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Physiological Study of Blood Pressure and Heart Rate at Road Intersections

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Abstract – *Intersections are the critical road network where two or more roads meet and are connected. There were two types of intersections, which are signalized and unsignalized. Next, the physiological factor of a driver is one of the indicators for the condition of the driver. A condition such as drowsiness and fatigue that could affect the focus and performance of drivers during driving could be the major cause of traffic accidents. Besides that, stress and tension could lead to a temporary increased in blood pressure and heart rate of drivers. In this research, drivers aged 20 to 30 years old have been selected and the driver's blood pressure and heart rate have been sampled by using OMRON digital wrist blood pressure monitor before, during, and after driving, including their driving speed. Thus, the focus of this study was to study Physiological behavior while driving throughout a signalized intersection. An analysis by using the Regression Method to obtain the r-squared value has been applied to determine the correlation level between both of the variables. According to the sampling software, 36 participants are required to be tested. But due to Movement Control Order (MCO), only six participants were successfully sampled. A signalized T-junction of Jalan Persiaran Kayangan near Universiti Selangor (UNISEL), Shah Alam has been selected, and by the data obtained, we could determine the driving behavior of drivers in a real-life situation.*

Keywords: Driver behavior, blood pressure, heart rate, intersection, T-junction, driving experience, speeding

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1.0 INTRODUCTION

Different drivers have different behavior which could be affected by the way the perceives any variable and obstacles during driving throughout a course. These behaviors that require high cognitive, visual, and motor reactions to identify the next selection course of action during driving is crucial so that any accidents and errors in driving could be avoided (Freydier et al.,

2016). In an intersection, either it was signalized or non-signalized, the probability of a car crashed is higher due to a complicated decision that requires experience to go through it safely (Brookhuis & De Waard, 2010).

The intersection is one of the critical road networks where it connects and joins two or more roads. It could be signalized or non-signalized and classifications usually vary by the number of roads it connects. Figure 1 shows the example of a typical design of a signalized T-junction.

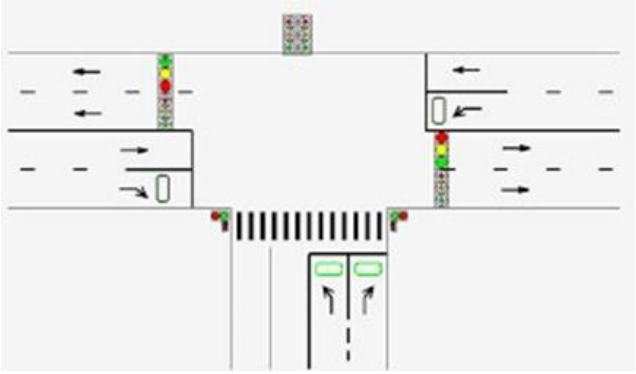

Figure 1: Example of T-junction

In this research, the objectives were to identify the speed of vehicles, driver's blood pressure, and heart rate; to establish the trend pattern of driver's behavior based on the speed of vehicles, driver's blood pressure, and heart rate; to develop the relationships between drivers' speed, blood pressure, and heart rate in the critical road network

Next, physiological behavior is a health indicator where the responses show the mental condition of a person (Xu et al., 2018). By learning this behavior, the condition of the drivers either they are good in health to drive through a certain course could be determined (Rendon-Velez et al., 2016). Blood pressure is the pressure of the blood within the arteries, while Heart rate is the measure of how many heartbeats per minute. Each person has different blood pressure and heart rate level. Various activities could affect physiological behavior such as physical activities, feeling threatened, or even nervousness (Batrakova et al., 2016). And the major focus of this study was to determine these indicators' levels while driving through an intersection. The data obtained will be studied for further discussions and conclusions.

2.0 METHODOLOGY

2.1 General Flow Chart

Figure 2 shows the general flowchart of the methodology in this research.

2.2 Location

The location that has been selected for this research was the signalized T-junction nearby Universiti Selangor (UNISEL). Figure 3 shows the location taken by using Google Maps.

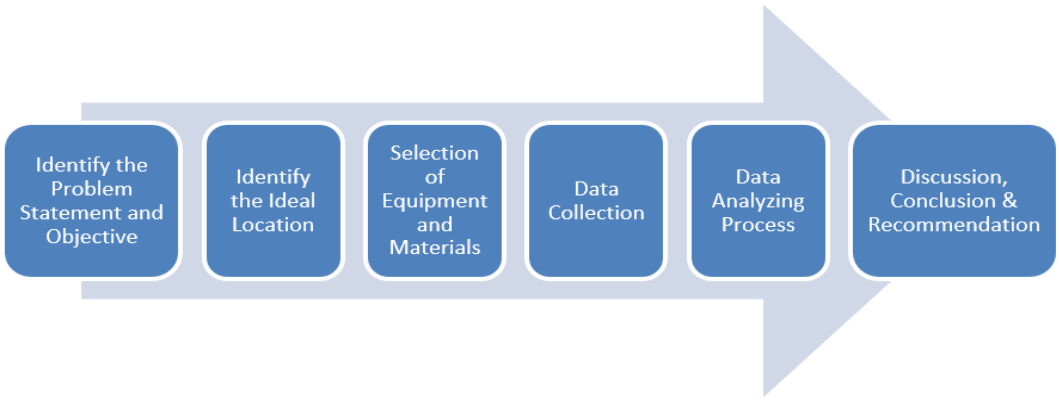

Figure 2: General flowchart of the research

Figure 3: T-junction of Persiaran Kayangan (nearby UNISEL)

2.3 Equipment and Materials

Figure 4 shows the OMRON digital wrist blood pressure monitor. This equipment was able to read and examine the blood pressure of the participants during driving throughout this research. The blood pressure and heart rate measurements were taken in millimeters of mercury (mmHg) and bpm respectively.

Figure 4: OMRON digital wrist blood pressure monitor

2.4 Data Collection

The data that was taken is the blood pressure and heart rate by using OMRON digital wrist blood pressure monitor, the age of drivers, and the driving speed by self-monitoring. Initially, the sample size calculator using Daniel Soper (Figure 5) shows that 36 youths have been selected. But due to the pandemic of Covid-19, Movement Control Order (MCO) has been enforced which causing the data sampling to stop. The data obtained was only from 6 participants.

The participant's blood pressure and heart rate were measured in three phases, which are before, during, and after driving throughout the intersection where three readings will be taken in each phase to increase the data accuracy. The data were collected from 2 P.M. until 4 P.M. on weekdays where there were non-peak hours at the roundabout. The unit for the blood pressure is in mmHg and heart rate in bpm. All readings taken will be described by classification by following the guidelines from the Ministry of Health Malaysia (MOH).

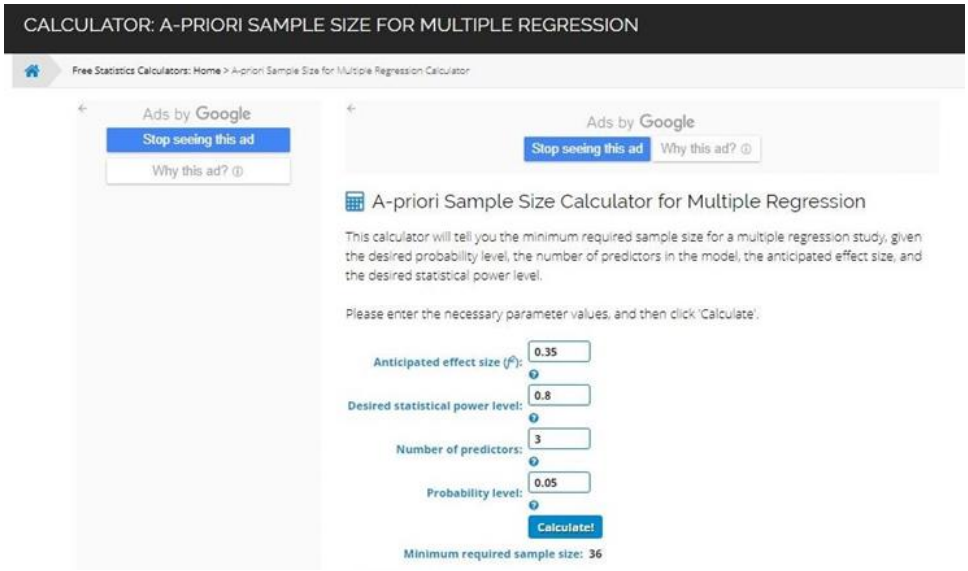

Figure 5: Sample Size Calculator using Daniel Soper

3.0 RESULTS AND DISCUSSION

The tables below show the data obtained from the participants before, during, and after going through the intersection.

3.1 Before Entering the Intersection

Based on the data obtained, 83% of the participants have a lower blood pressure than the recommended healthy range, which is 90 mmHg to 120 mmHg. While none of the drivers has high blood pressure during the test was conducted.

Table 1 shows that the lowest speed of the participants was 24 km/h and the highest was 28 km/h. While the highest speed also has the highest maximum blood pressure reading, which is 126 mmHg while having a reading of 84 bpm. Besides, the second-highest driving speed, which is 27 km/h has a maximum blood pressure reading of 111 mmHg and a 90 bpm heart rate.

Table 1: Data of speed, average maximum and minimum blood pressure and average heart rate of participants before entering the intersection

Driver	Speed (km/h)	Average Maximum BP (mmHg)	Average Minimum BP (mmHg)	Average Heart Rate (bpm)
1	25	89	52	73
2	27	111	70	90
3	25	115	80	89
4	24	116	62	80
5	24	117	80	78
6	28	126	86	84

Based on relationships of average maximum blood pressure and heart rate against speed obtained in Figure 6, the R^2 reading for Blood Pressure and Heart rate were 0.086 and 0.2485. Both of the graphs have a steadily positive relationship with speed.

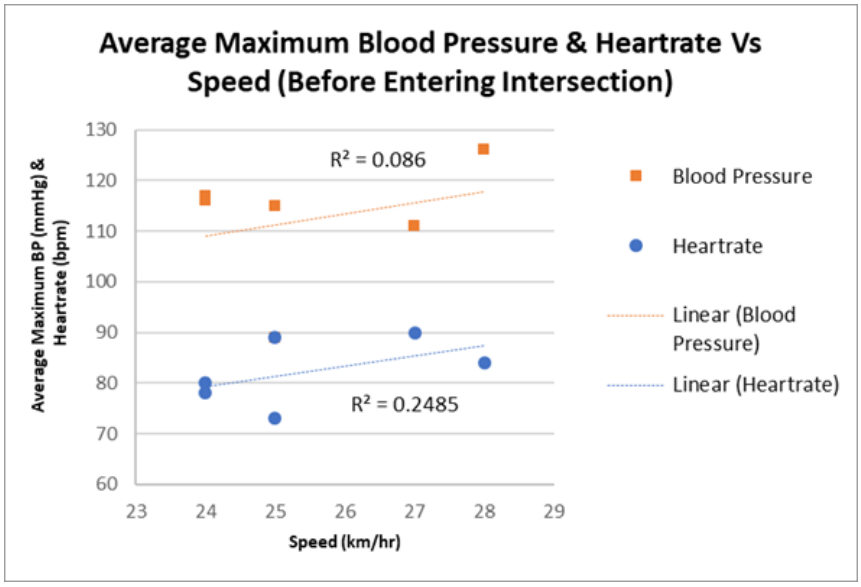

Figure 6: Graph of blood pressure and heart rate vs. speed for before entering the intersection

3.2 Driving Through the Intersection

Table 2 shows the data physiological data obtained from the participant while driving through the intersection. The highest speed is 29 km/h, where the same participants also have the second-highest of the heart rate which is 98 bpm, and 103 mmHg of blood pressure. Next, the lowest speed was 22 km/h, where the blood pressure was the highest 116 mmHg, and heart rate 97 bpm.

Table 2: Data of speed, average maximum and minimum blood pressure and average heart rate of participants driving through the intersection

Driver	Speed (km/h)	Average Maximum BP (mmHg)	Average Minimum BP (mmHg)	Average Heart Rate (bpm)
1	26	97	55	79
2	29	103	60	98
3	27	113	68	95
4	22	116	91	97
5	26	104	71	85
6	27	98	67	101

Figure 7 shows the relationship between average maximum blood pressure and heart rate against the speed obtained during driving through the intersection. The blood pressure shows a steadily negative relationship where the R^2 obtained was 0.2975. While for heart rate, the relationship obtained was steadily positive with an R^2 of 0.0092.

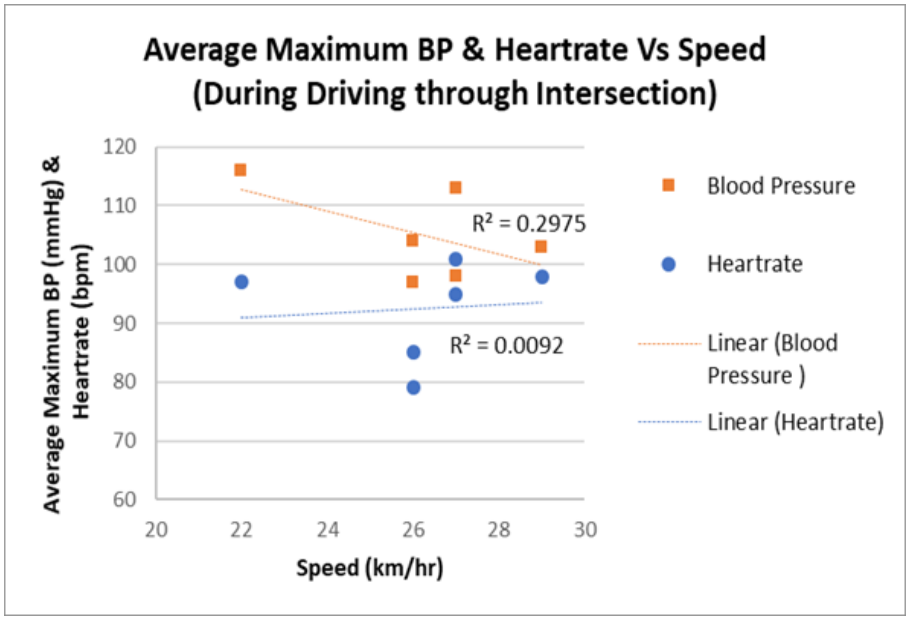

Figure 7: Graph of blood pressure and heart rate vs. speed for during driving through the intersection

3.3 After Exiting the Intersection

According to Table 3, the highest speed was 20 km/h, which was followed by the highest blood pressure and heart rate which is 113 mmHg and 91 bpm respectively. The average speed during exiting the intersection was 26 km/h.

Table 3: Data of speed, average maximum and minimum blood pressure and average heart rate of drivers exiting the intersection

Driver	Speed (km/h)	Average Maximum BP (mmHg)	Average Minimum BP (mmHg)	Average Heart Rate (bpm)
1	26	87	54	71
2	24	101	64	83
3	29	113	77	91
4	25	118	76	78
5	25	110	77	72
6	27	108	73	87

Figure 8 shows the data obtained for the relationship between average maximum blood pressure and heart rate against speed after exiting the intersection. Both of the relationships show a steadily positive relationship, where the R^2 were 0.0302 and 0.3697 for blood pressure and heart rate respectively.

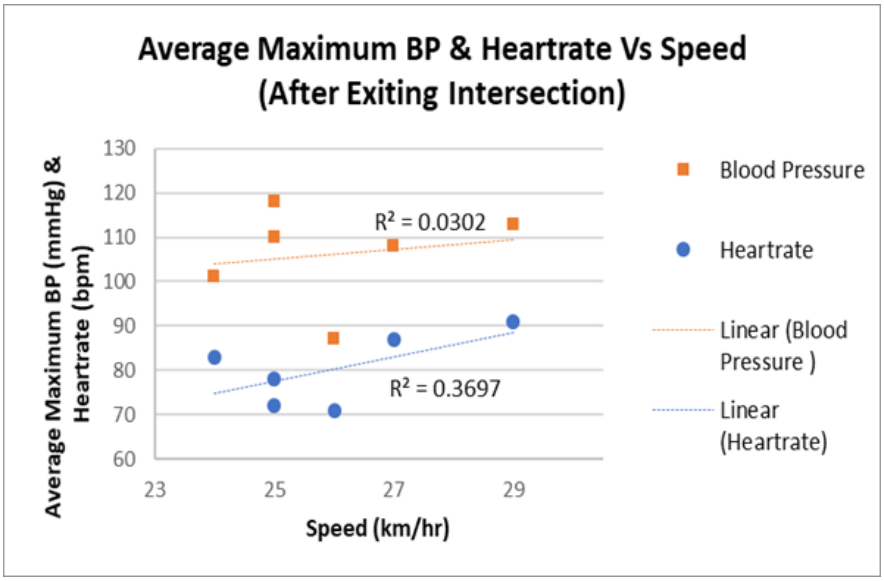

Figure 8: Graph of blood pressure and heart rate vs. speed after exiting the intersection

According to the field test that has been conducted, the drivers' physiological data of blood pressure and heart rate along with their driving speed has been obtained. Table 1 shows the data obtained before entering the intersection. Before entering, the highest driving speed was 28 km/h, where the blood pressure and heart rates were 126 mmHg and 84 bpm respectively. In this area, it shows that the physiological readings were high due to the cognitive process of determining the proper steering angle and speed to cross over the intersection in a safe manner (Bou et al., 2017). While the lowest speed was 24 km/h, followed by the second lowest heart rate of 78 bpm and 117 mmHg of blood pressure reading. By referring to Figure 6, the steadily positive relationships for both the blood pressure and heart rate obtained show a steadily positive relationship, where the range of the R^2 obtained is from 0.2 – 0.09.

While in Table 2, the highest driving speed was 29 km/h, where the blood pressure and heart rate obtained were 103 mmHg and 98 bpm respectively. On the other hand, the lowest speed obtained was 22 km/h, where the blood pressure and heart rates were 116 mmHg and 97 bpm. During driving through the intersection, the R^2 obtained in Figure 7 shows a steadily negative relationship (0.2975) comparing to the R^2 obtained in Figure 3 and Figure 8, which is 0.086 and 0.0302 respectively. Comparing these three data obtained shows that the drivers' blood pressure has decreased while driving through the intersection. According to (Wang et al., 2019), this was a sign of relief where they had successfully going into the intersection safely. Although the R^2 reading was far from 1.0, deeper research is needed to understand more of the human physiological behavior due to the cause of relationships involving human behavior tend to have a weaker correlation of coefficient. This is because people are hard to predict (Frost, 2018).

Lastly, R^2 in Figure 8 shows the same trend as in Figure 6 and Figure 7 which is a steadily positive relationship. The obtained value for R^2 of exiting the intersection was 0.0302 and 0.3697 for blood pressure and heart rate respectively. As mentioned by Frost (2018), studies that relate to human behavior generally have the value of R^2 less than 50% and a relationship that was in the range of 0 to 0.1, could be considered as a weak relationship.

4.0 CONCLUSION

To truly understand the way of human acts in a certain situation, physiological studies that have a various variable need to be conducted. In this research, the physiological responses of drivers by entering, driving through, and exiting the intersection have been successfully investigated. Based on the result obtained, the highest R^2 reading of blood pressure and heart rate obtained was 0.2975 and 0.3697 respectively. All these reading has shown a similar trend where a steadily positive gradient where the higher the speed, the higher the reading of the physiological behavior response. According to Silva et al. (2014), there were a lot of factors and variables that could affect the response of physiological behavior. Whereas in this research, speed was the main factor for the higher reading of blood pressure during driving. Further studies are needed to bring a better understanding of the factor that influence the reading of blood pressure during driving, especially at the unsignalized intersection.

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