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Modeling reaction time and accidents rate of drivers

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Abstract— The huge number of accidents makes the study of accidents causation one of the priorities in the design of roads, location of traffic signs, specifying the permitted ages for driving, improving license procedure and to provide local data to predicate the behavior. The characteristics of drivers affect results in roads. Drivers' data, vision test and reaction time of the drivers taken, head cover and spectacle considered in the drivers' abilities and accidents background involvements in the questionnaire form. Drivers' reaction time and drivers' accidents rate (accidents+1/experience) through the years of driving experience are modeled. The results revealed the negative impact of head cover and/or spectacle on vision abilities, while it didn't show obvious effect on accidents rate The best reaction time is 0.5708 (sec) for age group (29-39) years, while the worst reaction time is 0.6974 for age (>=51) years. The maximum accident rate is 0.482 for age group (18-28) and decreases with age increase to a minimum accidents rate of 0.0808 for age group >=51.

Keywords— Reaction time, Accidents rate, drivers' characteristics, head cover.

1. Introduction

One of the most important problems that designers in the field of highways, roads, streets and other transportation means face are drivers characteristics, the drivers differs from each other in abilities, their abilities divided into the vision, hearing, evaluating and reacting to situations in roads, another factor of the difference in drivers characteristics variations and attributed to drugs, alcoholic drinks and the state of the drivers of being tired, sleepy or exhausted [2], the study focus on the problem that is taken under consideration and gave it the priority in research, the increase in number of accidents in Iraq followed the increase in number of various types of vehicles after 2003 to reach the 5.8 million vehicles in Baghdad as the statistics that are collected from general traffic directorate in Baghdad. Vision test and drivers' characteristics at Mosul city evaluated. The results show that vision test must be used in driving licensure. Head cover and eye class, worsen the vision of drivers in all meridian cases [6]. the safety effects of Swedish drivers teaching at 16 years old evaluated, to increase the period of learning and to gain more skills, the results shows decrease in the odds of dangers, while it did not in the absent of practicing before driving. The advantages of learning programs for small age drivers did not appear immediately, the research extract proved the need for continuous enhancing system for such training programs that are useful in safety issues [3]. The drivers' characteristics in commercial Baghdad district estimated. The clear and peripheral vision angles assessed. Tradition and spectacle were considered. The Perception-reaction time for various drivers was within limits. The wear of spectacle and head cover worsen field of vision to driver eye in horizontal meridian by 20 percent for peripheral vision and 42 percent for clear vision [7]. The reaction time of drivers were examined by [7, 8], the results revealed that the second higher age group is of the optimum speed in response time, the reaction time values are 0.775 second for first research and 0.77 and 0.8 for males in urban and suburban, area and recorded equal value of 0.81 seconds for females in both mentioned areas for second research. The behavior and characteristics of drivers in Mosul and its relation with accidents participation demonstrated, and discovered that drivers of old age >50 less participated in accidents. The reaction time of different age groups were tested and finds that reaction time of over than 50 years old is the maximum value, the second maximum group is 41-50 years, the third is 18-30, the best group is 31-40 years old. the minimum value of reaction time occurred with the increase in age for the second age group, and the reason of such enhancement in response time due to the increase in experience and confidence of drivers, the maximum value of drivers' reaction activity increases with the increase in age and that's mean elderly drivers suffering from slow reactions (high reaction value), due to the reduction in their abilities [6]. A studies recognized young drivers of highest involvements of accidents percents up to 30 years old and old drivers of the lowest percent in participating in accidents over 50 years, because they are more conservative in knight driving.

2. Methodology

The drivers' characteristics were studied, their performance while breaking, when sudden incidents occurred in the road, and the perception reaction time of a driver for various age groups will be evaluated. Questionnaire form prepared to each driver, the form containing age of driver, experience of driving, average hours of driving daily, education level, traffic education, road accident participation (the whole life), tradition and spectacle wearing Accidents information was taken From the general directorate of traffic; the information of real traffic accidents was compared and related to the sample data of drivers that is tested by the previous mentioned methods. Two mathematical models were found that explain the data of the drivers.

2.1 *Site of experimental work*

The sites of experimental field test are AL-Alawy garage (north & south garages), Bayaa garage, Nahda garage, Dura garage, the reasons of choosing garages for experimental tests are the presence of many drivers that are not busy because they wait their turn for transporting passengers to the required places in all the cities in Iraq, all the sample drivers from males, the number of drivers that are tested is 1052 driver, from January to June 2018. Figure 1 contain of pictures of two important garages in Baghdad AL-Alawy & AL-Nahda garage that are considered of the two big garages in Iraq.

Figure 1: the various vehicles in two garages in Baghdad CBD

Figure 2 shows the location of the 4 important places to test drivers in Baghdad CBD (Dura, Baya, Alawy and Nahda).

Figure 2: the 4 important places for garages in Baghdad CBD (google earth pic.)

2.2 *Measurement method and tools*

To measure the angles of vision (clear and peripheral) for horizontal and vertical meridians, half circle of wood manufactured by the carpenter and all the dimensions of the semi circle chosen to a value that it would be easier for the tester to carry it to the site. It is divided to equal degrees, 70 cm diameter, the tester put the half circle in front of the driver, in his neck, the driver asked to look forward, and for Clear angle of vision (CH) a test cards having different shapes (circle, triangle, rectangle), with different colors (red, green, blue, black) used for that purpose. The test card moved from the centre of the half circle slowly to the sides of the circle and making sure that the driver's eyes forwards and the tester hands under the half circle that is not observed by the drivers eye, and asking the driver for clear vision, some colors except black changed to black while testing the drivers, after that, the shape becomes unclear. If that happened we stepped back till the shape becomes clear and that is called the angle of clear vision, this process accomplished twice from centre to the right, and from centre to the left, the summation of both degrees represent the total angle of clear vision for both eyes of the driver. The same procedure for the angle of clear vision (CV) but reversing the half circle beside the driver head, and making sure of the centered location, and fixing it vertically by drivers' hands, by moving the test card from the centre of the half circle to up and down, the summation of two readings represent the (CH) above and down the line of sight. The use of different shapes and colors makes the reading for same driver having errors because of the difference in colors perceptions from driver to driver, so the tester uses the red color to the circle only to unify the reading for all drivers after examining the data results and making corrections to the way of objects moving (colored shape) and speed of the process **[9]**. **Figure 3** shows the test cards used and pens used in the angle's measurements.

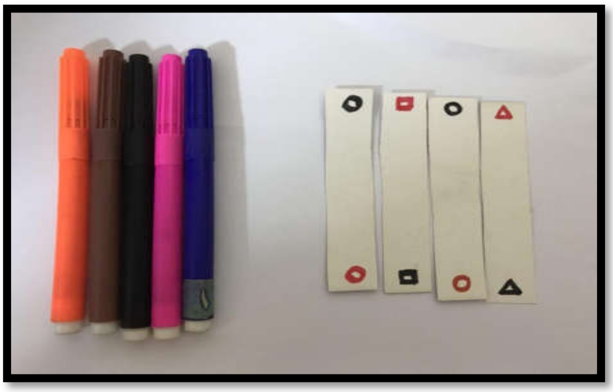


Figure 3: cards test for clear angles& pens for peripheral angles

Figure 4 and **Figure 5** illustrate the way to measure the angles by semicircle.

Figure 4: drivers with half circle from wood to PH&CH measure

Figure 5: PVand CV shape measurements

Figure 6: the battery, screen, and pedal for the reaction time device

Figure 7 shows the way to test driver in his state of tradition and/or spectacle wearing. The driver sits on a chair and distracted by a conversation and suddenly the red lamp lighted suddenly and that's mean a sudden incidents occurred while driving needed a response from driver to break, and this is a simulation for real driving situations.

2.3 *Range of data ages collected*

ages from 18-72 years old divided into 4 groups.

2.4 *Tradition cases and types*

The cases of tradition and/or spectacle wearing are 4 cases and the head cover differs in its folds as shown by Figure 7 and Figure 8.

Figure 7: The Folds of head cover and types.

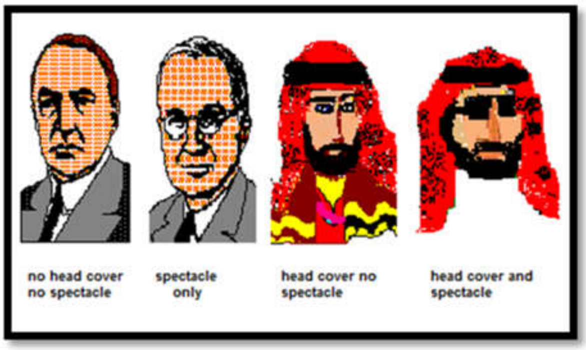


Figure 8: four cases of tested drivers [6]

3. Results and discussion

3.1 *Reaction time and accidents rate models*

The modeling is a method used to predict the relation of dependent variables with independent variable, in the form of equations that is valid statistically, the steps for modeling started with knowing the effective variables and the shape of relation, and the strength of the models. The final equation that is modeled includes (reaction time and accidents rate) as dependent variables related to drivers characteristics. Many methods can be used to find this relation and the coefficient of variation to the models. The stepwise regression analysis is used for the calculation of the most appropriate models that describe the linear equations.

3.2 *Variables used in equations*

The following variables used to predict the models

RT=response time of drivers to sudden incidents in road based on simulated device for that purpose (seconds).

Rate=rate of accidents (number of accidents+1) per years of experience for driver [1].

Age=age of driver (years).

Dhours=driving hours per day (hours/day)

Dexperience=years of experience for drivers (years)

CH=horizontal angle of clear vision (degree)

CV=vertical angle of clear vision (degree)

PH=horizontal angle of peripheral vision (degree)

PV=vertical angle of peripheral vision (degree)

Spectacle & head cover wearing two variables denoted as (2=yes, 1=no)

3.3 *Sample size calculations*

Sample size calculation used from equation (1), [4], knowing that level of confidence is 0.95

$$n = p(1-p)[\frac{Z\,\alpha/2}{E}]^2 \qquad (1)$$

n = sample size

p = proportion of sample size

z ∝/2 =z score =1.96

E =significant level (0.05)

Maximum n occurred when the proportion p=0.5, so 384 is the corresponding value as in Table 1.

Table 1: sample size determination

	Std.dev.	N	Max. sample size req.
Reaction time(sec.)	0.125	804	384
Accident rate(accidents/year)	0.073	675	384

3.4 *Outlier's detections*

the experimental work includes collected data, the distribution of data contains of group concentrated within limited margin calculated from the frequency of data, but sometimes due to mistakes or other abnormal condition, a data set considered as extreme or outliers and by checking those extreme values using Chauvinist's criterion and absolute tabulated of sample size value [5] as in Table 2 the accuracy checked. The maximum and minimum values substituted in the equations forms and all the values are less than tabulated values, so there are no outliers.

Table 1: chauvinist's test

	N	min value	Mean	max Value	Std. dev.	$\left\lvert\frac{xmin-mean}{s}\right\rvert$	$\left\lvert\frac{xmax-mean}{s}\right\rvert$	$\left\lvert\frac{xm-mean}{s}\right\rvert$ Tabulated
Reaction time	804	0.212	0.522	0.877	0.125	2.48	2.84	3.407
Accident rate	675	0.02	0.0985	0.222	0.0485	1.619	2.546	3.358

3.5 *normality test*

The advantage of the Kolmogorov-Smirnov test is to know the normality and to test the null hypothesis, and if the null hypothesis is accepted, then the data is normally distributed. Z value of The Kolmogorov-Smirnov is determined from largest value of subtraction the observed from theoretical value of a function cumulatively distributed (neglecting positive and negative sign), the test shows the distribution type if it is normal or other than normal type or the observation is not coming from distribution type. Table.3 shows results of normality test based on SPSS software analyses version 23. It seems there is a problem in normality depending on significant that is less than 0.05. The 4 tests in Kolmogorov-Smirnov test for the types of distribution revealed that the data of reaction time and accidents rate, do not represent any of the four distributions in the test because of the p-value is less than 0.05 in all the cases.

Table 3: one -sample K-S test for drivers' reaction time and rate of accidents.

N (70% of sample)		Reaction time	Accidents rate
		564	470
Normal parameters mean Standard deviation		0. 521 0.125	0.0967 0.0483
Most extreme differences	**absolute**	0.054	0.101
	Positive	0.054	0.101
	Negative	-0.044	-0.056
Kolmogorov-Simirnov Z		4.740	4.640
Asymp. Sig. (2-tailed)		0.000	0.000

3.6 *Multicollinearity*

to identify the multicollinearity among the independent variables by correlating between them, the predictors that are highly correlated affect the evaluation of model, and must be removed or entered step by step depending on significance for each variable and the final strength of predicted equation and the enhancement in the coefficient of determination(R^2). Table 4 and Table 5 shows the correlation between each independent variable with other independents alone for all the variables used in modeling (bivariate correlation matrix of accidents rate and RT models). The applications used to find such correlations is (IBM SPSS Statistics v23 x64), the (+ve) sign is an indication of positive relationship (the higher the variable the higher the other variable, while (–ve) sign is an indication of negative relationship (the higher the variable the smaller the other variable). In spite of high collinearity for age and Dexperience (+ve. linear relation) we include it in both models because of its significance on reaction time prediction with age and it is not very high to cause a problem in the prediction. the accident rate model as dependent variable calculated by dividing the total accidents+1 by Dexperience, noting that we add 1 to number of accidents to recognize between the risks of the drivers with high experience and low experience with no accidents [1]. The CV and CH highly correlated in accidents rate matrix and because they are highly non significant they can be excluded from accidents rate, while they are significant in reaction time model.

Table 2: Correlations matrix of accidents rate variables

PEARSON CORRELATION	AGE	DEXPERIENCE	DHOURS	CH	CV	PH	PV	RT
AGE	1	.836	.211	-.052-	-.107-	-.312-	-.228-	.277
DEXPERIENCE	.836	1	.258	-.059-	-.100-	-.276-	-.199-	.203
DHOURS	.211	.258	1	.004	-.030-	-.058-	-.108-	.058
CH	-.052-	-.059-	.004	1	.894	.165	.267	-.046-
CV	-.107-	-.100-	-.030-	.894	1	.184	.332	-.092-
PH	-.312-	-.276-	-.058-	.165	.184	1	.362	-.237-
PV	-.228-	-.199-	-.108-	.267	.332	.362	1	-.223-
RT	.277	.203	.058	-.046-	-.092-	-.237-	-.223-	1

Table 5: Correlation matrix of reaction time variables

PEARSON CORRELATION	AGE	DEXPER.	DHOURS	CH	CV	PH	PV	SPEC.	TRAD.
AGE	1	.864	.301	-.024	-.075	-.283	-.256	.067	.212
DEXPER.	.864	1	.357	.010	-.032	-.274	-.230	.022	.172
DHOURS	.301	.357	1	.031	.032	-.123	-.185	.028	.077
CH	-.024	.010	.031	1	.877	.244	.224	-.200	-.171
CV	-.075	-.032	.032	.877	1	.268	.286	-.231	-.193
PH	-.283	-.274	-.123	.244	.268	1	.401	-.193	-.216
PV	-.256	-.230	-.185	.224	.286	.401	1	-.178	-.238
SPECTACLE	.067	.022	.028	-.200	-.231	-.193	-.178	1	.240
TRADITION	.212	.172	.077	-.171	-.193	-.216	-.238	.240	1

3.7 *Stepwise Regression models*

To find the coefficients of the predictors, we can use one of the methods in finding the value of parameters; the table below shows the summery of calculations by using stepwise with default F to enter equal to 3.84 and depending on probability criteria or F out value the convergence decide the final model with its variables, Table 6 and Table 7 shows the summary of accidents rate and RT models calculations, while Table 8 and Table 9 shows the coefficients predicted for accidents rate and reaction time models.

Table 6: Model Summary of accidents rate

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.945	0.893	0.889	0.038

Table 7: Model Summary of reaction time

model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.972	0.945	0.944	0.1261997

Table 8: the ceofficients of accident rate

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
AGE	.001	.000	.473	3.914	.000	.001	.002
DEXPERIENCE	-.003-	.000	-.740-	-9.615-	.000	-.004-	-.002-
DHOURS	.001	.001	.036	.862	.389	-.001-	.002
CH	.000	.000	.055	.500	.617	.000	.001
CV	2.011E-5	.000	.005	.048	.962	-.001-	.001
PH	.001	.000	.739	6.587	.000	.000	.001
PV	3.74E-4	.000	.305	2.775	.006	.000	.001
RT	-.004-	.008	-.025-	-.516-	.606	-.020-	.011

Table 9: the coefficients of reaction time

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
AGE	.007	.001	.537	8.668	.000
SPECTACLE	.070	.012	.069	5.894	.000
TRADITION	.028	.013	.026	2.188	.029
DHOURS	.005	.002	.058	2.533	.012
CH	.003	.001	.229	4.255	.000
CV	-.006-	.001	-.328-	-5.967-	.000
PH	.001	.000	.345	5.156	.000
PV	.001	.000	.226	3.582	.000
DEXPERIENCE	-.004-	.001	-.150-	-4.201-	.000

3.8 *Error analysis*

By setting the dependent variable estimated on x axis and plotting the difference of observed and theoretical value with it on the other axis, the results are standardized residuals. Figure 9 and Figure 10 examine the linear model goodness of the accident rate and reaction time models and the distribution of points around the horizontal line drawn from y=0, the error can be observed from the scatter point distribution about the line and should be distributed in equal shape around the zero line, some error observed in top of y=2 of accidents rate standardized residuals and from top and bottom of the line out the y=(-2, 2) points on y axis of Reaction time standardized residuals as in Figure 9 and Figure 10 in sequence.

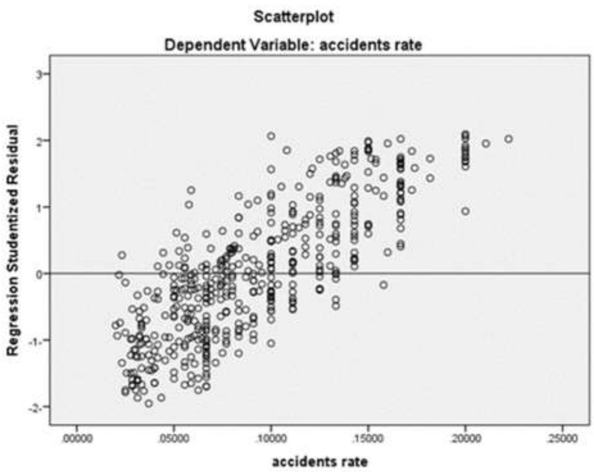


Figure 9: scatter plot of residuals and accidents rate.

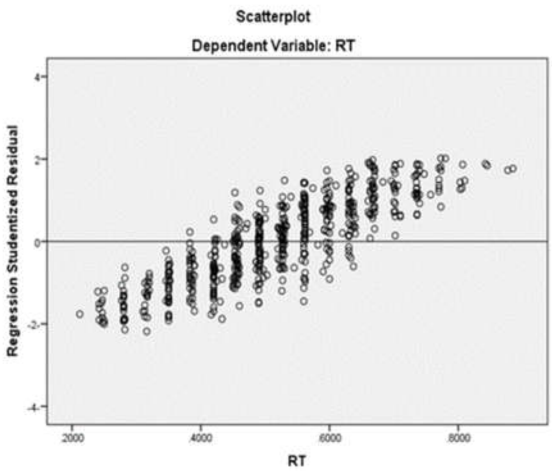


Figure 10: scatter plot of residuals and reaction time.

3.9 *Variance analyses of anova test*

To check the significant differences of the independent variables mean, the ANOVA applied by F-test. The F -test called the test of linearity which determines by a straight line the deviations of means. Table 10 and Table 11 shows the ANOVA test for RT and accidents rate in sequence. The results shows significant relation for the two models since the p-value is less than 0.05.

Table 10: ANOVA test for reaction time

Model	Sum of Squares	Df	Mean Square	F	Sig.
1 Regression	153.318	7	21.903	1419.956	.000
Residual	8.592	557	0.015		
Total	161.909	564			

Table 11: ANOVA test for accidents rate

Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression	2.363	7	.338	235.348	.000
Residual	.284	198	.001		
Total	2.647	205			

3.10 *The results of analyses*

The following Table 12 summarizes the parameters extracted from the analyses and other calculations in equation forms.

Table 12: results of predicted models

Mathematical model	R^2	Adjusted R^2	Std. error of estimates
RT=(7Age- 4DExperience + 5Dhours +PH +PV +3CH-6CV +70Spectacle+28Tradition) / 1000	0.949	0.948	0.123
rate=(AGE-3Dexperience-4RT+Dhours + PH +3.74*10 $^{-7}$ PV +2.11*10 $^{-2}$CV)/1000	0.89	0.886	0.039

Where

RT=reaction time of drivers in Baghdad CBD (second)

Rate=accidents rate (number of accidents+1) /experience of driver

Dhours= average driving hours

Age= age of driver (years)

DExperience=experience of drivers (years)

CH=horizontal angle of clear vision (degrees)

CV=vertical angle of clear vision (degrees)

PH= horizontal angle of peripheral vision (degrees)

PV=vertical angle of peripheral vision (degrees)

Spectacle wearing and head cover wearing each denoted by 1 for presence and else is denoted by 0 In order to check the wellness of the model with data, R value calculated should not be exceeded by the critical R value (tabulated R value). The tabulated R value for each model predicted is less than the calculated R value, so the relation between independent variables and the predicted variable is strong, as in Table 13. DF=n-2, significance level =0.05

Table 13: tabulated R-values for the final model

dependents	N	R-calculated	R-tabulated
RT	804	0.976	0.0723
Accidents rate	675	0.949	0.0789

3.11 *Models limitations*

The data used limited to rage of maximum and minimum values; the purpose of limitation is not meaning that the work is not effective; simply it is only a caution of data limits used as in **Table 14**.

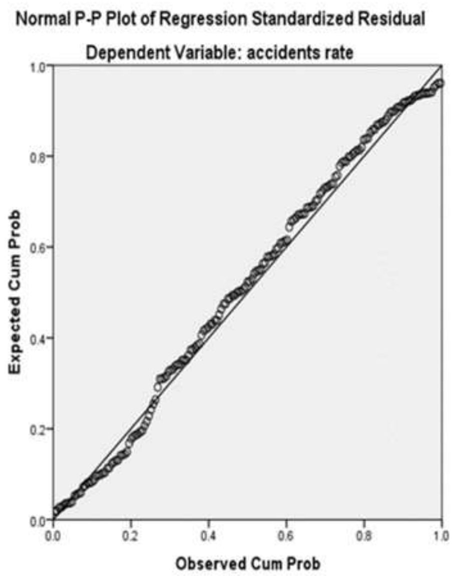
Table 14: Summaries of models limitations

Model	minimum	maximum	Mean
Reaction time	0.212	0.887	0.522
Accidents rate	0.02	0.22	0.0985

Figure 11: the estimated value of accidents rate

3.12 *Validity of the predicted models*

To assess the performance of predicted models by regression analyses, a good techniques used for that purpose, by plotting observed and estimated data. If the data plot tend to be in angle of 45o, then we have best results, otherwise, less performance is performed. This method uses about 30% of the data for the validation, and 70% for the predicted equations. Figure 11 and Figure 12 shows the validation of accidents rate and reaction time models. The Figure 13 and Figure 14 shows the shape of the normal probability plot of histogram for the Two models RT and accidents rate in sequence, the results of the two models $p<0.05$ then the distribution is not normal. Figure 15 and Figure 16 shows the graph of predicted and measured data, for accidents rate and reaction time dependent variables, the predicted data tend to be less than measured data in RT values most of times and an error noticed in both predicted values because of the deviation from the straight line in 45 degree. The accidents rate values are better than RT in the distribution of scatter around the reference line (45o) from the origin



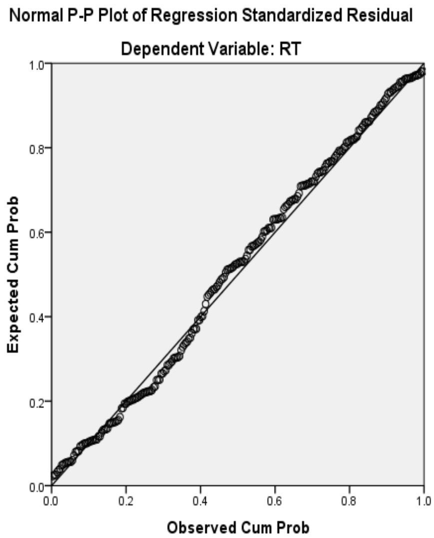


Figure 12: the estimated value of drivers' reaction time

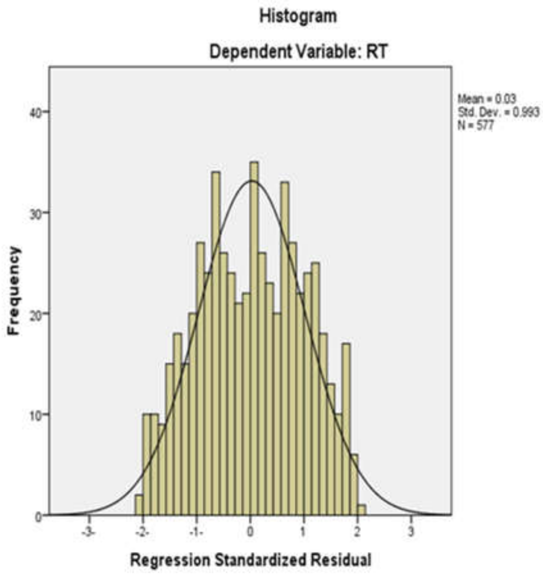


Figure 13: normal probability plot with histogram for reaction time model

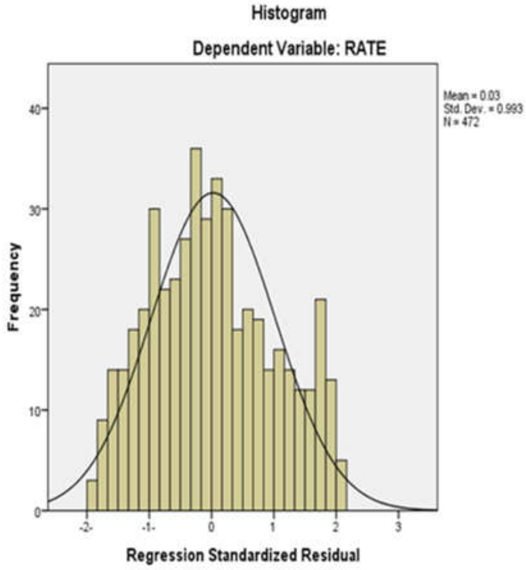


Figure 14: normal probability plot with histogram for accidents rate model

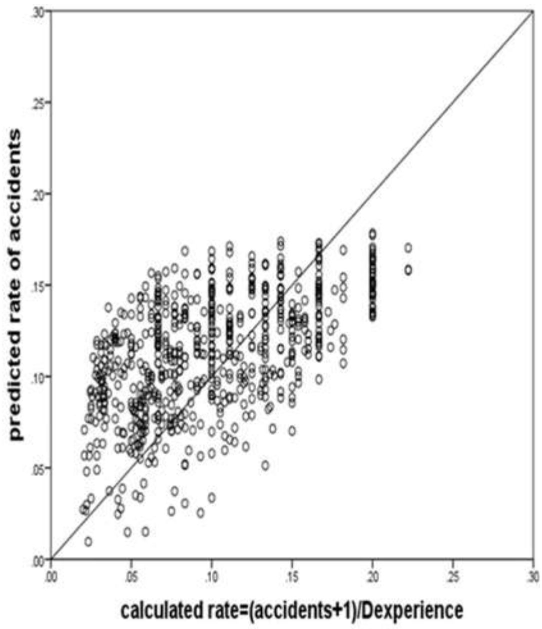


Figure 15: shows the predicted vs. calculated accidents rate data

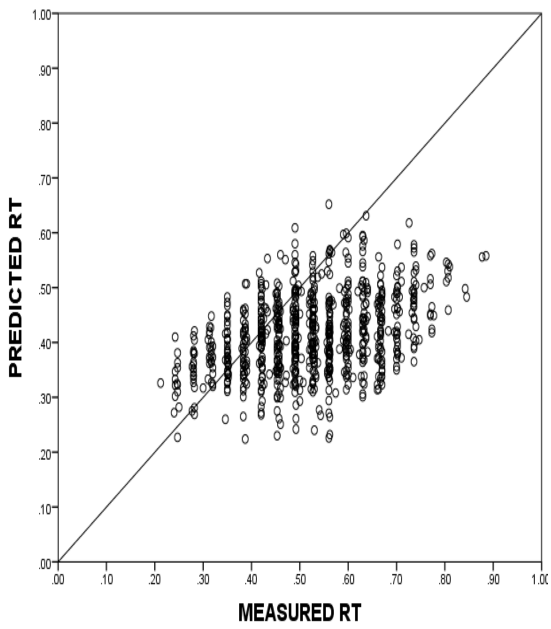


Figure 16: shows the predicted vs. measured reaction time data

4. Conclusions

1. Minimum reaction time value for age group (29-39) =0.5708 (sec), while the maximum reaction time value for age group (>=51)=0.6974 (sec) in an increase about 22%

2. 2.The accidents participation for age group >50 years recorded minimum accident participation of about 18.8%, and the age group 29-39 years recorded maximum accidents participation of 34% of total accidents participations.

3. Tradition wearing and spectacle together affects negatively the RT of driver more than other cases to about 15.5% increase, while spectacle and tradition wearing individually increases the RT to 8.33% and 8.84% in sequence

4. 4.The accidents rate (accidents+1/driving experience) decreases with the increase in age group from maximum accidents rate of 0.482 for age group (18-28) to a minimum accidents rate of 0.0808 for age group >=51 years, the decrease is 83%.

5. 5.The visual acuity (CH &CV), Reaction time and driving hours did not show significant effects on accidents rate (sig. >0.05), while it did on reaction time of drivers.

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Appendices

Table .15: some of drivers data tested in fields

744	511	783	694	**Drivers no.**
60	53	63	52	**Age**
Primary	Primary	Primary	Secondary	**Educational level**
Yes	Yes	Yes	Yes	**License presence**
Unsatisfactory	Unsatisfactory	Unsatisfactory	Fair	**Traffic education**
3	2	6	0	**Number of Accidents**
2	1	2	0	**Responsible**
1	1	4	0	**Not responsible**
0.582	0.527	0.63	0.56	**RT in sites(sec)**
PC	PC	Mini bus	PC	**Vehicles type**
Rural	Rural	Urban	Urban	**Area type**
No	No	Yes	Yes(1)	**Spectacle wearing**
Yes	Yes	Yes	No(0)	**Head cover wearing**
37	38	40	31	**Driving experience**
9	6	10	12	**Driving hours/day**
14	19	25	38	**CH**
12	18	23	36	**CV**
104	128	115	120	**PH**
80	76	57	85	**PV**
140	247	1012	439	**Drivers no.**
57	52	34	46	**Age**
Read & write	Illiterate	Read & write	University	**Educational level**
Yes	Yes	Yes	Yes	**License presence**
Good	Fair	Unsatisfactory	Fair	**Traffic education**
0	1	1	6	**Number of Accidents**
0	0	1	0	**Responsible**
0	1	0	6	**Not responsible**
0.56	0.523	0.49	0.52	**RT in sites(sec)**
Minibus	PC	PC	Minibus	**Vehicles type**
Rural	Rural	Urban	Rural	**Area type**
No	No	No	No(0)	**Spectacle wearing**
No	Yes	Yes	Yes(1)	**Head cover wearing**
40	38	18	28	**Driving experience**
2	7	7	8	**Driving hours/day**
60	47	27	22	**CH**
45	32	25	19	**CV**
140	115	143	122	**PH**
117	71	82	83	**PV**

تقييم خصائص السواق في المناطق التجارية لبغداد

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الخلاصة – العدد الضخم من الحوادث جعلت دراسة مسببات الحوادث من الاولويات لتصميم الطرق, مواقع العلامات المرورية وتحديد اعمار السائقين المسموحة وتطوير اجراءات منح رخصة القيادة وتوفير بيانات محلية للتنبؤ بسلوك السائقين حيث ان الخصائص للسواق له تأثير مهم وينعكس على الشارع . بيانات السائقين من عمر ,خبرة, تقاليد الملبس, لبس المناظر, وعدد الحوادث, تم اخذها ل1052 سائق في المراكز التجارية لبغداد. فحص الابصار, وفحص رد الفعل تم اخذه للسائقين. السائقين تم فحصهم على حالتهم من الملبس كغطاء الرأس والمناظر لاختبار التأثير والعلاقة مع قدرات السائقين وخلفيتهم من المشاركة في الحوادث . تم ايجاد موديلان رياضيان لرد فعل السائقين ونسبة الحوادث خلال سنين الخبرة. النتائج اظهرت التأثير السلبي لغطاء الراس والمناظر على حقل الابصار, بينما لم يكن لها تأثيرواضح على نسبة الحوادث. افضل معدل لرد الفعل هو0,571 من الثانية للفئة العمرية(29-39) سنة, بينما اسوأ معدل لرد الفعل كان 0,697 من الثانية للفئة العمرية الاكبر من 50 سنة. اعلى معدل لنسبة الحوادث نسبة الى سنين الخبرة هو 0,482 للفئة العمرية (18-28) سنة وتتناقص مع ازدياد فئة العمر الى اقل نسبة بلغت 0,0808للفئة العمرية الاكبر 50 سنة.

الكلمات الرئيسية – رد الفعل,نسبة الحوادث,خصائص السواق,غطاء الرأس,نظارات, موديل رياضي.