

# HAZARD PERCEPTION TEST AMONG YOUNG INEXPERIENCED DRIVERS AND RISK ANALYSIS WHILE DRIVING THROUGH A T-JUNCTION

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**Abstract:** *In this article, the hazard-based accident duration model and the reaction time due to various types of distractions are considered. This analysis is mainly considered T-junction or T-junctions like all other forms of road geometries which are more prone to accident. The model proposed is constructed by using a electronics devices along with driving simulator, to study the behavior of the yang inexperienced drivers as well as an experienced driver about their reaction by calling their phone from unknown numbers intentionally. The results show that drivers distracted by mobile phones uses the hard breaking due to least available time to respond after identification of an event. Some of the research and theory bearing on decision making and risk perception, driver situation awareness, and possible mediators of risk-taking is also analyzed here.*

**Key words:** *Accident Analysis, Decision Making, Driver Situation Awareness, Intersection Design, Modeling Of Driver Reaction Time, T-Junction, Traffic Accidents.*

## 1. Introduction

Traffic accidents are the single most common cause of injury (Dewan et al. 2016) and death among young people in all over the world (Kabir & Roy, 2020). Traffic signs and signals are necessary to meet the specifications set forth all over the country, and may differ from one another like driving lane of India and USA. Federally standardized signals and road signs provide pedestrians and drivers with the clear instructions sets they need to ensure minimum hazard on the highways. These instructions include about the sign and picture is made of, its color, and its shape (Fang et al. 2003). Ben-Bassat, et al. (2019) performed about twenty-seven ergonomics and human factors considered from 10 countries for analyzed the conventional sign relative to their expectation with the conventional sign with the same meaning. For example, diamond-

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shaped signs indicate a warning, whereas a circular sign with crossing indicates a railroad crossing (Almutairy et al. 2019). This is not always case, in the Europe countries warning is indicated by the signs with the triangle shape, and circular signs with white background and red bordure can indicate some limitation (e.g. speed limit) or can be used as information sign if it have circular shape, bluer background and white symbol. The color red is generally used dedicatedly for danger signs and lights, like the yield sign and the stop sign. Yellow indicates a warning message and cautionary message of some sort. Green with or without arrow provides directional guidance. Pavement markings like zebra crossing, side line, middle line, etc. provide pedestrians and drivers with information in the similar fashion that road signs do. This standardization and frequent use of symbols may be useful for those who can't understand the local language of the territory where they're driving, even for drivers who are color-blind.

There have been a number of reviews published in the last few years which have focused on accident risk (Eboli et al. 2020) and the possible causal factors underlying it (Schlögl, 2020). Along with geometric characteristics (Demasi et al., 2018), road surface conditions (Fancello et al. 2019), traffic status and driver behavior (Chang et al. 2019), weather conditions (Drosu et al. 2020) are among the most significant variables along with other causes (Mukherjee & Mitra, 2020) potentially influencing the incidence of highway crashes. Consequently, accidents due to the presence of different junctions and traffic on road have been in the focus of research efforts for several decades.

Traffic disruption is another possibility, and is a rising concern amongst legislators. Much analysis and interest in this field is linked to driver disruption, due in large part to the growing usage of cell phones and other technology by drivers (Backer-Grøndahl & Sagberg, 2011). The attention is about the mobile phone usage by drivers, highlighting the significance of the existing study, even though it is vital to recognize that many other disruption factors are also hazard triggers. Having this in view, the use of cell phones could be seen as an example of the wider driver interruption issue.

Driver disturbance continues an ambiguous and poorly described concept and may define as a diversion from tasks which are essential for driving safety to a competitive activity (Shahzad, 2020). Most of the research work that has already been published is basically based upon the braking behavior of the distracted drivers due to the usage of both hand held as well as hand free mobile phones during driving (McEvoy et al. 2006).

The main objective is to study the behavior of the drivers due to the combined effects of mobile phone usage like T- Junction, Y- Junction, 4 arms Junction, Staggered Junction and Round shape Junction.

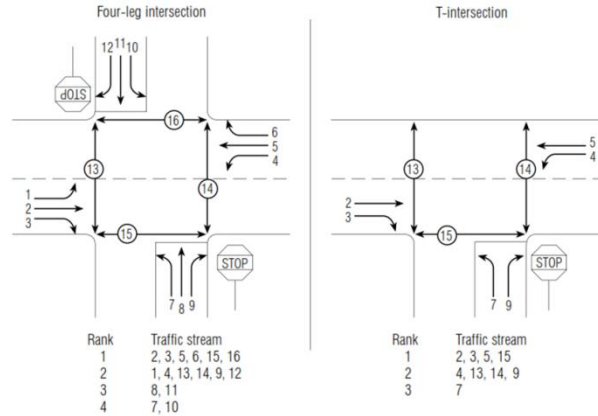
In order to design the proposed model effects of some external variables on the result has also been considered, such as speed of the vehicle, driving experience of the drivers, age and sex of the driver, duration and type of mobile phone usage during driving etc. To carry out this study a group of young distracted drivers within the age group of 18-25 years has been exposed to a T-junction where they interacts with incoming traffic from the other side of the road while driving. This study represents detailed analysis about the impacts of mobile phone conversation during driving through a T-Junction as well as measures the changes in the reaction time required by the drivers to stop the vehicle after detection of an event. The aim of this study is also to examine the reaction time (RT) taken by the drivers to stop the vehicle after detection of an event. To realize the effect of hazard exposure is on the driver situation awareness and effect with age and roadway complexity, the experiments done with the help of young (18–25 years), middle (26-35 years) and older (above 35 years)

Hazard Perception Test Among Young Inexperienced Drivers and Risk Analysis While ... participants drove in a simulator under rural and city environments. The studies investigated driver behavior using assistive device in yield-controlled T-junctions based on the reaction time. To identify the unique elements of the risk factors associated with fatal T junction crashes.

## **2. Research motivation**

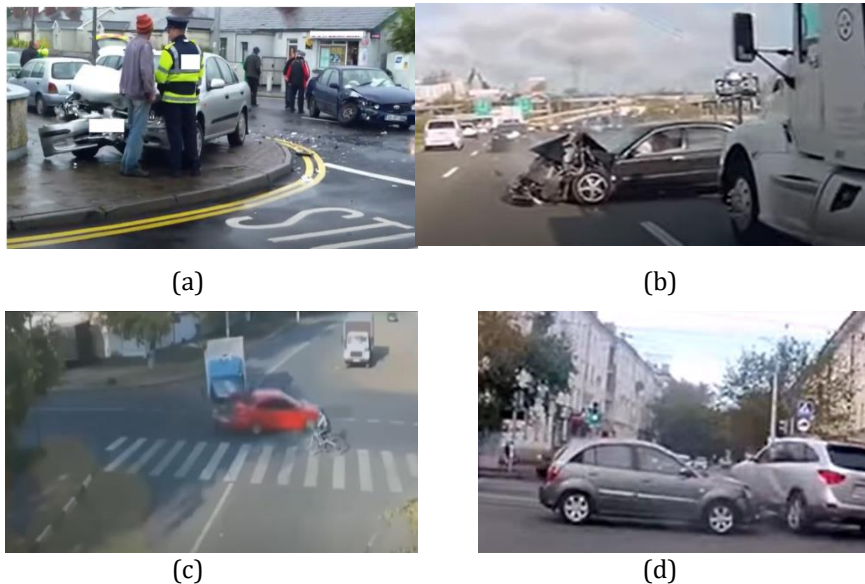
Accidents caused by distraction results in more number of injuries. Distraction can be various types such as- distraction caused by mobile phone conversations, typing during driving, looking the road side peoples etc. While driving, typing in mobile phones has more effect on drivers' actions as typing takes drivers' eyes off the road for more time than when the drivers engage in a call. Young drivers are more susceptible to distraction-related collisions, because the younger generation is more susceptible to use cell phones while driving than older ones. As can be seen from the literature review section, most of the research work based on the disruptions caused by cell phones has been conducted in developed countries like the US,, Canada, China, Korea etc. Despite being the second populous country in the world, only very few research work is carried out in developing countries such as India on the basis of disruptions caused by cell phones or other factors. This paper explores the effects of different types of distracted driving on accident severity and reaction time in Indian roads, particularly on rural roads. The current literatures as most of the studies are focused on disturbances caused by different forms of cell phone uses while driving (such as chat, text or multimedia). In addition, the present study is performed on several simulator-designed T-Junctions, as this type of junction is the most dangerous to drive between all other types of junctions. In addition, a comparative study of distracted and non-distracted driving and its effects on reaction time and braking activity is also presented in this work. Furthermore, in this work the impacts on the braking time due to the specific duration of cell phone usage and the amount of drug consumption while driving are also considered. Although some significant research work were conducted on the distractions caused by mobile phone usage during driving, the study findings explaining the cumulative impact of drug consumption and cell phone use are scarce available. The probability of drugs intake at night is unexpectedly high in comparison with day time (Das et al. 2012).

Several researchers were conducted over the mobile phone usage during driving that describes the variation in the reaction time due to distracted driving in comparison with the non-distracted driving. It is found that both the conversation and texting during has severe impact on the reaction time, as both conversation and texting distracts driver's focus from driving. Accident at the intersections is another major cause of road accidents. The standard shapes of T un-signalized intersection and Four-leg un-signalized intersections there are on the Fig 1 (Highway Capacity Manual , 2000) to flow the traffic smoothly.



**Figure 1.** Traffic streams at Four Leg intersection and T Junction of right hand side driving. Rank indicates the flow of traffic

Among all the types of junctions (T-Junction, Y-Junction, Round about Junction, Four arm Junction, Staggered Junction), accidents took place at the T-Junction contributes the most number of accidents in comparison with the accidents took place at all other junction (Robbins et al. 2019). In major cases of accidents at T-Junction the drivers are not aware of the incoming traffic from the other side of the road due to the presence of obstacles like walls, slow or stand by cars, road vendors, etc. as shown in the Figure 2.



**Figure 2.** Real images of accidents capture from CCTV footage (collected from web) occurred due to jumping red light also (a) due to the driver vision blocked by wall, and (b) slow moving truck, (c) driving on wrong side lane and (d) over speeding

If the driver is drunk or using mobile phone during driving then the combined effects of these can be very severe. A hazard based statistical approach has been utilized over here, in order to consider the impacts of mobile phone usage, video calling during driving with different ages and experience the non-distracted drivers. Combine effects of alcohol and mobile phone is not considered here due to the legal complexity and also not encourage, which is also considered criminal offence in India under Section 185 of the Motor Vehicles Act, 1988 (India, 2021).

### 3. Experimental Setup

The experimental technique was performed in a PS4 driving simulator by considering the health concerns of the participants. Logitech G29 force racing wheel is used as real time controller. The driving simulator is able to take input from accelerator, gear, brake, and steering wheel (Fig 3) for realistic driving experience with real jerking using force feedback. All participants completed an informed consent form and were voluntarily agreed for the said experiments. They were offered two different 10-min trial driving that would enable them to become familiar with the driving simulator. A helping team was instructed to create the experimental scenario and hazards. The choice route has multiple T-junctions. The participant experiences the near about same hazardous events while driving through the connecting arm of the T-Junctions. Behavior of the drivers when they face the hazardous event is collected with the help of the driving simulator that is used to measure the reaction time of the drivers. The difference between the time the hazards were noticed and the time the driver responded to the event, either by accelerating or by pressing the brake pedal is considered as the time of reaction.



**Figure 3.** Driving simulator (a) real view with full camera setting, (b) Logitech G29 Force Racing Wheel for realistic driving experience

The number of participants were 20 including 14 male and 6 are female. The driving experience variable it can be observed that 2 participants holds a driving experience of 0-1 year, whereas 9 participants holds minimum 2 years and maximum 4 years of experience and rest 7 participants hold more than 4 years of experience as details analysis is tabulated in Table 1.

**Table 1.** Sample Breakdown of Participants

Age group and number of drivers						
Gender	18-25 Years		26-35 Years		36-50 Years	
	Number	%	Number	%	Number	%
Female	3	50	2	33.33	1	16.67
Male	5	35.71	4	28.58	5	35.71

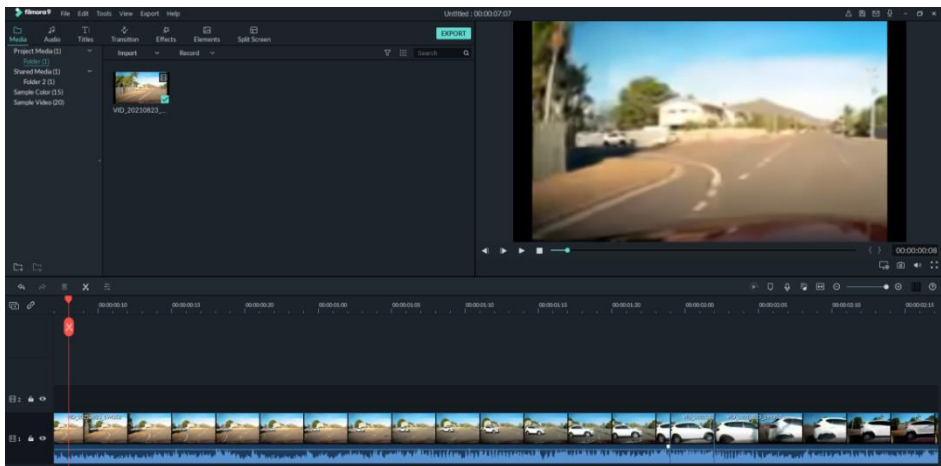
  

Driving experience in years						
Gender	0 - 1		2 - 4		Above 4	
	Number	%	Number	%	Number	%
Female	2	33.33	2	33.33	2	33.33
Male	2	14.29	7	50	5	35.71

Period of mobile phone usage during driving						
Gender	Short (< 5s)			Longer time (> 5s)		
	Number	%	Number	%	Number	%
Female	4	66.67	2	33.33		
Male	8	57.14	6	42.86		

Impact time stamp measurements were performed by using Filimora 9 video editing and analyzing software as shown in Figure 4.



(a)



(b)

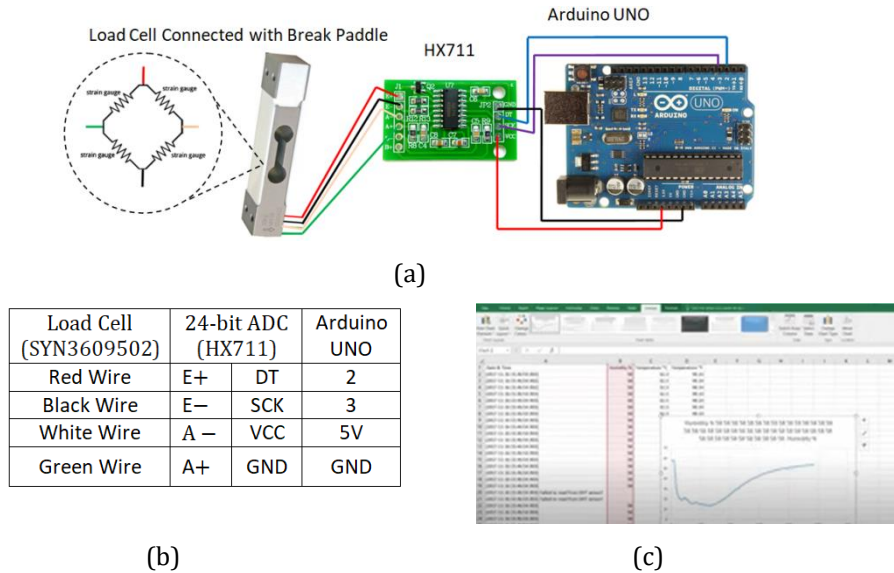


(c)

**Figure 4.** Experimental Setup for impact time stamp measurement using Filimora 9 video editing and analyzing software (a) hazard detected and (b) just before collision and (c) just after the collision

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The Arduino range of microcontrollers is able to provide analog inputs that can be used to measure the break instance by using the simple program. Data are captured and sent to Excel sheet with time stamp for breaking behavior analysis. Details configuration, pin connection and sample output is shown in Figure 6.



**Figure 5.** Circuit Configuration to study breaking behavior (a) Circuit configuration, (b) pin connection and (c) sample output in Excel

## 4. Modeling Procedure and Data Analysis

To observe the driving characteristic in the T junction crossing, three preset conditions were tested which are categorized as no distraction, distraction by mobile phone calling, and distraction by video calling. In all three situations, the tested motor vehicle begins to increase speed from the initial position to the desired speed of 25, 40, or 55 km/h. For each trial, the drivers are instructed to achieve the desired speed and maintained the desired speeds and also avoid hazard as much as possible. The tested vehicle's driver is directed to keep the speed fixed as much as possible all over the trial. At the intersection of T junction, the hazard vehicle appears at a certain position and speed in each type of proposed scenario. In the entire three scenarios, the hazard vehicle appears at the moments when distance of tested vehicle's driver from hazard vehicles is about of 10m, 15m, and 20m and travels at a speed as taken from selected speeds of 10-25, 26-40 and 41-55 km/h. Here nine combination of scenario is considered as shown in Figure 6.

		Vehicle Speed (km/h)		
		10-25	26-40	41-55
Hazard Distance (m)	10	Scenario 1	Scenario 4	Scenario 7
	15	Scenario 2	Scenario 5	Scenario 8
	20	Scenario 3	Scenario 6	Scenario 9

**Figure 6.** Description of the scenario considered for testing

The reaction time data were collected for three scenarios: no distraction, distraction by mobile phone calling, and distraction by video calling. The reaction time data were analyzed using IBM SPSS Statistics for a 3 x 2 x 3 x 2 x 9 x 3 repeated measures ANOVA: (a) (i) with gender two levels i.e. male and female, (ii) with age three levels (iii) with driving experience three levels i.e. learner, new driver (1-2 years driving experiences) and rest (iii) mobile usage (two levels) as between-subjects factor and (b) with the different scenarios as shown in Figure 6 i.e. nine levels different scenario type along with three levels of effects within-predetermined subject factors. There was a considerable variation in the means of the reaction time at each level of no distraction, distraction by mobile phone calling, and distraction by video calling scenarios. Hence, an independent repeated measures ANOVA (Kim, 2015) was performed for every driving condition. The result analysis revealed that the independent variables that have considerable consequences on the reaction time for all scenarios. It also examined that hazard distance, speed, gender, and age were important factors that directly affect driver reaction time in all kind of driving situations. Basically modeling of reaction time due to distractions is conducted through two approaches which are Field study and Simulation based study (Choudhary & Velaga, 2017). Although several researchers adopted the field study approach for the collection of data for the measurement of reaction time caused by distractions but by considering the safety of the participants and the accuracy in the data collection, simulation based study is considered as the more suitable approach for the measurement of the reaction time due to distracted driving.

In order to analyze the braking behavior of the distracted drivers various methods has been adopted by the researchers such as T-test, ANOVA test, linear regression test etc. Whereas only a few researchers used the statistical approach such as hazard based duration model and linear mixed model to find out the impacts of external variables on the reaction time of the distracted drivers. At first, a brief of the present work is shared through a seminar to all the participants. After that all the participants was asked to fill a questionnaire that contains all the valuable information that is required to predict their habitants during driving (details of questionnaire form is illustrated in participants section). After the completion of paper work all the participants goes through a test drive on the simulator, to make them familiar with the simulator. The next day after another test drive, the participants (as grouped in the participants' section) finally drove on the simulator in 3 conditions: (i) non-distracted, (ii) distracted by mobile phone usage by calling from an unknown number, and fake calls



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 and (iii) distraction by video calling. The variables and their modeling procedure are shown in Tables 2.

**Table 2.** Statistical descriptive details of explanatory variables used for modeling proposed model

External variables		Descriptions of the variables
Demographic details of the participants	Age	Age of the participants
	Gender	If the participant is a male = 1, otherwise = 0 If the participant is a female = 1, otherwise = 0
Driving experience (in years)	0 - 1	If the participant has driving experience of 0 to 1 year = 1, otherwise = 0
	2 - 4	If the participant has driving experience of minimum 2 year and maximum 4 year = 1, otherwise = 0
	Above 4	If the participant has driving experience of more than 4 years = 1, otherwise = 0
Driving history	Type of license	If the participant holds an open license =1, otherwise = 0 If the participant holds an provisional license =1, otherwise = 0
	Traffic offense	If the participant received any kind of violation notice (due to mobile phone usage) in real life driving =1, otherwise = 0 If the participant does not received any kind of violation notice in real life driving =1, otherwise = 0
	Crash involvement history	If the participant involved in any type of traffic collision in real life driving =1, otherwise = 0 If the participant does not involved in any type of traffic collision in real life driving =1, otherwise = 0
Distractions history of the participants (during driving)	Type of mobile phone	If the participant use hand held mobile phone during driving = 1, otherwise = 0 If the participant use hand free mobile phone during driving = 1, otherwise = 0
	Period of mobile phone usage	If the participant involved in a conversation for less than 5s = 1, otherwise = 0
		If the participant involved in a conversation for more than 5s but less than 10s = 1, otherwise = 0 If the participant involved in a conversation for more than 10s = 1, otherwise = 0

The reaction of the participants when they drove through the connecting arm of the T-Junction, were noted and analyzed, as soon as the event enters into the visual range of the driver from the main road. The reaction time of the drivers was calculated with no-distractions, distractions due to mobile phone usage and distraction by video calling during driving with the help of hazard based duration model of a survival rate

of the drivers were developed by considering some external variables such as demographic detail of the drivers (age and gender), driving characteristics of the drivers (driving experience in years, mobile phone usage history of the participants (conversation/text, period of usage)of the road.

Accelerated Failure Time (AFT) models are a class of mainly parametric models, which generates from the observation that time to event variable (T) cannot be negative; hence this can be work with its logarithm. The generalized AFT model is as follows,

$$\log T_i = x_i' \beta + \epsilon_i$$

where,  $x_i'$ ,  $\beta$ , and  $\epsilon_i$  are covariates, coefficients and error term with given distribution (mean 0, SD 1).

The distribution of the log survival model is just shift of the base line distribution of the error term.

## 5. Hazard Function

In order to measure the reaction time (time taken by drivers to react after detection of an event) of the distracted drivers a hazard based duration model has been utilized in this present study. As reaction time is defined as the time difference between detection of an event and reacting against that event, so the hazard based probabilistic method is perfectly suited for the for the measurement of reaction time (duration model). The reaction time of the driver is taken as the duration variable in this study. Because of the promising characteristics and appropriateness to the modeling of duration variable, AFT based model was applied in this present study. The reaction time (i.e., duration model) is a continuous time variable  $\tau$ , with respect to a probability density function  $f(t)$  and cumulative function  $F(t)$  as shown in Eq. (1):

$$F(t) = P(\tau < t) = \int_0^t f(t)dt \quad (1)$$

Hazard function ( $h(t)$ ) of the used AFT model can be expressed as a function of conditional probability and mathematically written as shown in Eq. (2):

$$h(t) = \frac{f(t)}{[1 - F(t)]} \quad (2)$$

As time passes the probability of detection of the event by the drivers will also increases, so it can be concluded that the  $h(t)$  is a monotonously increasing function with time.

The survival model duration model is also known hazard based as where the rate of survival  $\psi(t)$ , can be expressed as the probability  $P(\tau)$  of wrong detection and can be formulated as sown in Eq. (3):

$$\psi(t) = P(\tau \geq t) = 1 - F(t) \quad (3)$$

In this paper, measurement of reaction time is conducted with the help  $\psi$ based on statistical analysis of data, where the impacts of the explanatory variables on the result, are also considered in the analysis. Basically the explanatory variables integrates with the model through two approaches, named as: (1) AFT and (2) Proportional hazard based (PH), but as the AFT model provides better results than the PH model when more than one variable is introduced in the model analysis, so AFT model is more suitable than the PH model for this present work.

In this present study, Weibull distributional function is considered as the

required distributional function for the complete analysis of reaction time (duration variable), as the  $h(t)$  is a monotonically increasing function and Weibull distributional function is applicable to both monotonically increasing as well decreasing  $h(t)$ .

The hazard function of the Weibull distributional function can be presented as a function of location parameter  $\lambda$  and scale parameter  $P$ , as shown in Eq. (4):

$$h(t) = P\lambda^P t^{P-1} \quad (4)$$

and the corresponding survival rate of the Weibull distributional function can be represented as shown in Eq. (5):

$$S(t) = \exp(-\lambda t)^P \quad (5)$$

To incorporate the Weibull distributional function with the AFT model, natural logarithm of the duration variable ( $T$ ) is represented as a linear function of two vectors: explanatory variables ( $X$ ) and estimated parameter ( $\beta$ ), as shown in Eq. (6):

$$\ln(T) = \beta X + \Delta \quad (6)$$

where  $\Delta$  represents the error term.

In this present study is repeated observations for each participant were collected so the reaction time of each of the participants might be correlated at individual level. The measurement of reaction time of each of the participants is possible through two approaches: one is the clustered model of heterogeneity and another one is based on the estimation of standard error. Standard error estimation approach is considered as the best suited approach in this study as this study measures the reaction of each of the individual separately.

## 6. Result Analysis and discussion

All the obtained values of scale parameter from the designed model were greater than 1, which indicates that the probability of detecting an event got increased with passage of time for all the events. The explanatory variables which affect the designed model are as follows: driving experience of the participants, type of license hold by the participants, traffic offense received by the participants, and period of cell phone usage while driving. The driving experience of the participants has significant impact on the reaction time. Type of license holds by the participants is also an important factor in the calculation of reaction time as it is found that the provisional license holders are less prone to involved in a collision with a less reaction time in comparison with the open license holders.

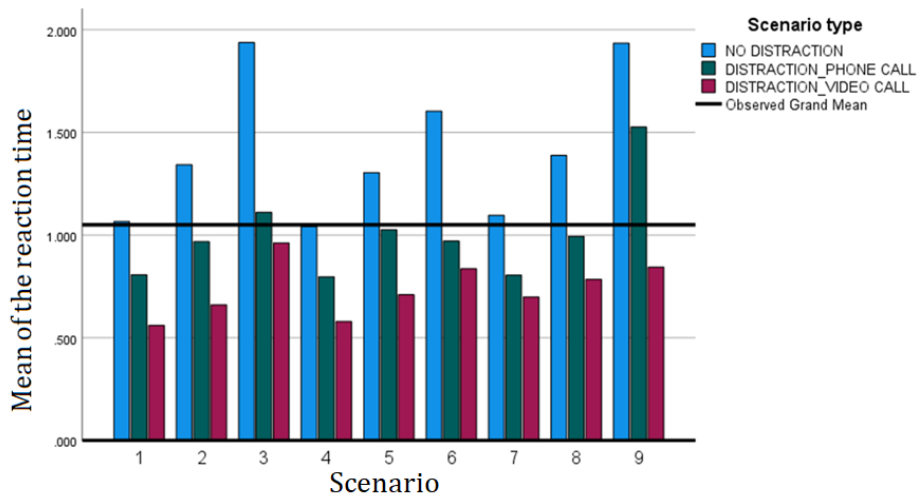
In case of driver's distraction due to mobile phone usage, all the three periods of phone usage (short, moderate and longer) were analyzed. It is found that moderate periods of mobile phone usage during driving have maximum impacts on the reaction time. As in the shorter period drivers are more concentrated in driving other than the distractions whereas in case of the participants who involved in longer periods of mobile phone usage, adapt themselves with the cell phone usage during driving. Increment in the reaction time due to moderate period of cell phone usage during driving is due to the fact that in this case the driver's focus shifts from the roadway to the mobile, which results in wrong judgment and ended with a fatal collision. Actually this situation is responsible for the delay in detection of the event which in turn increases the reaction time. From the estimated parameter it can be observed that

with the increment of driving experience of 1 year, the reaction time is increased as shown in Table 3.

**Table 3.** Statistical analysis of reaction time

Scenario	Distraction			Significance by a liner mixed model		Estimated Marginal Means			
	Normal	Phone calling	Video calling	R	F (10%)	Mean	Std. Error	95% Confidence Interval	
								Lower Bound	Upper Bound
1	1.066	0.807	0.561	0.927	35.52	0.811	0.011	0.789	0.833
2	1.343	0.968	0.660	0.954	59.10	0.989	0.011	0.966	1.011
3	1.938	1.111	0.962	0.888	21.53	1.334	0.017	1.299	1.368
4	1.042	0.797	0.580	0.915	29.71	0.806	0.011	0.784	0.828
5	1.304	1.027	0.710	0.939	43.34	1.019	0.011	0.996	1.042
6	1.604	0.971	0.836	0.904	26.04	1.139	0.012	1.115	1.163
7	1.097	0.805	0.699	0.871	18.16	0.867	0.011	0.845	0.888
8	1.388	0.994	0.785	0.834	13.23	1.056	0.021	1.014	1.097
9	1.935	1.527	0.844	0.919	31.37	1.435	0.024	1.387	1.483

Impacts on the estimated reaction time due to the uses of mobile phone during driving are shown in Figure 7.



**Figure 7.** Mean reaction time of different scenario

The participants who receives traffic rules violation notice exhibits slowest reaction time after the detection of any event than the open license holders and the participants with driving experience of (0-1) year. When the traffic rules violators are distracted due to mobile phone usage they achieved best result to react against that event, whereas the open license holder got moderate value and the un-experienced participants got more time to stop the vehicle after detection of an event. From the simulation data it can be seen that in any unknown city, the pedestrian fatality risk is increased. The results emphasize the importance of intersection design to increase drivers' compliance to the traffic rules. Experienced drivers exhibited greater speed

control and lane control in response to all kind of hazards mostly in the T-junctions and blind turn with heavy traffic; whereas, inexperienced and young driver maintained higher speed than the recommended speed, as compared to usual driving, when faced blind junctions. The average increment in the reaction time due to the distractions caused by mobile phones is of in comparison with the non-distracted driving. In their study, it is found that intake of alcohol affects the actions of drivers in many ways such as control over steering, visual ability, braking time, taking a decision while driving etc.

Expert practice divides the driver's response into simple and complex. As a rule, during automated technical testing, forensic experts encounter a complex response, such as diagnosing a person whose response to a threat is not prepared in advance. A road accident will be occurred where participants reach the point of collision. The general options given in these recommendations for determining the various values (Whittaker, 2020) of the driver's response time during an emergency do not fully cover the possible mechanisms of accident development. In particular, the driver's response to the danger of exceeding the speed limit, which was introduced at the scene of an accident, when a pedestrian or car was hit, was not determined. A complex response is usually associated with choosing the best solution out of several possible solutions. When a driver detects an object (danger or obstacle) it depends on how likely it is. The more the object appears, the more closely the driver has to monitor the traffic situation, the sooner he will be able to detect it. If the object is not likely to appear (danger or obstruction), the driver may be distracted by direct observation of the road to perform other functions, such as the control device, reading observation of other objects. In such traffic situations, the detection time of the object (obstacle) in the carriageway, which appears suddenly, can be much longer than in the first case.

### **6.1. Advantages and Limitation of the Study**

Studies have revealed that two major issues involved in most of the rear-end clashes are drivers' failure to recognize and respond to the actions of preceding vehicle and going after a lead vehicle too closely. The perception and the reaction of the driver to the lead vehicle's action is the primary influencing cause in rear-end clashes. In this modern era hand-held-phone usage while driving is a crucial factor to divert drivers' concentration to react against the action of lead vehicle. In this article exclusively three different states of distances and driving speeds were experimented. These states are classified as no distraction, distraction by mobile phone calling, and distraction by video calling. In field experiments, engaging drivers in surprised or emergency situations on the road for measuring the perception and movement durations is very tough job to accomplish. It is also not an easy task to propose a scenario that can comprise all the factors simultaneously. This study prevails over these hindrances by modeling nine different experimental car-following situational combinations using acquired data.

The approach in this study is advantageous in implicating Car-following hazard perception test of the drivers to develop rear end clash prevention algorithms and mimicking traffic simulation models specifically in the driving through a T-junction while using hand held phones. The most significant factor used to calibrate car-following models for risk analysis is driver's typical reaction time considering particular influencing constraints such as usage of phone. The brake-reaction time in reaction to deceleration of the preceding vehicle conclusively varies with the response for obstruction on road or with the response to a passing vehicle at the crossroads.

The present study is advantageous for exploration of the result of driver demography and circumstantial issues on the driver reaction time while driving through a T-junction using hand held phones and presentation of analytical models which have immense contributions for car-following analysis algorithms. In particular, the reaction time model for the no distraction scenario (without phone usage), on phone call and on video call conditions will be necessary to model the rear-end collision warning systems.

The difference between the times, the hazards was introduced and the driver response time to the event either accelerating or pressing the brake pedal is known as the time of reaction. Several researchers adopted the field study approach, keeping in view that riding machine tests can vary with realistic riding environments and thus the findings can undoubtedly involve some bias but by considering the safety of the participants and the accuracy in the data collection, simulation based study is considered as the more suitable approach for the measurement of the reaction time due to distracted driving.

As reaction time is defined as the time difference between detection of an event and reacting against that event, so the hazard based probabilistic method is perfectly suited for the measurement of reaction time. With the help of hazard based duration model a survival rate of the drivers were developed by considering some external variables such as demographic detail of the drivers (age and gender), driving characteristics of the drivers, mobile phone usage history of the participants as well as the geometry (straight/T-Junction) and environment in the both urban and rural road. In this present study 9 repeated observations of reaction time for each participant were collected so the reaction time of each of the participants might be correlated at individual level. Standard error estimation approach is considered as the best suited approach in this study as this study measures the reaction of each of the individual separately. All the obtained values of scale parameter from the designed model were greater than 1, which indicates that the probability of identifying an event enhanced with the elapse of time for all the three events.

Few limitations in this study must be accounted for. The hazard-based reaction test was obtained using only 20 participants. However, a development of this research could be with the more drivers but due to the extensive scenarios performed with every participant the sample size is quite healthy to run this study.

In this research the knowledgebase of the route was not evaluated. This variable could be a major factor impacting drivers' activities while driving through a T-junction. If a rider has prior knowledge about the route, may have a greater chance of risk management from the one who is not familiar with this route. In future study, an extension of the research should be planned to validate the impacts of variables such as road geometry, traffic volume on the risk analysis.

At the start of the experiment, the variations in reaction levels of the drivers (too slow or very fast) produce some biased data. The test did not deliver the reaction time data concerned with the deceleration and the acceleration. In the next study investigation to be designed to exclude the outliers while verifying the variations for the reaction times at the acceleration and deceleration phases.

Finally, considering that the drivers' consciousness for involving in the experiment could affect the reaction time, a future study has been aimed for collecting data from an instrumented vehicle and for analyzing the behavior of unaware drivers. This research may be taken as a directive study and an initial step towards future advancement on drivers' behavior at T-junction maneuver. In addition, although with the limitations above acknowledged, the outcomes of this study could aid to the

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improvement of advanced driver supporting systems for the risk analysis while driving through a T-junction based on existing driving situations.

## 7. Conclusion

This study measured the reaction time of the young inexperienced drivers distracted by mobile phone in various hazardous conditions. We examine the reaction time of the participants against an event, in both distracted and non-distracted condition. The impacts of distractions on the reaction time were most evident for the participants who violate the traffic rules in their real life driving, than the un-experienced drivers and the participants with open license holders. The proposed model was designed with the help of Weibull distributional function with clustered heterogeneity. Driving performance may consider in terms of reaction time, speed control and lane maintenance. Results demonstrated hazards to cause declines in various conditions awareness and speed control or liability to various hazard type was dependent on drivers experience and age. These observations are applicable to modeling driver behavior under hazardous environments and may helpful for the design of smart vehicle assistive devices for collision predictions with over speeding, overtaking procedure, study of over loaded vehicle characteristics and its effects on the reaction time or on the braking behavior of the drivers before issuing the driver licenses and post accident analysis.

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## References

- Almutairy, F., Alshaabi, T., Nelson, J., & Wshah, S. (2019). ARTS: Automotive Repository of Traffic Signs For The United States. *IEEE Transactions on Intelligent Transportation Systems*, 22(1), 457-465.
- Backer-Grøndahl, A., & Sagberg, F. (2011). Driving and Telephoning: Relative Accident Risk When Using Hand-Held and Hands-Free Mobile Phones. *Safety Science*. 49(2), 324-330.
- Chang, X., Li, H., Rong, J., Huang, Z., Chen, X., & Zhang, Y. (2019). Effects of On-Board Unit on Driving Behavior In Connected vehicle Traffic Flow. *Journal of Advanced Transportation*, 2019(2), 1-10. <https://doi.org/10.1155/2019/8591623>.
- Choudhary, P., & Velaga, N. R. (2017). Modelling Driver Distraction Effects Due to Mobile Phone Use on Reaction Time. *Transportation Research Part C: Emerging Technologies*, 77(4), 351-365.

Das, A., Gjerde, H., Gopalan, S. S., & Normann, P. (2012). Alcohol, Drugs, and Road Traffic Crashes in India: A Systematic Review. *Traffic Injury Prevention*, 13(6), 544-553.

Demasi, F., Giuseppe, L., & Laura, M. (2018). Road Safety Analysis of Urban Roads: Case Study of an Italian Municipality. *Safety*, 4(4), 58.

Dewan, M. C., Mummareddy, N., & Wellons III, J. C. (2016). Epidemiology of Global Pediatric Traumatic Brain Injury: Qualitative Review. *World Neurosurgery*, 91(7), 497-509.

Drosu, A., Cofaru, C., & Popescu, M. V. (2020). Influence of Weather Conditions On Fatal Road Accidents on Highways And Urban and Rural Roads in Romania. *International Journal of Automotive Technology*, 21(2), 309-317.

Eboli, L., Forciniti, C., & Mazzulla, G. (2020). Factors Influencing Accident Severity: An Analysis by Road Accident Type. *Transportation Research Procedia*, 47(2020), 449-456.

Fancello, G., Michele, C., & Paolo, F. (2019). Road Intersections Ranking for Road Safety Improvement: Comparative Analysis of Multi-Criteria Decision Making Methods. *Transport Policy*, 80(8), 188-196.

Fang, C. Y., Chen, S. W., & Fuh, C. S. (2003). Road-Sign Detection And Tracking. *IEEE Transactions on Vehicular Technology*, 52(5), 1329-1341.

Transportation Research Board (2000). *Highway Capacity Manual*. National Academy of Sciences, Washington DC.

Kim, H. Y. (2015). *Statistical Notes For Clinical Researchers: A One-Way Repeated Measures ANOVA For Data With Repeated Observations*. *Restorative Dentistry & Endodontics*, 40(1), 91-95.

Motor Vehicle Act. Govt. Of India. (Last Seen 18<sup>th</sup> Dec 2021). Retrieved From <https://www.indiacode.nic.in/bitstream/123456789/9460/1/A1988-59.pdf>

Kabir, M. F., & Roy, S. (2020). Design Of Hazard Based Model And Collision Avoidance System . *Journal of Critical Reviews*, 7(19), 5979-5989.

Mcevoy, S. P., Stevenson, M. R., & Woodward, M. (2006). Phone Use And Crashes While Driving: A Representative Survey of Drivers in Two Australian States. *Medical Journal of Australia*, 185(11-12), 630-634.

Mukherjee, D., & Mitra, S. (2020). Comprehensive Study of Risk Factors for Fatal Pedestrian Crashes in Urban Setup in a Developing Country. *Transportation Research Record*, 2674(8), 110-118.

Robbins, C. J., Harriet, A. A., & Peter, C. (2019). Comparing Drivers' Visual Attention At Junctions In Real And Simulated Environments. *Applied Ergonomics*, 80(10), 89-101.

Schlögl, M. (2020). A Multivariate Analysis of Environmental Effects on Road Accident Occurrence Using a Balanced Bagging Approach. *Accident Analysis & Prevention*, 136(3), 105398. 10.1016/j.aap.2019.105398.

Shahzad, M. (2020). Review of Road Accident Analysis Using GIS Technique. *International Journal of Injury Control and Safety Promotion*, 27(4), 472-481



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Whittaker, S., Khalfan, M. M., &Ulhaq, I. (2020). Developing Community Disaster Resilience Through Preparedness. *International Journal of Critical Infrastructures*, 16(1), 53-76.



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