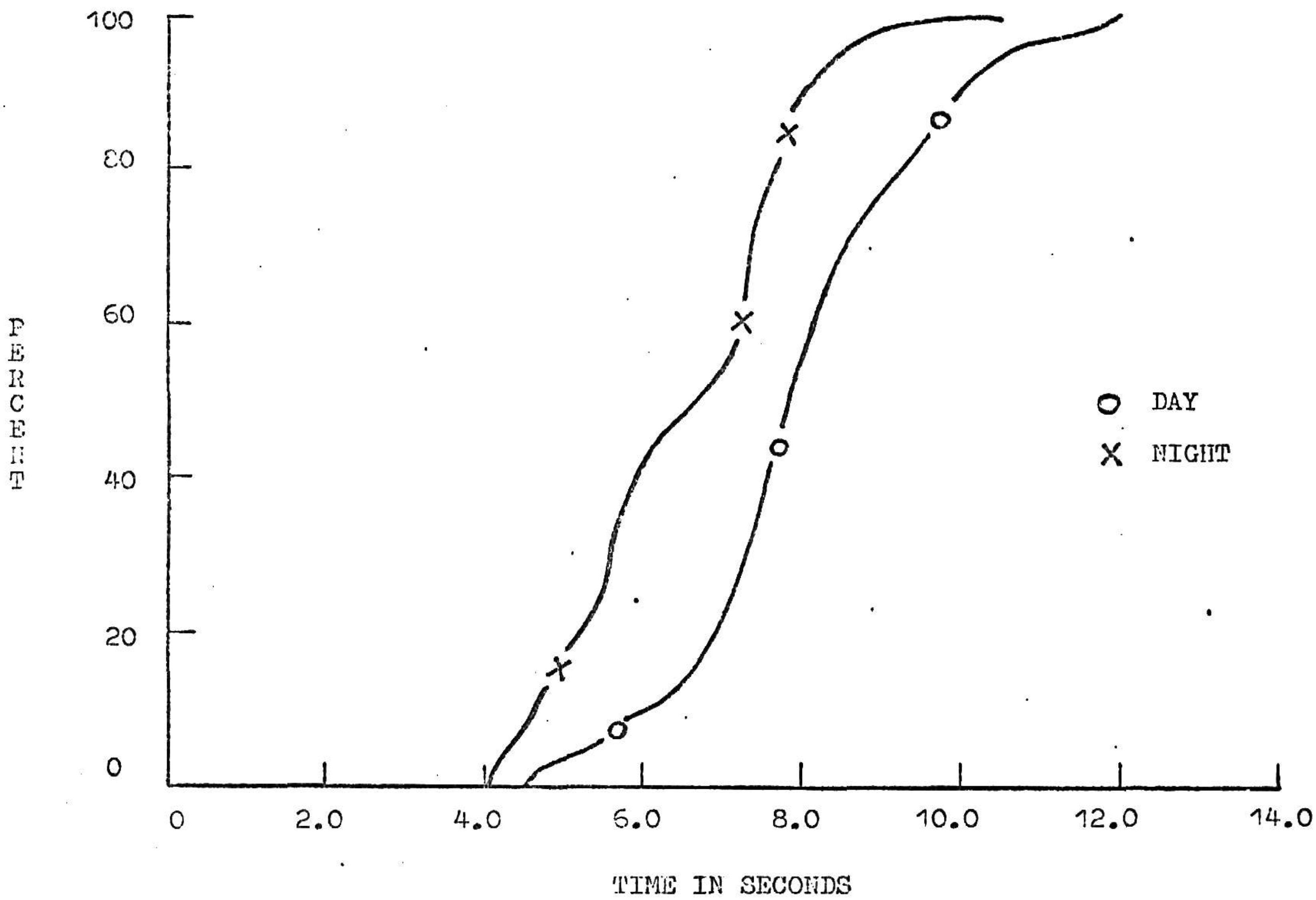

FIGURE 5. SPEED DISTRIBUTION OF PEDESTRIAN MOVEMENT(DAY vs NIGHT)

GAP ACCEPTANCE EXPERIMENT

CRITERIA FOR SAMPLE TAKEN

Each pedestrian apparently makes his or her own decision to accept a traffic gap when crossing the street. The probability of getting a larger gap, when traffic volumes are low, is very high. For instance, when the west bound vehicles are stopped by the red light at the Anderson-14th street intersection, sometimes the section east of the observation location immediately is clear for approximately 45 seconds (the time required for a vehicle to reach the observation location from that intersection by driving at the 30 mph speed limit). This assumes there are no left or right turn movements from 14th and 16th street. Also, there could be approximately a 23 seconds clearance for the section west of the observation location when the traffic is stopped at the Anderson-17th street intersection (See Figure 6). In that case, a pedestrian could cross the street without any hesitation, and it seems unreasonable to include that subject when determining an acceptable gap interval. Therefore, some criteria must be established for the sample collecting:

1. Robinson (5) found, for a 44 feet wide two-way street, that the median acceptable gaps are 7.3 and 7.7 seconds for the near-side and far-side flows, respectively. The sample criterion used in this experiment was double those

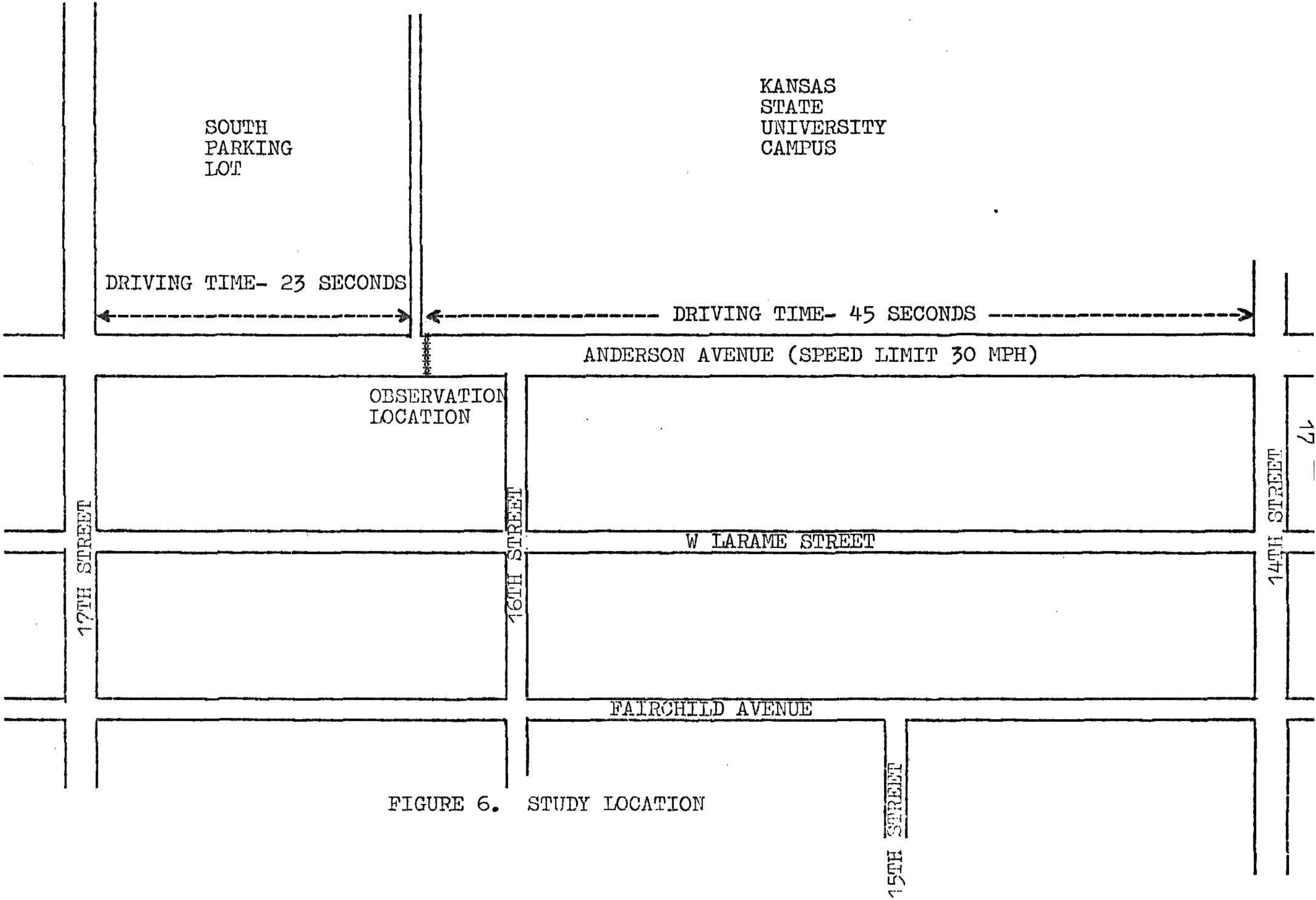

FIGURE 6. STUDY LOCATION

values; that is, the largest gaps could not exceed 14.6 and 15.4 seconds for the near-side and far-side flows, respectively. Any sample which was greater than this criterion was not included as an observation.

2. Any case when one or more vehicles stopped at the crosswalk to let the pedestrian have the right of way was not recorded as an observation.
3. Any case when a pedestrian stopped at any point in the crosswalk to let the far-side approaching vehicle have the right of way was not included as an observation.
4. Sometimes one or more pedestrians crossed the street together; in this case the one who stepped off the curb first was the only one recorded. The rationale for this criterion is that the behavior is probably different for individuals than for groups.
5. Sometimes a number of people crossed the street during the same short time period, this forced all vehicles in either direction to stop. In this case, none of the subjects was included.

SUBJECTS

In the day time, there were 267 males and 185 females, at night there were 77 males and 42 females included. Table 3 shows the distribution of the subjects in the various categories with

TABLE 3. SUBJECTS IN VARIOUS CATEGORIES

TIME	TOTAL PEDESTRIANS CROSSED		TOTAL SUBJECTS		NEARSIDE SUBJECTS		FARSIDE SUBJECTS		OLD SUBJECTS		CHILD SUBJECT	
	* M	F	M	F	M	F	M	F	M	F	M	F
8:30-9:30	71	43	38	29	33	22	25	22	0	0	0	0
9:30-10:30	60	47	27	19	26	18	22	16	0	0	0	0
10:30-11:30	54	31	32	13	26	12	24	11	0	2	1	0
11:30-12:30	67	52	33	19	30	18	30	14	1	3	0	0
12:30-1:30	83	59	35	29	31	25	33	22	1	3	0	0
1:30-2:30	49	38	38	23	34	19	28	18	2	1	0	0
2:30-3:30	66	45	31	19	31	16	26	16	0	0	0	0
3:30-4:30	87	63	33	23	30	20	32	21	1	0	0	0
DAY SUBTOTAL	686	378	267	174	241	150	220	140	5	9	1	0
5:30-6:30	62	30	31	15	27	15	24	12	1	0	1	0
6:30-7:30	46	41	22	14	21	12	14	9	0	1	0	0
7:30-8:30	52	22	24	13	24	12	18	9	0	2	0	0
NIGHT SUBTOTAL	168	93	77	42	72	39	56	30	1	3	1	0
TOTAL	846	471	344	216	313	189	276	170	6	12	2	0

* M : male subjects

F : female subjects

respect to the time of observation. Again, the subjects were roughly devided into three age groups; old, young and child (defined as before). However, of the 560 subjects, there were only 6 old males, 2 child male, 9 old female and no child female subjects.

PROCEDURE

There are 15 different situations a pedestrian encounters at the location. If "A" represents the approaching vehicle heading west at lane 1, "B" represents the approaching vehicle heading west at lane 2, "C" represents the approaching vehicle heading east at lane 3, and "D" represents the approaching vehicle heading east at lane 4 (See Figure 3), the situations presented in this experiment were as follows:

VEHICLES WEST BOUND	VEHICLES EAST BOUND	VEHICLES BOTH DIRECTION	
A	C	A+C	A+B+C
B	D	A+D	A+B+D
A+B	C+D	B+C	A+C+D
		B+D	A+B+C+D

Any two or more vehicles, no matter what lanes they are in, are unlikely to hit the observation location at exactly the same time. Therefore, this experiment only dealt with eight of these fourteen cases (A, B, C, D, A+C, A+D, B+C, B+D).

Any pedestrian who was within either the near-side or far-side gap criterion was recorded separately no matter which of the eight situations he or she met.

MEASUREMENT AND INSTRUMENTATION

Three persons were involved in the data collection task. One held a stop watch in each hand and started both watches at the time the subject stepped on the street. He stopped the watches individually as the near-side and far-side approaching vehicles reached the observation location where the subject was crossing. If either time interval was within the criterion, the recorder then recorded the time. The recorder also counted the total male and female pedestrians who crossed that crosswalk during that given time period. The third person counted the traffic flow in each time period in an attempt to determine the relationship between the rate of traffic flow and acceptable pedestrian gap.

The observations were taken:

1. November 17, 1972

    8:30 A. M. to 9:30 A. M.

    9:30 A. M. to 10:30 A. M.

    10:30 A. M. to 11:30 A. M.

    The sky was cloudy, and it was cold; the temperature was about 42 degrees F. The pavement was dry and the visibility was good.

2. November 17, 1972

5:30 P. M. to 6:30 P. M.

The sky was dark and it was cold; the temperature was about 36 degrees F. The pavement was dry. Visibility was poor. The pole lights to the northwest in the parking lot and the street lights on both sides of the observation location provided a light intensity of approximately 60 footcandles.

3. November 19, 1972

11:30 A. M. to 12:30 P. M.

12:30 P. M. to 1:30 P. M.

1:30 P. M. to 2:30 P. M.

The sky was cloudy and it was cold; the temperature was about 39 degrees F. The pavement was dry and the visibility was good.

4. November 19, 1972

6:30 P. M. to 7:30 P. M.

7:30 P. M. to 8:30 P. M.

The sky was dark and it was cold; the temperature was about 36 degrees F. The pavement was dry. Visibility was poor. And the pole lights to the northwest in the parking lot with the street lights on both sides of the observation location provided a light intensity of approximately 60 footcandles.

5. November 20, 1972
   2:30 P. M. to 3:30 P. M.
   3:30 P. M. to 4:30 P. M.
   The sky was clear, and the temperature was about 48 degrees F. The pavement was dry and the visibility was excellent.

The periods 7:30 A. M. to 8:30 A. M. and 4:30 P. M. to 5:30 P. M. were eliminated because since those two time intervals were during sunrise and sunset, it was hard to determine whether the visibility was good or poor during those two time intervals. And those time periods after 8:30 P. M. were eliminated because of scarce pedestrians and low traffic volumes.

RESULTS

The average gap for each sex group in each time period was calculated for both near-side and far-side (See Tables 4 & 5). The two-tail Student's-t test, again was introduced to test the hypotheses among those values. The test was run between:

1. male-day vs female-day (near-side & far-side)
2. male-night vs female-night (near-side & far-side)
3. male-total vs female-total (near-side & far-side)
4. male-day vs male-night (near-side & far-side)
5. female-day vs female-night (near-side & far-side)
6. total-day vs total-night (near-side & far-side)

Table 4 shows the mean gap for each time interval with respect to male, female and total subjects. All the data obtained with respect to time period and sex group are shown in Appendix 5. The analysis and necessary calculation for the requirements of the Student's-t test are shown in Appendix 6.
The comparison between values obtained from these calculations and critical values is shown in Appendix 7.
Table 5 shows the average gap for male, female and total subjects with respect to day, night and their average.

TABLE 4. MEAN GAP (IN SECONDS) FOR EACH TIME INTERVAL

TIME	MALE NEAR SIDE	MALE FAR SIDE	FEMALE NEAR SIDE	FEMALE FAR SIDE	TOTAL MEAN NEAR SIDE	TOTAL MEAN FAR SIDE
8:30-9:30	7.77	10.53	10.68	11.09	8.92	10.80
9:30-10:30	7.86	10.11	8.45	9.70	8.11	9.94
10:30-11:30	7.01	10.92	8.07	10.39	7.34	10.76
11:30-12:30	8.05	10.21	9.54	10.88	8.61	10.42
12:30-1:30	7.99	9.43	9.34	10.61	7.29	9.90
1:30-2:30	7.35	10.18	8.41	10.33	7.73	10.24
2:30-3:30	7.45	9.21	8.04	11.25	7.65	9.99
3:30-4:30	8.27	9.43	8.57	9.69	8.39	9.54
DAY SUBTOTAL	1860.80	2192.00	1349.30	1469.00	3210.10	3661.00
MEAN	7.72	9.96	8.99	10.49	8.35	10.22
5:30-6:30	9.44	12.04	9.52	10.72	9.47	11.59
6:30-7:30	8.77	10.91	9.01	11.82	8.86	11.26
7:30-8:30	9.00	10.76	9.54	11.27	9.18	10.92
NIGHT SUBTOTAL	655.10	635.20	365.40	336.40	1020.50	971.60
MEAN	9.09	11.34	9.36	11.21	9.22	11.27
TOTAL	2515.90	2827.20	1714.70	1805.40	4230.60	4632.60
MEAN	8.04	10.24	9.07	10.62	8.23	10.39

TABLE 5. MEAN GAP WITH RESPECT TO SEX AND TOTAL SUBJECTS

CONDITION		MALE	FEMALE	TOTAL
DAY	nearside	7.72	8.89	8.35
	farside	9.96	10.49	10.22
NIGHT	nearside	9.09	9.36	9.22
	farside	11.34	11.21	11.27
TOTAL	nearside	8.04	9.07	8.23
	farside	10.24	10.62	10.29

The comparisons are based on the values listed on Table 5. And the results are as follows:

DAY vs NIGHT

1. Male- when comparing the male subjects (7.72 vs 9.09, 9.96 vs 11.34), the difference was significant for both near-side and far-side. The average acceptable gap at night was about 16% larger than that in the day.
2. Female- when comparing the female subjects (8.89 vs 9.36, 10.49 vs 11.21), the difference was not significant in either near-side or far-side. The acceptable gap was not different between day and night.

3. Total- the difference was significant when comparing the total subjects in day with total subjects at night (8.35 vs 9.22, 10.22 vs 11.27) for both near-side and far-side. The acceptable gap was about 9% larger on the average at night than in the day.

MALE vs FEMALE

1. Day- when comparing the male and female subjects in the day, the near-side acceptable gap difference (7.72 vs 8.89) was significant, the near-side average acceptable gap for female was about 13% larger than male. But the difference was not significant in the far-side acceptable (9.96 vs 10.49).
2. Night- when comparing the male and female subjects at night, the difference was not significant either in near-side (9.09 vs 9.36) or in far-side (11.34 vs 11.21) acceptable gap.
3. Total- when comparing the male subjects total vs female subjects total, the difference was significant in near-side (8.04 vs 9.07) in that the average acceptable gap for total female was about 11% larger than male total. But the difference in the far-side acceptable gap (10.24 vs 10.62) was not significant.

CONCLUSION

As stated before, the results were complicated. The difference between day and night was significant when comparing the total subjects in near-side and far-side acceptable gap. But the rest of the comparisons suggest that the acceptable gap for males was shorter than for females in the day time, but the average acceptable gap for males was about the same as for females at night. This difference was probably due to the fact that when poor visibility was brought about by the dark environment males were also forced, for their own safety, to await a larger gap to cross the street. As for female acceptable gap itself, it did not increase significantly in the situation of poor visual environment over that in the good visual environment even though the average acceptable gap at night was 0.47 second and 0.72 second larger than the average in the day in near-side and far-side acceptable gap respectively.

The average near-side acceptable gap in the day was 8.35 seconds, 9.22 seconds at night, and the average far-side acceptable gap was 10.22 seconds in the day and 11.27 at night with respect to the total subjects. It is obvious that the near-side acceptable gap was shorter than far-side acceptable gap in average in either day and night. The point could be explained by that a pedestrian has to walk to the middle of the street (it is 22 feet in this experiment) to meet the far-side gap, he or she might take the 22 feet walking time in consideration when he or she decides to take an traffic gap to cross the street.

The smallest acceptable gap for male in the day time was 2.2 seconds for the near-side street in this experiment, 4.2 seconds for the far-side street, for female was 3.8 and 4.7 seconds respectively.

I would like to suggest that the average acceptable gap might be much greater in the situation when the surrounding environment is completely dark; when the headlight from an approaching vehicle is the only information for a pedestrian, he or she will be more hesitant in acceptable gap decision making.

When a pedestrian accident occurs, the vehicular driver is also deeply involved. Therefore, the relationship between driver and pedestrian might be an interesting field to develop.

RELATIONSHIP BETWEEN ACCEPTABLE GAP AND TRAFFIC FLOW

The traffic flow was counted during each time period when the experimental observations were taken. Table 6 indicates the traffic flow and the average near-side acceptable gap with respect to the same time period.

A polynomial curve fitting computer program then was used to find the relationship by using traffic flows as independent variables, and the average near-side acceptable gap in 11 individual time intervals as dependent variables. Examining the outcome from the computer program (See Figure 6), it shows that the average near-side acceptable gap increased when traffic flow either increased or decreased. However, it is very difficult to certain that this curve really shows some relationship between those two variables, because we could almost put any curve on the figure and it would fit as well as the one from the computer program since the correlation coefficient (R) is only about 0.65 which is not high enough to prove the relationship.

TABLE 6. AVERAGE NEAR-SIDE ACCEPTABLE GAP AND TRAFFIC VOLUME WITH RESPECT TO EACH TIME INTERVAL

TIME	TRAFFIC VOLUME(VEHICLES/HOUR)	MEAN GAP(IN SECONDS)
8:30-9:30	1104	8.925
9:30-10:30	835	8.115
10:30-11:30	663	7.345
11:30-12:30	797	8.615
12:30-1:30	1021	7.295
1:30-2:30	888	7.730
2:30-3:30	808	7.655
3:30-4:30	966	8.390
5:30-6:30	743	9.470
6:30-7:30	760	8.865
7:30-8:30	571	9.185

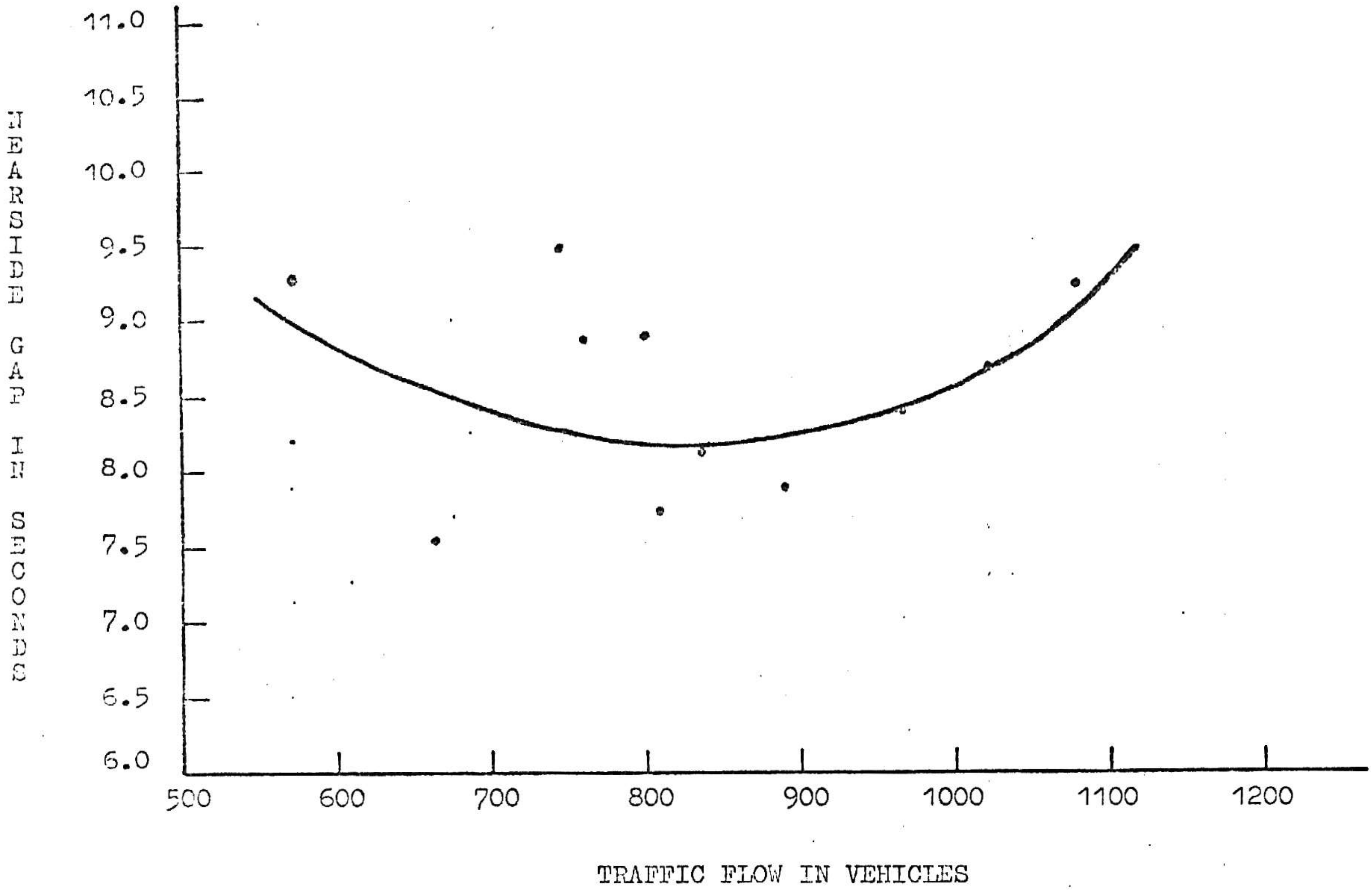

FIGURE 7. POLYNOMIAL CURVE FITTING FOR PEDESTRIAN GAP AND TRAFFIC FLOW

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APPENDIX 1

WALKING RATE DATA GROUPED BY SEX

DAY (MALE)

OBSERVATION	TIME	OBSERVATION	TIME
1	4.2	26	5.4
2	7.2	27	8.9
3	10.2	28	7.2
4	7.9	29	7.4
5	8.3	30	7.6
6	7.8	31	6.7
7	10.2	32	9.4
8	9.6	33	4.7
9	7.2	34	4.7
10	9.5	35	7.2
11	9.7	36	9.0
12	10.2	37	10.8
13	7.1	38	5.9
14	9.0	39	8.0
15	7.2	40	7.7
16	9.0	41	9.7
17	6.1	42	8.4
18	7.8	43	8.0
19	9.0	44	8.4
20	10.2	45	7.7
21	7.2	46	7.5
22	9.3	47	6.0
23	7.2	48	8.4
24	6.6	49	6.6
25	12.0	50	9.1

DAY (FEMALE)

OBSERVATION	TIME	OBSERVATION	TIME
1	7.2	26	8.7
2	7.8	27	8.4
3	8.4	28	6.6
4	7.4	29	7.4
5	7.8	30	8.1
6	4.8	31	6.5
7	7.8	32	7.8
8	11.7	33	9.5
9	9.7	34	6.8
10	7.2	35	7.3
11	11.4	36	5.3
12	7.8	37	8.6
13	9.7	38	8.4
14	10.3	39	6.6
15	6.7	40	7.1
16	8.1	41	8.9
17	9.0	42	6.7
18	5.9	43	6.7
19	8.7	44	9.7
20	7.8	45	6.8
21	7.1	46	9.6
22	7.2	47	8.3
23	9.1	48	10.8
24	5.9	49	7.7
25	7.4	50	8.0

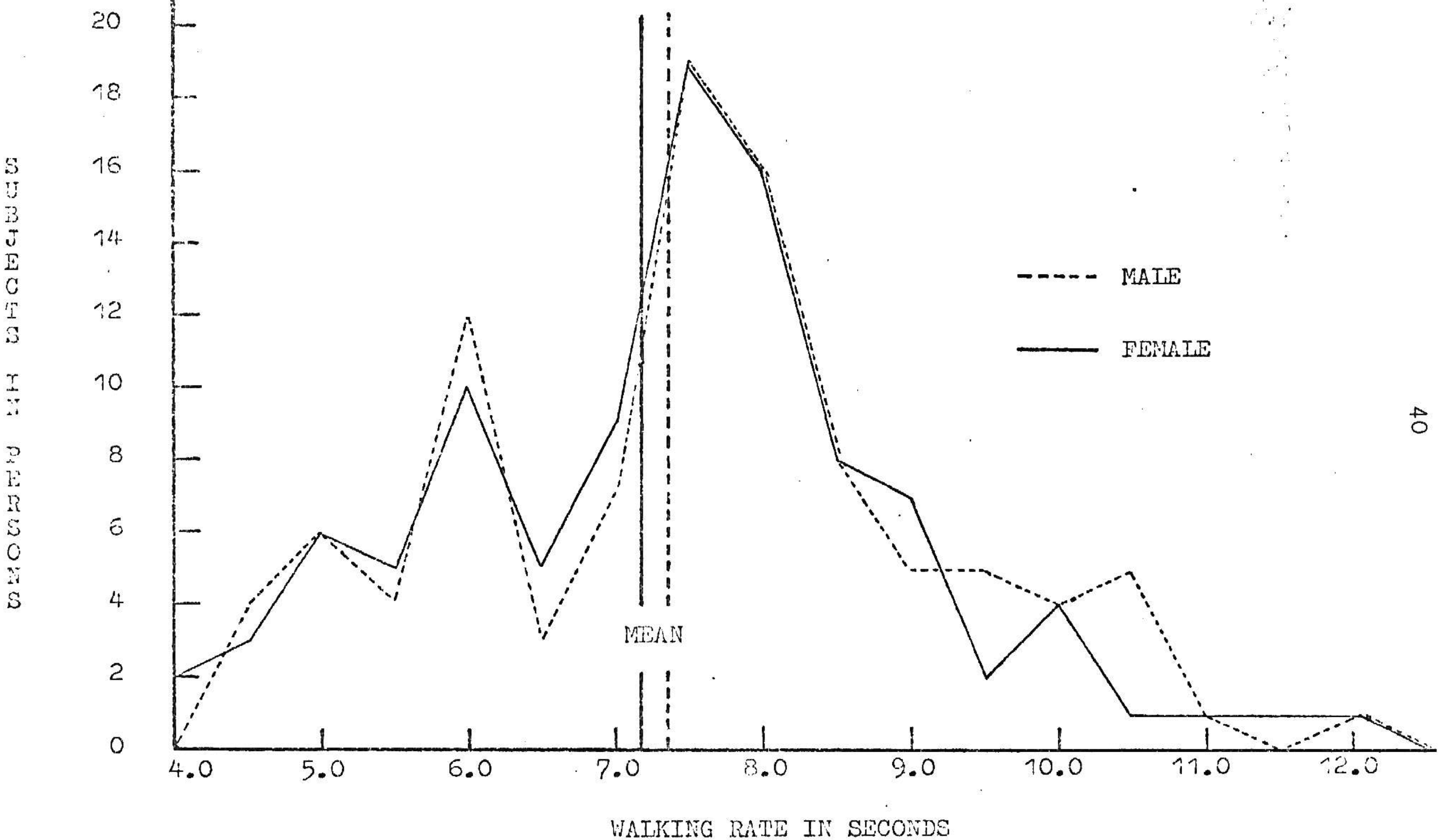
NIGHT (MALE)

OBSERVATION	TIME	OBSERVATION	TIME
1	8.3	26	7.2
2	5.7	27	7.4
3	8.3	28	4.6
4	5.6	29	7.2
5	6.6	30	7.9
6	5.9	31	5.8
7	6.8	32	7.6
8	5.2	33	6.0
9	6.4	34	7.8
10	8.2	35	6.6
11	4.4	36	7.3
12	5.8	37	7.4
13	8.0	38	4.6
14	5.0	39	7.0
15	7.4	40	8.4
16	5.6	41	10.1
17	5.4	42	7.5
18	7.9	43	4.7
19	4.1	44	8.5
20	6.4	45	7.7
21	7.9	46	7.4
22	5.9	47	9.5
23	4.3	48	7.1
24	6.0	49	5.9
25	7.9	50	5.3

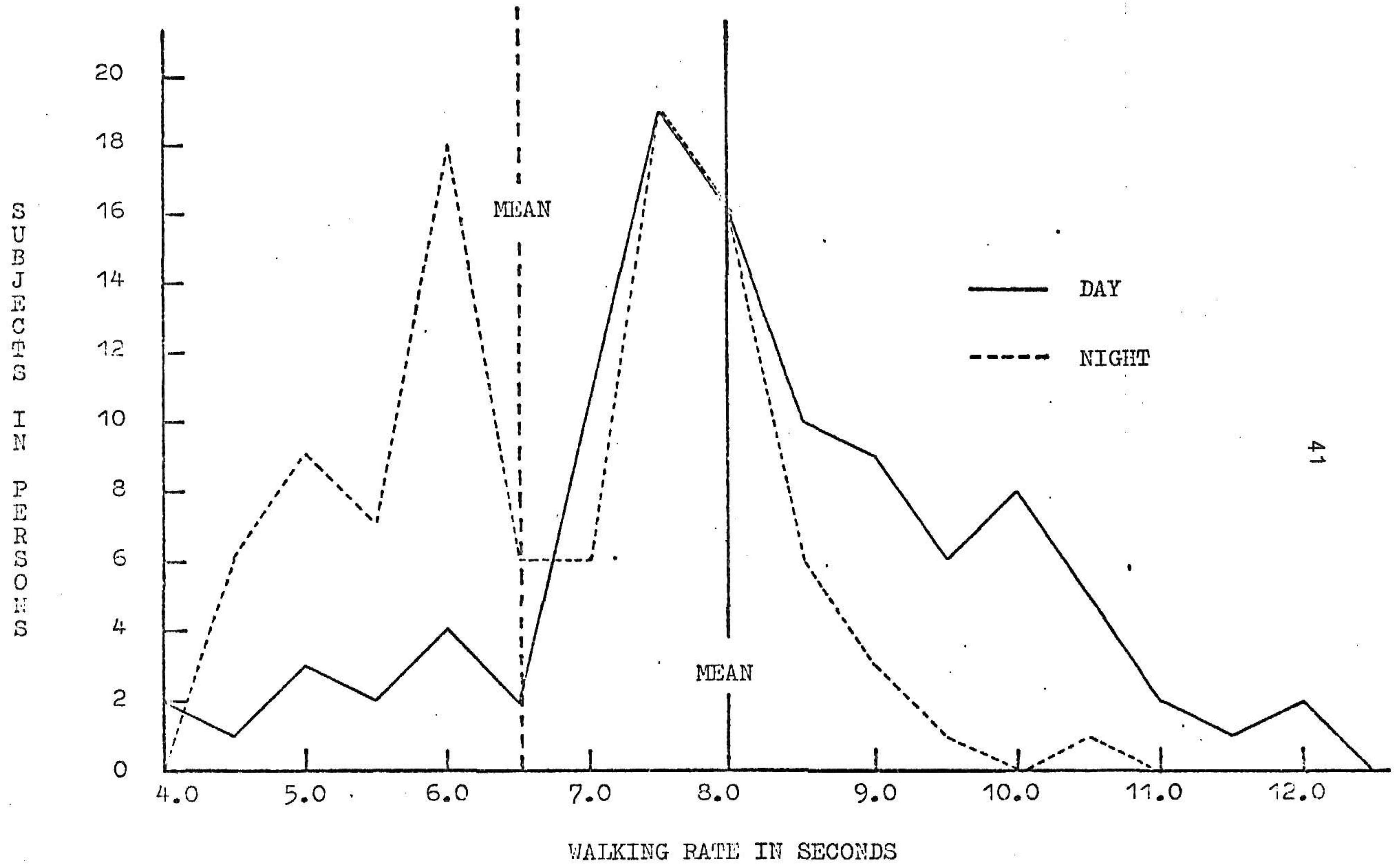
NIGHT (FEMALE)

OBSERVATION	TIME	OBSERVATION	TIME
1	3.6	26	7.6
2	4.1	27	4.6
3	6.7	28	5.5
4	7.7	29	5.9
5	4.7	30	5.8
6	5.9	31	7.1
7	7.3	32	7.4
8	5.3	33	5.9
9	5.6	34	7.7
10	7.6	35	8.1
11	7.1	36	7.8
12	6.4	37	7.9
13	4.5	38	8.9
14	5.8	39	7.2
15	7.1	40	7.6
16	8.0	41	5.8
17	4.4	42	6.3
18	6.1	43	7.1
19	4.9	44	7.4
20	3.8	45	5.2
21	8.3	46	5.9
22	8.8	47	6.5
23	4.6	48	6.8
24	7.2	49	5.2
25	7.2	50	5.0

APPENDIX 2



MALE-TOTAL SUBJECTS vs FEMALE-TOTAL SUBJECTS



TOTAL SUBJECTS-DAY vs TOTAL SUBJECTS-NIGHT

APPENDIX 3

ANALYSIS OF WALKING RATE DATA WITH RESPECT TO THE REQUIREMENTS OF THE STUDENT'S-t TEST

ΣX:	total walking time
N:	number of observation
$\Sigma X/N$:	average walking time
$(\Sigma X)^2$:	square of total walking time
$(\Sigma X)^2/N$:	correction factor; square of total walking time devided by total number of observation
ΣX^2:	total of squared individual walking time
Σx^2:	equals to $\Sigma(X - \bar{X})^2$, also equals to $\Sigma X^2 - (\Sigma X)^2/N$

DAY

	MALE	FEMALE	TOTAL
ΣX	400.8	398.2	799.0
N	50	50	100
$\Sigma X/N$	8.02	7.96	7.99
$(\Sigma X)^2$	160,640.64	158,563.24	638,401.00
$(\Sigma X)^2/N$	3,213.81	3,171.26	6,384.01
ΣX^2	3,345.66	3,273.92	6,619.58
Σx^2	132.85	102.66	235.57

NIGHT

ΣX	335.5	318.9	654.4
N	50	50	100
$\Sigma X/N$	6.71	6.38	6.74
$(\Sigma X)^2$	112,560.25	101,697.21	428,239.36
$(\Sigma X)^2/N$	2,251.21	2,033.94	4,282.39
ΣX^2	2,345.85	2,122.65	4,468.50
Σx^2	94.64	88.71	186.11

	TOTAL MALE	TOTAL FEMALE
ΣX	736.3	717.1
N	100	100
$\Sigma X/N$	7.36	7.17
$(\Sigma X)^2$	542,137.69	514,232.41
$(\Sigma X)^2/N$	5,421.38	5,142.32
ΣX^2	5,691.51	5,396.57
Σx^2	270.13	254.25

APPENDIX 4

STUDENT'S-t TEST CALCULATIONS FOR THE WALKING RATE EXPERIMENT

$$SE_{diff} = \sqrt{\frac{\Sigma x_1^2 + \Sigma x_2^2}{N_1 + N_2 - 2} \left(\frac{1}{N_1} + \frac{1}{N_2} \right)}$$

Where x_1^2 is the sum of the squared deviations from the mean for the first sample, while x_2^2 is the sum of the squared deviations from the mean for the second sample.

We estimate standard error (SE_{diff}) by pooling the sums of squared deviation from the respective two sample means. In other words, we estimate it by means of adding the sum of squared deviations from first sample and second sample, then divided by $N_1 + N_2 - 2$ degrees of freedom.

$$t = \frac{\bar{X}_1 - \bar{X}_2}{SE_{diff}}$$

Subtract the mean of second sample from the mean from first sample, then divided by standard error of two samples. If either samples are amall and the population variances are unknown, we can test the null hypothesis on an suitable t statistic, provided it is reasonable to assume that both populations are normal distributions with same variance. Under this condition it can be shown that the sampling distribution of the statistic is the t distribution with $N_1 + N_2 - 2$ degrees of freedom.

MALE-DAY vs FEMALE-DAY

$$SE = \sqrt{\frac{132.85 + 102.66}{50 + 50 - 2}\left(\frac{1}{50} + \frac{1}{50}\right)} = \sqrt{\frac{235.51}{2450}}$$

$$= \sqrt{0.0961} = 0.31$$

$$t = \frac{8.02 - 7.96}{0.31} = \frac{0.06}{0.31} = 0.1935$$

MALE-NIGHT vs FEMALE-NIGHT

$$SE = \sqrt{\frac{94.64 + 88.71}{50 + 50 - 2}\left(\frac{1}{50} + \frac{1}{50}\right)} = \sqrt{\frac{183.35}{2450}}$$

$$= \sqrt{0.0748} = 0.2735$$

$$t = \frac{6.71 - 6.38}{0.2735} = \frac{0.33}{0.2735} = 1.2066$$

MALE-TOTAL vs FEMALE-TOTAL

$$SE = \sqrt{\frac{270.13 + 254.25}{100 + 100 - 2}\left(\frac{1}{100} + \frac{1}{100}\right)} = \sqrt{\frac{524.38}{9900}}$$

$$= \sqrt{0.0530} = 0.2302$$

$$t = \frac{7.36 - 7.17}{0.2302} = 0.8341$$

MALE-DAY vs MALE-NIGHT

$$SE = \sqrt{\frac{132.85 + 94.64}{50 + 50 - 2}\left(\frac{1}{50} + \frac{1}{50}\right)} = \sqrt{\frac{227.49}{2450}}$$

$$= \sqrt{0.0929} = 0.3048$$

$$t = \frac{8.02 - 6.71}{0.3048} = \frac{1.31}{0.3048} = 4.2979$$

FEMALE-DAY vs FEMALE -NIGHT

$$SE = \sqrt{\frac{102.66 + 88.71}{50 + 50 - 2}\left(\frac{1}{50} + \frac{1}{50}\right)} = \sqrt{\frac{191.37}{2450}}$$

$$= \sqrt{0.0781} = 0.2795$$

$$t = \frac{7.96 - 6.38}{0.2795} = \frac{1.58}{0.2795} = 5.5630$$

TOTAL SUBJECTS-DAY vs TOTAL SUBJECTS-NIGHT

$$SE = \sqrt{\frac{235.57 + 186.11}{100 + 100 - 2}\left(\frac{1}{100} + \frac{1}{100}\right)} = \sqrt{\frac{421.68}{9900}}$$

$$= \sqrt{0.0426} = 0.2064$$

$$t = \frac{7.99 - 6.74}{0.2064} = \frac{1.25}{0.2064} = 60.562$$

SE: standard error

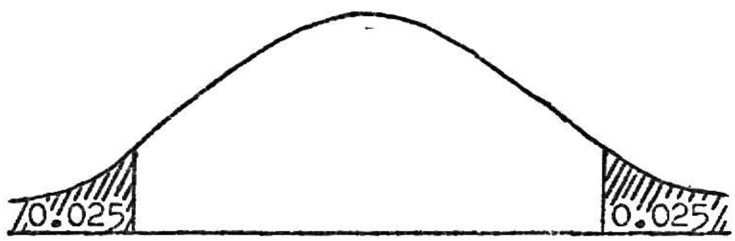
t: obtained value from the equation

$$t = \frac{\overline{X}_1 - \overline{X}_2}{SE_{diff}}$$

d.f.: obtained from $N_1 + N_2 - 2$ degrees of freedom

t_c: critical value of t, obtained from statistical table.
in this experiment, we use risk 0.05, since this experiment uses two-tail test, it is t = 0.025 for each tail.

the comparison of the test is between the obtained t value and the critical t value. If the obtained t value is greater than the critical t value, we accept the null hypothesis. if not, we reject the null hypothesis.



1. Male-day ve Female-day

   a) SE = 0.31

   b) $t = 0.1935$

   c) d.f. = 98

   d) $t_c = 1.960$

   e) t is smaller than t_c

   f) The difference was not significant

2. Male-night vs Female-night

   a) SE = 0.2735

   b) $t = 1.2066$

   c) d.f. = 98

   d) $t_c = 1.960$

   e) t is smaller than t_c

   f) The difference was not significant

3. Male-total vs Female-total

   a) SE = 0.2302

   b) $t = 0.8341$

   c) d.f. = 198

   d) $t_c = 1.960$

   e) t is smaller than t_c

   f) The difference was not significant

4. Male-day vs Male-night

   a) SE = 0.3048

   b) $t = 4.2979$

   c) d.f. = 98

   d) $t_c = 1.960$

   e) t is greater than t_c

   f) The difference was significant

5. Female-day vs Female-night

   a) SE = 0.2795

   b) $t = 5.6530$

   c) d.f. = 98

   d) $t_c = 1.960$

   e) t is greater that t_c

   f) The difference was significant

6. Total subjects-day vs Total subjects-night

   a) SE = 0.2064

   b) $t = 6.0562$

   c) d.f. = 198

   d) $t_c = 1.960$

   e) t is greater than t_c

   f) The difference was significant

APPENDIX 5

ACCEPTABLE GAP INTERVAL DATA CLASSIFIED BY SEX, AGE AND DIRECTION

NOTE:

1. any number without a star in the right upper corner is a near-side gap.
2. any number with a star in the right upper corner is a far-side gap.
3. any number with a bottom line is a used datum.
4. any number without a bottom line is an unused datum.
5. in the "MARK" column, Y represents young subjects, O represents old subjects, and C represents child subjects.
6. "E-BOUND" represents the traffic gap produced by east-bound vehicles. "W-BOUND" represents the traffic gap produced by west-bound vehicles.

DAY (8:30-9:30)

MALE

MARK	E-BOUND	W-BOUND
Y	5.0	17.7*
Y	7.2*	6.1
Y	19.0*	7.8
Y	6.0	20.0*
Y	19.2	12.5*
Y	9.0*	13.1
Y	13.8	24.0*
Y	11.1*	8.7
Y	7.6*	4.2
Y	19.2*	8.8
Y	10.6*	37.1
Y	4.2	19.2*
Y	10.9*	17.5
Y	10.0	11.4*
Y	7.8	24.0*
Y	7.9	17.0*
Y	6.6	9.6*
Y	6.1	16.0*
Y	7.2*	18.7
Y	6.2	22.8*
Y	10.2*	17.9
Y	10.0	16.2*
Y	6.6	21.0*
Y	5.7	13.2*
Y	6.8	8.0*
Y	8.8	11.2*
Y	9.8*	5.9
Y	13.8*	9.1
Y	12.7*	9.6
Y	6.6	12.7*
Y	6.0	12.1*
Y	8.5	16.8*
Y	12.0	8.5*
Y	10.8	11.6*
Y	7.4	7.6*
Y	7.9	10.0*
Y	4.8	9.9*
Y	7.5	15.0*
38		

TOTAL	SUBJECTS	MEAN
256.3	33	7.77
263.4*	25*	10.53*

FEMALE

MARK	E-BOUND	W-BOUND
Y	6.8	8.0*
Y	15.0	13.7*
Y	13.3*	8.5
Y	9.2	14.6*
Y	18.0	8.9*
Y	12.6	18.1*
Y	7.0	25.2*
Y	16.2	11.2*
Y	9.6	13.8*
Y	4.8*	13.8
Y	6.6	26.0*
Y	13.2*	19.8
Y	9.6*	29.2
Y	10.0	16.2*
Y	9.8	13.2*
Y	7.9	10.9*
Y	9.6	24.8*
Y	11.5	21.7*
Y	12.2	10.3*
Y	10.8*	11.6
Y	8.6	10.6*
Y	15.2	5.2*
Y	13.0	9.5*
Y	9.0	12.5*
Y	12.2*	13.6
Y	11.4	12.6*
Y	7.4	16.7*
Y	9.6*	10.1
Y	10.6*	10.0
29		

TOTAL	SUBJECTS	MEAN
235.0	22	10.68
244.1*	22*	11.09*

DAY (9:30-10:30)

MALE

MARK	E-BOUND	W-BOUND
Y	16.4*	7.8
Y	5.4	12.7*
Y	5.8*	7.7
Y	8.8*	11.5
Y	12.0*	4.9
Y	6.4	7.2*
Y	9.4*	7.8
Y	18.7	8.5*
Y	8.2	9.7*
Y	8.5	18.0*
Y	6.7	11.3*
Y	11.6*	10.7
Y	16.7*	14.3
Y	6.7	12.7*
Y	4.9*	7.9
Y	10.2	16.2*
Y	9.8*	7.0
Y	9.6	10.3*
Y	5.4	7.9*
Y	8.5	11.4*
Y	4.2	7.0*
Y	9.6*	6.6
Y	5.7	9.8*
Y	8.2	8.0*
Y	10.4*	6.9
Y	8.7*	12.0
Y	5.6	17.2*
27		

TOTAL	SUBJECTS	MEAN
204.4	26	7.86
222.5*	22*	10.11*

FEMALE

MARK	E-BOUND	W-BOUND
Y	12.8	14.8*
Y	9.0	24.3*
Y	6.6*	10.8
Y	10.3*	12.1
Y	9.4	7.8*
Y	20.4*	10.2
Y	5.3	10.4*
Y	5.3	11.4*
Y	8.3*	6.5
Y	8.6*	17.6
Y	7.9*	9.5
Y	3.8	6.7*
Y	9.6	24.0*
Y	15.1*	7.3
Y	6.6	12.0*
Y	11.2	5.4*
Y	4.4	8.8*
Y	13.2*	7.6
Y	10.9	7.0*
19		

TOTAL	SUBJECTS	MEAN
152.2	18	8.45
155.3*	16*	9.70*

DAY (10:30-11:30)

MALE

MARK	E-BOUND	W-BOUND
Y	7.0*	11.7
Y	4.9	10.8*
Y	9.1*	7.2
Y	11.8*	9.5
Y	19.2	11.6*
Y	4.0	7.4*
Y	5.8	14.0*
Y	14.9*	8.0
Y	18.0*	4.2
Y	5.8	10.2*
Y	14.0*	23.4
Y	14.8	9.7*
C	10.9	21.2*
Y	24.9*	3.7
Y	9.6	14.3*
Y	2.2	10.2*
Y	16.8*	7.4
Y	8.9*	15.6
Y	8.1	21.1*
Y	10.0	9.0*
Y	4.1	24.0*
Y	3.6	15.1*
Y	3.7	16.2*
Y	13.3*	11.8
Y	11.2*	13.2
Y	4.5*	20.5
Y	9.6	24.1*
Y	5.2	15.1*
Y	19.2	4.1*
Y	8.7*	4.9
Y	4.2	14.7*
Y	12.6*	8.9
32		

TOTAL	SUBJECTS	MEAN
182.2	26	7.01
262.2*	24*	10.93*

FEMALE

MARK	E-BOUND	W-BOUND
O	9.5*	7.6
Y	8.9*	9.1
Y	6.5	7.2*
Y	9.1*	7.3
Y	4.5	10.8*
Y	7.4	18.5*
Y	5.1	14.3*
Y	10.3*	23.4
Y	10.8*	7.3
Y	12.6	12.7*
Y	9.6	24.7*
Y	11.0*	13.1
O	6.7	9.7*
13		

TOTAL	SUBJECTS	MEAN
96.8	12	8.07
114.3*	11*	10.39*

DAY (11:30-12:30)

MALE

MARK	E-BOUND	W-BOUND
Y	10.4*	9.5
Y	12.0*	7.1
Y	8.9*	16.9
Y	11.0	25.8*
Y	12.4*	6.0
Y	9.6*	5.6
Y	26.9*	12.6
Y	10.9*	11.4
Y	4.2	11.2*
Y	7.9	13.3*
O	9.1*	7.2
Y	19.8*	8.4
Y	12.6*	16.1
Y	8.5	13.8*
Y	7.8	10.7*
Y	11.3*	6.7
Y	9.6*	8.5
Y	12.0*	14.3
Y	4.8	8.4*
Y	8.0*	8.9
Y	8.0	24.4*
Y	7.3*	9.7
Y	12.5*	8.6
Y	4.9	7.7*
Y	11.5	14.6*
Y	10.2	9.5*
Y	5.4	12.0*
Y	7.8*	9.0
Y	6.8*	9.8
Y	9.0*	7.8
Y	5.8	6.7*
Y	7.7*	6.6
Y	6.4	7.8*
33		

TOTAL	SUBJECTS	MEAN
241.5	30	8.05
306.2*	30*	10.21*

FEMALE

MARK	E-BOUND	W-BOUND
Y	12.5*	6.5
Y	14.0*	6.7
Y	11.6*	13.9
O	12.2	14.3*
O	16.2*	9.0
O	10.2*	23.4
Y	10.9	25.1*
Y	28.4*	13.4
Y	6.7*	12.4
Y	9.7	15.0*
Y	10.8*	6.0
Y	14.3	20.4*
Y	6.6	25.9*
Y	5.6*	7.2
Y	7.1	8.9*
Y	7.8	7.2*
Y	15.1*	13.1
Y	8.2	8.0*
Y	6.8	12.4*
19		

TOTAL	SUBJECTS	MEAN
171.8	18	9.54
152.3*	14*	10.88*

DAY (12:30-1:30)

MALE

MARK	E-BOUND	W-BOUND
Y	9.3*	3.0
Y	13.8*	4.1
Y	10.2*	13.3
Y	18.0	9.0
Y	4.2*	24.0
Y	8.4	8.5*
Y	7.7*	5.8
Y	8.3*	10.0
Y	10.9*	5.9
Y	8.9	10.8*
Y	19.2	8.5*
Y	4.8	12.9*
Y	8.1	11.3*
Y	13.0	8.0*
Y	7.0*	24.0
Y	13.3	9.4*
Y	10.3	10.7*
O	13.8*	12.1
Y	11.1*	11.7
Y	6.1*	8.4
Y	3.7	5.6*
Y	7.2	10.8*
Y	6.1	7.8*
Y	6.0*	7.4
Y	5.7*	3.1
Y	9.1	17.5*
Y	13.0*	9.1
Y	4.5	11.3*
Y	5.5*	13.9
Y	5.7	14.2*
Y	12.3	9.7*
Y	9.6	18.0*
Y	4.1	10.0*
Y	6.9*	7.4
Y	3.3	13.3*
35		

TOTAL	SUBJECTS	MEAN
247.6	31	7.99
311.3*	33*	9.43*

FEMALE

MARK	E-BOUND	W-BOUND
Y	13.6*	10.1
Y	10.0*	5.6
Y	11.3	7.2*
Y	8.4*	8.9
Y	8.5*	6.5
Y	7.0*	6.7
Y	11.0	24.0*
Y	16.1*	6.0
O	17.5	7.7*
Y	4.3	12.6*
Y	14.3	15.4*
Y	8.4*	10.6
O	20.4*	12.4
Y	7.2	10.8*
Y	16.1*	11.6
Y	10.7*	11.8
Y	4.9*	7.2
Y	12.9	10.4*
Y	12.4*	17.5
Y	6.6	20.9*
Y	9.3*	4.8
Y	13.6*	10.6
O	19.2	12.0
Y	10.4	18.0
Y	24.0*	10.8
Y	13.2*	27.0
Y	10.8	12.6*
Y	11.8	13.4*
Y	11.3*	9.4
29		

TOTAL	SUBJECTS	MEAN
233.6	25	9.34
233.4*	22*	10.61*

DAY (1:30-2:30)

MALE

MARK	E-BOUND	W-BOUND
Y	5.9	8.6*
Y	13.2*	10.1
Y	7.7	18.6*
Y	10.5	14.3*
Y	3.6	16.9*
Y	8.5*	8.4
Y	11.8*	3.0
Y	11.9	9.6*
O	6.3*	9.6
Y	7.1*	2.4
Y	14.3	16.1*
Y	7.6*	6.0
Y	9.7	12.7*
Y	12.9*	7.1
Y	6.0	5.3*
O	9.1	17.3*
Y	7.7	12.4*
Y	11.1*	11.9
Y	18.0	8.6*
Y	21.6	13.9*
Y	5.8	16.8*
Y	18.8*	5.6
Y	5.5	12.7*
Y	3.5	9.8*
Y	5.0*	21.0
Y	2.8	24.0*
Y	13.9*	4.9
Y	24.0*	3.7
Y	12.4	10.4*
Y	7.0	16.9*
Y	7.8	11.9*
Y	10.7*	24.0
Y	9.3*	8.0
Y	6.3	10.2*
Y	11.7	11.1*
Y	8.4*	11.4
Y	7.8*	3.1
Y	18.5*	5.4
38		

TOTAL	SUBJECTS	MEAN
249.8	34	7.35
285.1*	28*	10.18*

FEMALE

MARK	E-BOUND	W-BOUND
Y	5.4*	6.7
Y	7.1	16.8*
Y	5.6	13.6*
Y	19.3*	7.1
Y	9.5	9.9*
Y	8.5*	8.3
Y	14.3*	16.1
Y	9.7	13.2*
Y	7.9*	18.7
Y	8.0	13.4*
Y	9.0	9.7*
Y	11.4*	25.2
Y	16.9*	15.0
Y	13.7	14.3*
Y	9.7*	4.1
Y	13.3	19.1*
Y	7.6	7.4*
Y	7.9	16.1*
Y	10.2*	7.3
Y	4.7*	11.9
O	8.0	14.0*
Y	11.4	5.3*
Y	3.6	13.0*
23		

TOTAL	SUBJECTS	MEAN
159.8	19	8.41
185.9*	18*	10.33*

DAY (2:30-3:30)

MALE

MARK	E-BOUND	W-BOUND
Y	6.5*	6.0
Y	9.0	10.8*
Y	16.8*	10.8
Y	13.8	6.5*
Y	3.6	8.4*
Y	5.4*	9.7
Y	14.4*	5.7
Y	7.8*	12.6
Y	9.1*	3.8
Y	7.2*	6.3
Y	3.6	9.0*
Y	12.6*	7.8
Y	5.9*	11.7
Y	7.9	10.7*
Y	10.8*	7.1
Y	19.4*	6.3
Y	7.7	9.3*
Y	4.9	7.4*
Y	7.1	12.0*
Y	23.0*	5.0
Y	4.3	6.6*
Y	12.8	11.4*
Y	7.2*	4.8
Y	8.9	22.1*
Y	9.8*	11.9
Y	6.0	18.2*
Y	5.3	9.6*
Y	14.4	13.2*
Y	4.3	11.0*
Y	7.0*	5.8
Y	10.2	9.8*
31		

TOTAL	SUBJECTS	MEAN
231.0	31	7.45
239.4*	26*	9.21*

FEMALE

MARK	E-BOUND	W-BOUND
Y	13.9	7.2*
Y	7.4	13.1*
Y	8.3	16.1*
Y	14.4*	7.4
Y	10.8	14.4*
Y	7.2*	7.6
Y	11.3	18.1*
Y	12.6*	8.5
Y	15.6	12.2*
Y	7.8	24.2*
Y	23.4	13.1*
Y	10.6*	6.2
Y	5.5	8.9*
Y	7.0	11.4*
Y	7.2*	9.6
Y	12.6*	17.6
Y	8.8*	4.9
19		

TOTAL	SUBJECTS	MEAN
128.7	16	8.04
180.1*	16*	11.25*

DAY (3:30-4:30)

MALE

MARK	E-BOUND	W-BOUND
Y	10.8	13.0*
Y	9.1	12.1*
Y	8.8*	13.0
Y	11.6	13.6*
O	9.4	13.0*
Y	10.9*	9.1
Y	13.0*	15.4
Y	7.2*	7.1
Y	11.5*	11.4
Y	5.4*	8.7
Y	9.7	11.1*
Y	8.4*	5.0
Y	4.3	9.3*
Y	8.0*	6.6
Y	24.0	4.3*
Y	14.4*	17.7
Y	6.4*	5.6
Y	15.6*	6.0
Y	10.0*	6.1
Y	8.4*	9.1
Y	7.6*	11.8
Y	10.2	13.8*
Y	7.0*	4.6
O	8.8*	4.0
Y	12.6	9.8*
Y	7.8	10.8*
Y	13.7*	8.9
Y	5.7*	4.2
Y	6.0	12.7*
Y	6.6*	9.6
Y	7.0	10.6*
Y	6.0*	6.7
33		

TOTAL	SUBJECTS	MEAN
248.0	30	8.27
301.9*	32*	9.43*

FEMALE

MARK	E-BOUND	W-BOUND
Y	8.4*	6.7
Y	9.6*	19.2
Y	7.3*	8.2
Y	11.8	13.2*
Y	7.8	11.0*
Y	9.0*	7.8
Y	7.4*	10.0
Y	8.8	10.6*
Y	9.1*	10.9
Y	9.1*	7.2
Y	10.5*	7.6
Y	4.4	12.7*
Y	6.0*	10.5
Y	9.4	12.0*
Y	4.3	8.2*
Y	7.8	26.2*
Y	7.5*	15.6
Y	8.2*	7.6
Y	8.6	19.2*
Y	7.2*	12.4
Y	9.1*	6.4
Y	14.3*	36.6
Y	13.2	13.2*
23		

TOTAL	SUBJECTS	MEAN
171.4	20	8.57
203.6*	21*	9.69*

NIGHT (5:30-6:30)

MALE

MARK	E-BOUND	W-BOUND
Y	11.8*	5.6
Y	8.5	20.3*
Y	11.3*	9.8
Y	9.6*	10.1
Y	9.2	13.4*
C	12.0*	10.1
Y	14.2*	9.2
Y	7.8	18.9*
Y	14.2*	11.4
Y	13.1*	10.7
Y	9.4*	7.4
Y	14.3	24.8*
Y	19.6*	10.2
Y	17.7	14.4*
Y	12.1	27.7*
Y	6.1	12.1*
Y	11.9	21.1*
Y	14.6*	15.8
Y	9.6*	20.8
O	8.8*	8.8
Y	12.6*	8.4
Y	11.0	11.7*
Y	9.0*	7.4
Y	14.0*	11.2
Y	6.8	13.0*
Y	16.6*	7.8
Y	8.4	8.4*
Y	11.9	15.2*
Y	13.2*	5.3
Y	13.8	9.0*
Y	14.3*	17.0
31		

TOTAL	SUBJECTS	MEAN
255.0	27	9.44
288.9*	24*	12.04*

FEMALE

MARK	E-BOUND	W-BOUND
Y	13.2*	12.8
Y	10.2*	9.7
Y	10.0	11.6*
Y	13.4*	9.8
Y	7.8*	8.8
Y	9.1	17.8*
Y	19.4*	9.1
Y	10.4*	9.9
Y	7.0	7.9*
Y	14.2*	12.8
Y	12.0*	6.4
Y	11.3	12.7*
Y	9.0*	7.8
Y	6.2*	7.9
Y	10.4	20.3*
15		

TOTAL	SUBJECTS	MEAN
142.8	15	9.52
128.6*	12*	10.72*

NIGHT (6:30-7:30)

MALE

MARK	E-BOUND	W-BOUND
Y	14.2*	7.3
Y	10.0*	9.6
Y	10.2	8.4*
Y	4.2	13.8*
Y	12.0*	10.2
Y	14.0	20.9*
Y	7.7	7.7*
Y	4.8	23.0*
Y	16.9*	10.2
Y	14.1*	7.3
Y	6.1	26.5*
Y	6.1	16.1*
Y	5.3	16.1*
Y	17.2*	10.8
Y	19.9	7.6*
Y	7.1	20.9*
Y	9.2	15.0*
Y	13.7*	6.7
Y	31.4*	12.7
Y	14.2	15.0*
Y	8.5	12.0*
Y	9.2*	12.0
22		

TOTAL	SUBJECTS	MEAN
184.2	21	8.77
152.7*	14*	10.91*

FEMALE

MARK	E-BOUND	W-BOUND
Y	9.0	14.2*
Y	19.8	6.5*
Y	6.4	26.6*
Y	15.2*	9.2
Y	7.1	20.9*
Y	5.4	18.7*
Y	13.1*	9.1
Y	18.1	27.1
Y	9.0*	7.8
Y	9.6	24.0*
O	8.8	14.9*
Y	13.0*	11.5
Y	9.0	6.8*
Y	10.5	13.7*
14		

TOTAL	SUBJECTS	MEAN
108.1	12	9.01
106.4*	9*	11.82*

NIGHT (7:30-8:30)

MALE

MARK	E-BOUND	W-BOUND
Y	9.0	10.7*
Y	11.0	7.6*
Y	6.0	11.4*
Y	8.2	9.5*
Y	21.5*	4.6
Y	10.9	19.4*
Y	14.4*	14.3
Y	13.5*	7.3
Y	5.4	27.1*
Y	9.7*	9.2
Y	13.6*	8.0
Y	14.4	15.3*
Y	12.8	16.3*
Y	6.1	6.6*
Y	5.2	8.6*
Y	3.7	14.3*
Y	7.3	11.1*
Y	10.9	10.3*
Y	6.6*	12.8
Y	6.1	11.6*
Y	13.9	25.2*
Y	7.7	19.8*
Y	14.0	10.4*
Y	7.1	8.5*
24		

TOTAL	SUBJECTS	MEAN
215.9	24	9.00
193.6*	18*	10.76*

FEMALE

MARK	E-BOUND	W-BOUND
Y	19.7*	10.1
Y	6.3	14.3*
Y	8.9	17.3*
Y	14.4*	14.3
Y	9.7	9.2*
Y	12.8	16.3*
O	15.6	11.6*
Y	11.6	10.2*
O	6.6	12.8*
Y	27.5*	7.2
Y	7.7	12.4*
Y	7.6*	9.1
Y	10.2	8.9*
13		

TOTAL	SUBJECTS	MEAN
114.5	12	9.54
101.4*	9*	11.27*

APPENDIX 6

ANALYSIS OF THE ACCEPTABLE DATA WITH RESPECT TO THE REQUIREMENTS OF THE STUDENT'S-t TEST

DAY

	MALE		FEMALE		TOTAL	
	NEAR SIDE	FAR SIDE	NEAR SIDE	FAR SIDE	NEAR SIDE	FAR SIDE
ΣX	61.75	80.02	71.70	83.94	132.85	163.96
N	8	8	8	8	16	16
$\Sigma X/N$	7.72	10.00	8.89	10.49	8.30	10.24
$(\Sigma X)^2$	3813.0625	6403.2004	5055.2100	7045.9236	17649.1225	26882.8816
$(\Sigma X)^2/N$	476.6327	800.4001	631.901	880.7404	1103.0702	1680.1801
ΣX^2	477.8531	802.8898	637.6516	883.1442	1115.5077	1686.0340
Σx^2	1.2234	2.4897	5.7506	2.4038	12.4375	5.8539

NIGHT

ΣX	27.21	33.71	28.07	33.81	55.28	67.52
N	3	3	3	3	6	6
$\Sigma X/N$	9.07	11.24	9.35	11.27	9.21	11.25
$(\Sigma X)^2$	740.3841	1136.3641	787.9249	1143.1161	3055.8784	4558.9504
$(\Sigma X)^2/N$	246.7947	378.7880	262.6416	381.0387	509.3131	759.8251
ΣX^2	247.0265	379.7673	262.8221	381.6437	509.8486	761.4110
Σx^2	0.2318	0.9793	0.1805	0.6050	0.5355	1.5859

	MALE'S TOTAL		FEMALE'S TOTAL	
ΣX	88.96	113.73	99.17	117.75
N	11	11	11	11
$\Sigma X/N$	8.09	10.34	9.02	10.70
$(\Sigma X)^2$	7913.8816	12934.5129	9834.6889	13865.0625
$(\Sigma X)^2/N$	719.4438	1175.8648	894.0626	1260.4602
ΣX^2	724.8797	1182.6571	900.4737	1264.7879
Σx^2	5.4359	6.7923	6.4111	4.3277

APPENDIX 7

t-TEST CALCULATIONS FOR THE ACCEPTANCE EXPERIMENT

1. MALE-DAY vs FEMALE-DAY

NEAR-SIDE

$$SE = \sqrt{\frac{1.2234 + 5.7506}{8 + 8 - 2}\left(\frac{1}{8} + \frac{1}{8}\right)}$$

$$= \sqrt{0.1245} = 0.3528$$

$$t = \frac{8.99 - 7.72}{0.3528} = 3.5998$$

FAR-SIDE

$$SE = \sqrt{\frac{2.4897 + 2.4038}{8 + 8 - 2}\left(\frac{1}{8} + \frac{1}{8}\right)}$$

$$= \sqrt{0.0873} = 0.2956$$

$$t = \frac{10.49 - 9.96}{0.2956} = 1.7930$$

2. MALE-NIGHT vs FEMALE-NIGHT

NEAR-SIDE

$$SE = \sqrt{\frac{0.2318 + 0.1805}{3 + 3 - 2}\left(\frac{1}{3} + \frac{1}{3}\right)}$$

$$= \sqrt{0.0687} = 0.2621$$

$$t = \frac{9.76 - 9.09}{0.2621} = 1.0301$$

FAR-SIDE

$$SE = \sqrt{\frac{0.9793 + 0.6050}{3 + 3 - 2}\left(\frac{1}{3} + \frac{1}{3}\right)}$$

$$= \sqrt{0.264} = 0.5139$$

$$t = \frac{11.21 - 11.34}{0.5139} = -0.2530$$

3. MALE-TOTAL vs FEMALE-TOTAL

NEAR-SIDE

$$SE = \sqrt{\frac{5.4359 + 6.4111}{11 + 11 - 2}\left(\frac{1}{11} + \frac{1}{11}\right)}$$

$$= \sqrt{0.1077} = 0.3282$$

$$t = \frac{9.07 - 8.04}{0.3282} = 3.1383$$

FAR-SIDE

$$SE = \sqrt{\frac{6.7923 + 4.3277}{11 + 11 - 2}\left(\frac{1}{11} + \frac{1}{11}\right)}$$

$$= \sqrt{0.1011} = 0.3180$$

$$t = \frac{10.62 - 10.24}{0.3180} = 1.1950$$

4. MALE-DAY vs MALE-NIGHT

NEAR-SIDE

$$SE = \sqrt{\frac{1.2234 + 0.2318}{8 + 3 - 2}\left(\frac{1}{8} + \frac{1}{3}\right)}$$

$$= \sqrt{0.0741} = 0.2722$$

$$t = \frac{9.09 - 7.72}{0.2722} = 5.0331$$

FAR-SIDE

$$SE = \sqrt{\frac{2.4897 + 0.9793}{8 + 3 - 2}\left(\frac{1}{8} + \frac{1}{3}\right)}$$

$$= \sqrt{0.1767} = 0.4204$$

$$t = \frac{11.34 - 9.96}{0.4204} = 3.2826$$

5. FEMALE-DAY vs FEMALE-NIGHT

NEAR-SIDE

$$SE = \sqrt{\frac{5.7506 + 0.1805}{8 + 3 - 2}\left(\frac{1}{8} + \frac{1}{3}\right)}$$

$$= \sqrt{0.302} = 0.5495$$

$$t = \frac{9.36 - 8.99}{0.5495} = 0.6733$$

FAR-SIDE

$$SE = \sqrt{\frac{2.4038 + 0.6050}{8 + 3 - 2}\left(\frac{1}{8} + \frac{1}{3}\right)}$$

$$= \sqrt{0.1532} = 0.3914$$

$$t = \frac{11.21 - 10.49}{0.3914} = 1.8396$$

6. TOTAL-DAY vs TOTAL-NIGHT

NEAR-SIDE

$$SE = \sqrt{\frac{12.4375 + 0.5355}{16 + 6 - 2}\left(\frac{1}{16} + \frac{1}{6}\right)}$$

$$= \sqrt{0.1486} = 0.3855$$

$$t = \frac{9.22 - 8.35}{0.3855} = 2.2568$$

FAR-SIDE

$$SE = \sqrt{\frac{5.8539 + 1.5859}{16 + 6 - 2}\left(\frac{1}{16} + \frac{1}{6}\right)}$$

$$= \sqrt{0.0852} = 0.2919$$

$$t = \frac{11.27 - 10.22}{0.2919} = 3.5971$$

1. MALE-DAY vs FEMALE-DAY

NEAR-SIDE

a) SE = 0.3528

b) t = 3.5998

c) d.f. = 14

d) t_c = 2.145

e) t is greater than t_c

f) The difference was significant

FAR-SIDE

a) SE = 0.2956

b) t = 1.7930

c) d.f. = 14

d) t_c = 2.145

e) t is smaller than t_c

f) The difference was not significant

2. MALE-NIGHT vs FEMALE-NIGHT

NEAR-SIDE

a) SE = 0.2621

b) t = 1.0301

c) d.f. = 4

d) t_c = 2.776

e) t is smaller than t_c

f) The difference was not significant

FAR-SIDE

a) SE = 0.5139

b) t = 0.2530

c) d.f. = 4

d) t_c = 2.776

e) t is smaller than t_c

f) The difference was not significant

3. MALE-TOTAL vs FEMALE-TOTAL

NEAR-SIDE

a) SE = 0.3282

b) t = 3.1383

c) d.f. = 20

d) t_c = 2.086

e) t is greater than t_c

f) The difference was significant

FAR-SIDE

a) SE = 0.3180

b) t = 1950

c) d.f. = 20

d) t_c = 2.086

e) t is smaller than t_c

e) The difference was not significant

4. MALE-DAY vs MALE-NIGHT

NEAR-SIDE

a) SE = 0.2722

b) $t = 5.0331$

c) d.f. = 9

d) $t_c = 2.262$

e) t is greater than t_c

f) The difference was significant

FAR-SIDE

a) SE = 0.4204

b) $t = 3.2826$

c) d.f. = 9

d) $t_c = 2.262$

e) t is greater than t_c

f) The difference was significant

5. FEMALE-DAY vs FEMALE-NIGHT

NEAR-SIDE

a) SE = 0.5495

b) $t = 0.6733$

c) d.f. = 9

d) $t_c = 2.262$

e) t is smaller than t_c

f) The difference was not significant

FAR-SIDE

a) SE = 0.3914

b) $t = 1.8396$

c) d.f. = 9

d) $t_c = 2.262$

e) t is smaller than t_c

f) The difference was not significant

6. TOTAL SUBJECTS-DAY vs TOTAL SUBJECTS-NIGHT

NEAR-SIDE

a) SE = 0.3855

b) $t = 2.2568$

c) d.f. = 20

d) $t_c = 2.086$

e) t is greater than t_c

f) The difference was significant

FAR-SIDE

a) SE = 0.2919

b) $t = 3.5971$

c) d.f. = 20

d) $t_c = 2.086$

e) t is greater than t_c

f) The difference was significant

A STUDY OF PEDESTRIAN'S WALKING RATE AND ACCEPTABLE GAP INTERVAL WHEN CROSSING THE STREET

by

HSI CHIH LIN (JIMMY)

B.S., Taipei Institute of Technology, 1968

AN ABSTRACT OF MASTER'S REPORT

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MASTER OF SCIENCE

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1974

ABSTRACT

The purpose of this study was to determine the difference in pedestrian walking rate and gap interval acceptance distribution when crossing the street between day and night.

A particular T type intersection in Manhattan, Kansas was selected for the study. Fifty male and fifty female subjects were observed during both the day and the night for the walking rate experiment. There were 267 male and 185 female observations in the daytime, 77 male and 42 female at nighttime in the gap acceptance experiment.

The Student's-t test was introduced to examine the data. The results showed that walking rate for the subjects was significantly faster at night than in the daytime, but the difference between male and female was not significant in either day or night.

The difference of acceptable gap between day and night was significant when comparing the subject total in near-side and far-side gap. But the rest of the comparisons suggest that the acceptable gap for men was shorter than women in the daytime, but no significant difference was shown at night.

Also, a polynomial curve fitting computer program was used in an attempt to find the relationship between acceptable gap and traffic flow. It is hard to certain the relationship between these two variables since it has a low correlation coefficient, besides, we could plot any curve on the figure which would fit almost as well as the one from the computer.