Article 4

Analysing Driver Behaviour within Dilemma Zone at Signalised Intersection: The Observational and Survey Methods

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Abstract
Signalised intersections is deemed amongst complex issues in road safety control system. Due to the growing number of crashes at signalised intersection every year in Malaysia, this research aims at understanding driver behaviour at signalised intersection. This paper discusses the methods to analyse driver behaviour at signalised intersection, which consist of field data collection using video recording technique and administration of a survey pertaining to driving behaviour within dilemma zones with selected participants (car driver).The methods are designed to gain a better understanding of driver behavioursthat influence their decision-making of non-compliance at signalised intersection, within the dilemma zones.The main goal is to reveal driver responses at dilemma zone during amber signal light, with respect to the vehicle distance from stop line, signal timing and approaching speed.

Keywords:*driver behaviour, signalised intersection, dilemma zone, observational methods, survey methods*

Introduction
MIROS (2016) reported that 1.24 million road traffic deaths are recorded worldwide every year and the death toll in 2015 in Malaysia is 6 706, causing a loss to national economy up to RM 8.7 billion. The high rate of severity and the incurring cost after crashes at signalised intersection can negatively impact the country since the outcome of the result are damages of infrastructure, property and loss of lives. In order to maintain traffic safety, it is important to identify driver behaviours that lead to unsafe traffic conduct.
In the aspect of driving, the two terms that are commonly used and related to each other, but can cause confusion, are driver behaviour and driver performance. Driver performance can be defined as a condition of what the driver can do, as driver's knowledge, perceptual skills and cognitive abilities(Evans, 2004). In contrast, driver behaviour explains the driver choices on how to react with all attributes that has been mentioned before (Evans, 2004). For instance, the capability to control the vehicle speed and the ability to judge the speed, are driver performance aspects, while the speed chosen falls under driver behaviour aspect. According to Cacciabue & Carsten (2010), there are factors that influence the driver performance and behaviour which are attitudes/personality, experience, driver state (impairment level), task demand (workload) and situation awareness.

Traffic signal compliance is a main indicator in determining driver behaviour at signalised intersections, which in any case is not free of the whole condition at the intersection. Non-complying with traffic signal regulation leads to violations and eventually to near accidents or accidents. Drivers' behaviour can be influenced by other factors such as the intersection layout, trip purpose, flow conditions, weather conditions, and signal settings. It is stated that the driver generally face difficulty to decide whether they have to stop or proceed, when approaching the onset of amber light; which is known as dilemma zone (Jamil, Shahabadin, & Ho, 2012).

Dilemma Zone

Dilemma zone can be categorised into Type I and Type II, controlled and affected by different factors (Lavrens, Pyrialakou, & Gkritza, 2014; Machiani, 2014). A Type I dilemma zone, is a condition where the driver does not comply to clear the intersection during the onset of amber, which is a result from the physical parameters, such as the short of time of yellow phase, geometric characteristics of the road and vehicle speed limit (Machiani, 2014). On the other hand, Type II dilemma zone, involving difficult interpretation and prediction of driver behaviour, depends essentially on driver characteristics, impairment, and distraction level. In other words, a hard decision need to be made by driver in a short amount of time either to stop at the stop line of signalised intersection or vice versa. This research focuses on Type II dilemma zone.

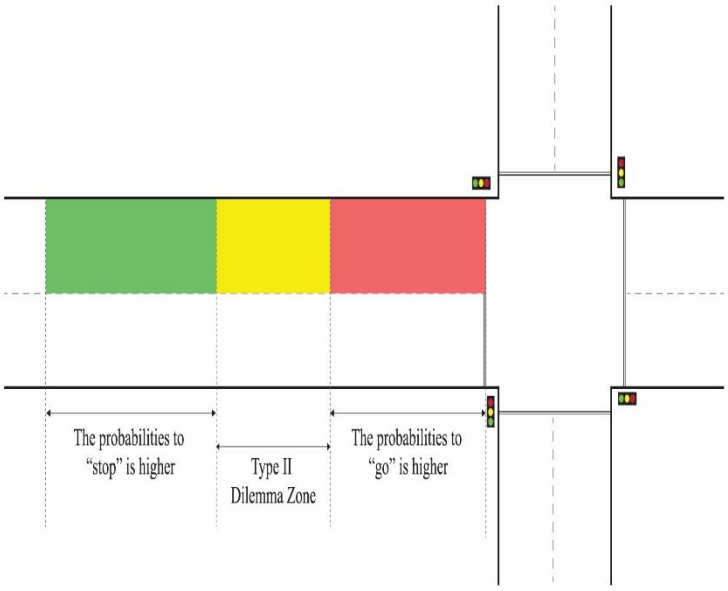
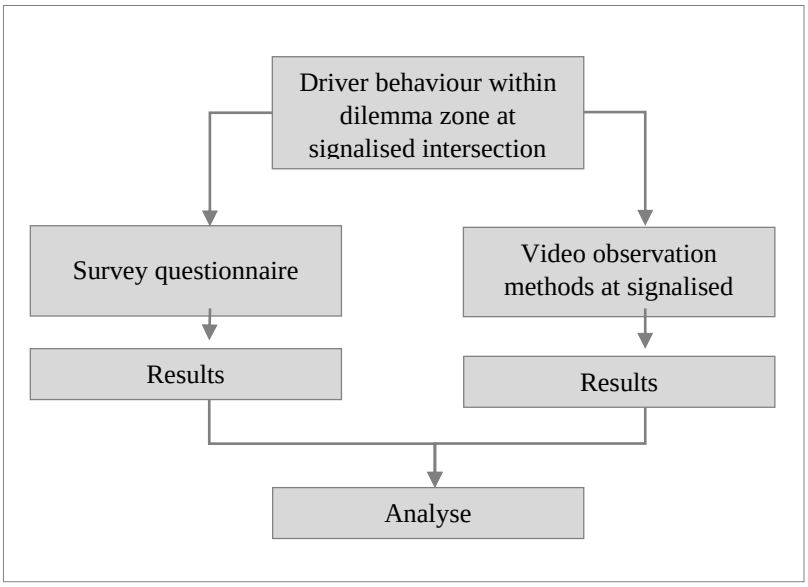


Figure 1: Type II Dilemma zone, adapted from Urbanik&Koonce(2007)

Driver behaviour and responses at dilemma zone during amber light and compliance to red signal light is important because the results will contribute to the rate of accident at signalised intersection. Therefore, it is important to develop a driver behaviour models based on localised subjects and scenarios, such as the traffic conditions, driver habits, and vehicles characteristics. Accordingly, the primary goal of this study is to develop knowledge of the characteristics of driver behaviour and compliance at signalised intersection and establish the driver behaviour models. In order to maintain traffic safety, it is important to identify driver behaviours that lead to unsafe traffic conducts.

The Methods to Study Driver Behaviour within Dilemma Zone

To study the driver behaviour at signalised intersection within the dilemma zone, an observational method and survey method is designed, as shown in Figure 2, which will fulfil the research objectives and to ensure the correct value of data is collected.



\Figure 2: Flow of the methods to study driver behaviour within dilemma zone

Data of driver responses to amber light are collected via observation and survey. Observation uses field video recording at signalised intersections, while survey will be carried out with any car driver who volunteers to participate in the study. The video data collected in the field will be used to analyse driver behaviours during amber light at signalised intersections on actual road, while the survey would be able to personally inquire participants' likely driving response during amber light.

i. Survey through questionnaire

This method focuses on the car's driver experiences and responses while approaching the signalised intersection during the amber signal light. A survey is developed and will be administered to a selected group of drivers through Google Form, a free online tool offered by Google to create and manage documents such as surveys. This survey responses will be stored online.

The main criteria of the survey's participant is they must be more than 18 years old, own a driving licence and have an experience of driving a car. All participants will be informed that their participation in the survey is voluntary and their responses and information will be discreet.

The questionnaire will be delivered in two ways; (1) via email link, or (2) the researcher will approach the selected participants and they will answer the questionnaire online, with the presence of researcher, so the researcher can explain in details if there is any inquiry regarding the question in the survey. In the former delivery, the questionnaire will be sent to selected participants via e-mail, which can be accessed and answered instantaneously. A user guide will

also be given before the participant access the questionnaire. It is to ensure the participant get a brief idea on what this survey is all about and how to answer the survey.
Before using the questionnaire for actual study, a reliability test will be conducted with 40 participants to compute the questionnaire's alpha value.

The outline of survey's question
The survey questionnaire will be divided into two sections. The first section of the survey will be inquiries of the basic personal information, such as participant's gender, age, years of driving experience and how often they drive. The second section will deliver questions regarding participants' response that could influence their decision during amber signal light at signalised intersection. The questions will include images of on-road situation at signalised intersection, along with short brief that will help them to answer the questions. Questions involving their driving response while in dilemma zones will also be designed, which include their prediction of the duration of the amber signal light, and an open-ended question regarding the factors that influence their decision-making. Participants will be advised to answer based on their actual behaviour while encountering the same traffic situation.

ii. Observation methodusing video recording
This method focuses on getting the quantitative data of driver behaviour within dilemma zone at signalised intersection. The recordings may help transpires the driver behaviour so that an understanding of driver's behaviourcan be achieved. Moreover, the video recording allows an opportunity to transcribe all the data needed and plays the video recording repeatedly, which is very useful in the analysis process.

The data collections
The data of driver behaviour from observation area will be collected via video recording, which includes (1) layout of the observation site, (2) particulars of the site as date, time, and weather conditions, (3) signal timing, and (4) traffic volume and violations. The observation location will be a signalized intersection nearby the university area, and consists two lanes for each directions. A video camera attached to a tripod will be installed 120 meters from stop line of signalised intersection, to get a clear view of video recording starts from 100 meters until stop line. The video recording will last for two hours during peak-off hours (10AM to 12PM) and peak hours (4PM to 6PM), considering different numbers of traffic congestion on a randomly selected weekday and weekend.

Conclusion
This paper discusses the design of observational and survey methods to study driver behaviourwithin the dilemma zone at signalised intersection. The decision-making process within the dilemma zone is critical because wrong decision could lead to a crash at signalised intersection during the amber light intervals. The questionnaire's purpose is to reveal specific factors that influence the driver's perception and decision-making during the amber light intervals. On the other hand, observational method using video recording technique is administered to get a quantitative result of driver behaviour within the dilemma zones during the amber light intervals. The quantitative data includes distance of non-compliant car from the traffic light, acceleration and deceleration rate of vehicle during the yellow light intervals, and brake perception-reaction time which impacted by the vehicle's time to stop line at intersection. The result of this study will provide necessary guidance for future study and could be used to develop scenarios in driving simulator.The new knowledge of local driver behaviour patterns from this research will allow us to make our road safer, which is in line with NKRA vision to improve transportation.

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