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The Effect of Driver's Sex and Age on Human Responsible Involvement in Two-Car Crashes

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ABSTRACT

Assuming the majority of car accidents are due to driver errors, we use rear-end collisions which occurred in the State of Washington, USA, in 1982, 1983, and 1984, to study human responsible involvement associated with the sex and age of drivers. Rear-end collisions involving two passenger cars are included in this study. The driver of a car which struck the rear end of another car is considered responsible for the accident, and the driver of a car which was struck in the rear end is not considered responsible for the accident. In addition to male and female drivers, we used three different age groups: 16 to 24 years old, 25 to 34 years old, and 35 years or older. Hence, six diferent groups of drivers are considered in this study.

1. INTRODUCTION

This study investigates and establishes the relationship between driver sex and age on the likelihood of driver responsibility for an accident in two-car crashes. In regard to human, environmental, and vehicular factors involved in traffic accidents, detailed investigations of individual crashes have shown that driver errors are associated with the majority of crashes. For instance, using the "tri-level" study conducted by Indiana University, Treat reported that probable causal or severity-increasing human factors were identified in 92.6% of crashes investigated[5]. Based on the same spirit that the majority of car accidents are due to driver errors, we use rear-end collisions to examine human responsible involvement associated with the sex and age of drivers. The driver of a car which struck the rear end of the other car is considered responsible for the accident, and the driver of a car which was struck in the rear end is not considered responsible for the accident.

Driver risk taking in every day driving has been analyzed based on headways (time intervals between successive vehicles) in freeway driving

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and choice of speed on a suburban two-lane road by Evans and Wasielewski[2] and by Wasielewski[6], respectively. Male drivers are found to take more risk in the former study. And, in both studies, younger drivers take more risk in everyday driving than their older counterparts.

In this study, for a particular driver sex and age combination, we use the ratio between the number of responsible involved drivers and that of nonresponsibly involved drivers to measure the responsible involvement rate. The nonresponsible involvement is used as a normalizer, i.e., as a measure of exposure. Different from the induced exposure model reported by Thorpe [4] or the induced responsibility model reported by Wasielewski and Evans[7], the above measure of responsible involvement, suggested by Evans[3], has the advantage that it can directly be estimated from the data on two-car crashes since our attention is focused on rear-end collisions.

2. DATA AND METHOD

The data base for this study is the State of Washington accident data residing in the University of Michigan Transportation Research Institute (UMTRI) computer file. This data set consists of all motor vehicle accidents that were recorded by the state patrol. From this data base, all two-vehicle accidents in which both vehicles involved were passenger cars are included in this study. Then, we selected rear-end collisions from these two-car accidents. The information needed to classify a two-car crash as a rear-end collision is available only to those accidents which occurred on State and U.S. routes. In this report, driver's age is classified into the following three groups:

16 to 24 years old (16-24);
25 to 34 years old (25-34); and
35 years or older (35+).

Throughout, 16 to 24 year old drivers are called young drivers, 25 to 34 year old drivers are called median age drivers, and the rest are called older drivers.

There are six different driver groups using two sex and three age categories. Table 1 shows the number of rear-end collisions which occurred on State and U.S. routes in the State of Washington in 1984. For the sake of simplicity, we use three classifications, young male drivers, young female drivers, and the rest. The rest could include those drivers who do not belong to the six driver groups due to missing values on any of the two factors, sex and age, or due to age below sixteen (see Table 8 in Appendix for details). There were 135 rear-end collisions in which both drivers involved in the collisions were young males. There were 92 cars driven by young males which struck the rear end of cars driven by young females; and, conversely, there were 66 cars driven by young females who struck the rear end of cars driven by young males. The rest of the entries in Table 1 can be interpreted similarly.

To assess the relationship between driver sex and age on the likelihood of responsible involvement in rear-end collisions,

ξ (male, 16-24) = (Probability that a car driven by a young male strikes the rear end of the other car)/(Probability that a car driven by a young male is struck in the rear end by the other car) ············ (1)

is used as a muasure of responsible involvement

Table 1. Number of rear-end collisions which occurred on State and U.S. routes in the State of Washington in 1984.

Strike \ Struck	Male, 16-24	Female, 16-24	Rest	Total
Male, 16-24	135	92	602	829
Female, 16-24	66	74	389	529
Rest	321	280	1967	2568
Total	522	446	2958	3926

Strike : A car which struck rear end of the other car
Struck : A car which was struck in the rear end by the other car

for young male drivers. Then, using the rear-end collisions which occurred in 1984(see Table 1), ξ(male, 16-24) is estimated by

$$R(\text{male}, 16\text{-}24, 1984) = \{(135+92+602)/3926\}/\{(135+66+321)/3926\} = 829/522 = 1.59 \quad \cdots\cdots (2)$$

and, modifying some theorems in Bishop[1], its standard error is calculated as

$$\{(135+694)(694+387)/(135+387)^3\}^{1/2} = 0.08.$$

Using the same data, ξ(female, 16-24) is estimated by

$$R(\text{male}, 16\text{-}24, 1984) = 529/446 = 1.19 \quad \cdots\cdots (3)$$

with a standard error of 0.07.

Figure 1, 2 and 3 show the estimated responsible involvement rates associated with driver sex and age using the rear-end collisions which occurred in 1982, 1983, and 1984, respectively (see Tables 6, 7 and 8 in Appendix for detailed data). All of these figures indicate that younger drivers have a higher responsible involvement rate and male drivers have a higher rate than female drivers for all three age categories.

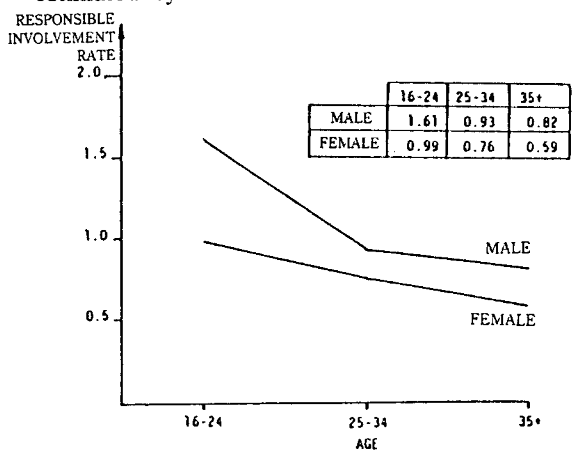

Figure 1. Responsible involvement rates according to driver sex and age based on rear-end collisions which occurred on State and U.S. routes in the State of Washington in 1982.

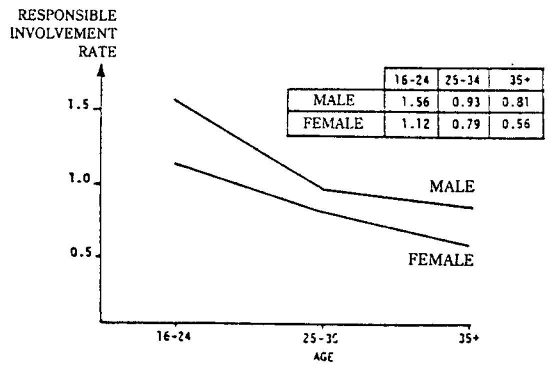

Figure 2. Responsible involvement rates according to driver sex and age based on rear-end collisions which occurred on State and U.S. routes in the State of Washington in 1983.

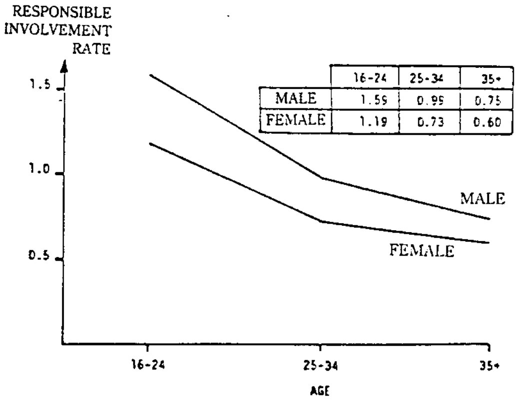

Figure 3. Responsible involvement rates according to driver sex and age based on rear-end collisions which occurred on State and U.S. routes in the State of Washington in 1984.

To estimate the overall effect of driver sex and age on responsible involvement, an analysis of variance model is used. In comparing responsible involvement rates, say, between young male and young female drivers, 1.34(=1.59/1.19), the ratio between 1.59 and 1.19, has a natural meaning rather than 0.40(=1.59 − 1.19), the difference between the two rates. Based on this ratio, young male drivers have a 34% higher responsible involvement rate than young female drivers. Therefore, an analysis of variance model is applied to the logarithms of Rs(ln Rs) rather than the untransformed Rs. The following model is used:

$$\ln R_{ijk} = \ln \xi_{ij} + \varepsilon_{ijk} \quad \cdots\cdots\cdots\cdots \quad (4)$$

in which i=1, 2 denote male and female drivers; j=1, 2, and 3 denote young, median age, and older drivers; and, k=1, 2, and 3 denote rear-end collisions which occurred in 1982, 1983, and 1984, respectively. Since the analysis is carried out using the logarithms of Rs, the final estimates of responsible involvement associated with driver sex and age can be obtained using the exponential(exp) transform of the estimates based on the logarithms of Rs. By doing so, we are using geometric means rather than usual averages in comparing the overall responsible involvement rates between the two levels within each of the two factors considered, namely, driver sex and age. Table 2 below shows ln Rs and their standard errors as well as Rs. Due to the variation in standard errors (the smallest is 0.045 and the largest is 0.070), a weighted analysis has been used.

Table 2. ln Rs and their standard errors as well as Rs (responsible involvement rates) according to driver sex and age based on rear-end collisions which occurred on State and U.S. routes in the State of Washington in 1982, 1983, and 1984.

	R	ln R	Standard Error
Male, 16-24, 1982	1.61	.47	.052
Male, 16-24, 1983	1.56	.44	.054
Male, 16-24, 1984	1.59	.46	.050
Male, 25-34, 1982	.93	−.07	.057
Male, 25-34, 1983	.93	−.07	.060
Male, 25-34, 1984	.99	−.01	.055
Male, 35+, 1982	.82	−.20	.048
Male, 35+, 1983	.81	−.21	.047
Male, 35+, 1984	.75	−.28	.045
Female, 16-24, 1982	.99	−.01	.066
Female, 16-24, 1983	1.12	.11	.064
Female, 16-24, 1984	1.19	.17	.059
Female, 25-34, 1982	.76	−.27	.070
Female, 25-34, 1983	.79	−.23	.069
Female, 25-34, 1984	.73	−.32	.066
Female, 35+, 1982	.59	−.52	.062
Female, 35+, 1983	.56	−.58	.059
Female, 35+, 1984	.60	−.52	.056

3. RESULTS AND CONCLUSIONS

After applying the full model (decomposing ln ξ_{ij} (see (4)) into overall, sex, age, and sex and age interaction effect), the following results are obtained using a weight analysis of variance technique to the logarithms of Rs in Table 2. Table 3 shows that the model explains the variation in the data well. That is indicated by a high r-square value, 0.98, whose maximum value is 1. The model p-value 0.0001 indicates that not all the parameters considered in the model are equal to 0, statistically. In detail, sex and age effect are statistically significant. In other words, the difference in responsible involvement between male and female drivers is not negligible (p-value: 0.0001). Similarly, the three age effects are not the same (p-value: 0.0001). However, sex and age interaction effect is negligible (p-value: 0.12).

Table 3. The results of a weighted analysis of variance by analyzing 1n Rs in terms of driver sex and age effect, and sex and age interaction effect.

Source	Degrees of Freedom	Sum of Squares	F Value	P-Value	R-Square
Model	5	1.57	155.25	0.0001	0.98
Error	12	0.02			
Corrected Total	17	1.59			
Source	Degrees of Freedom	Sum of Squares	F Value	P-Value	
Sex	1	0.32	156.15	0.0001	
Age	2	1.24	307.46	0.0001	
Sex* Age	2	0.01	2.59	0.1159	

After deleting the sex and age interaction term, Table 4 shows the estimated responsible involvement rates and their standard errors in logarithmic scale for each level within the two factors considered (see Table 9 in Appendix for detailed results of an analysis of variance). Figure 4 illustrates the data (ln Rs - see Table 2) and the estimated effects in logarithmic scale.

After transforming these estimates of responsible involvement rates in logarithmic scale using an exponential function, Table 5 shows the ratios of responsible involvement between two levels within each of the two factors considered.

Table 4. Estimated responsible involvement rates according to driver sex and age in logarithmic scale

	Estimate	Standard Error
Male	0.06	0.017
Female	−0.24	0.020
16-24	0.28	0.022
25-34	−0.17	0.025
35+	−0.38	0.021

Here, a value of 1 implies the equivalence in responsible involvement between two levels.

After examining rear-end collisions which occurred on State and U.S. routes in the State of Washington in 1982, 1983, and 1984, We conclude as follows: Male drivers have a (36 ±4%) higher responsible involvement rate than

Table 5. Average ratios of responsible involvement between two levels within each of the two factors, driver sex and age

	Ratio	Standard Error
Male/Female	1.36	0.04
16-24/25-34	1.57	0.05
16-24/35+	1.95	0.06
25-34/35+	1.24	0.04

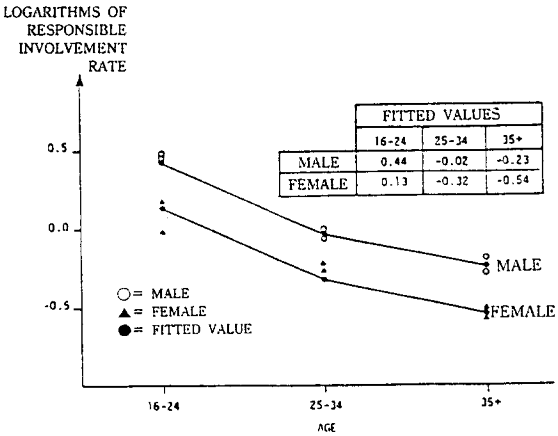

Figure 4. Logarithms of resposible involvement rates according to driver sex and age based on rear-end collisions which oc curred on State and U.S. routes in the State of Washington in 1982, 1983 and 1984, and their fitted values from a weighted analysis of variance using two main effects, driver sex and age

Note : Although each cluster represents four points, three 1n Rs and their fitted value, Figure 4 fails to show all of them due to the closeness among these values (for 1n Rs, see Table 2)

female drivers. Young drivers are responsible for the accidents (57± 5%) and (95± 6%) more often than median and older age drivers, respectively. Likewise, median age drivers are (24± 4%) more often responsible for the accidents than their older counterparts. This shows that responsible involvement, or risk taking while driving, decreases as we get older. Absence of interaction between driver sex and age indicates that the driving behavior for both male and female drivers mature at the same rate.

4. REFERENCES

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APPENDIX

Tables 6, 7, and 8 below show the frequencies of rear-end collisions which occurred in 1982, 1983, and 1984, respectively. For all three tables, each entry* represents the number of rear-end collisions in which cars driven by the drivers whose sex and age are written vertically struck the rear and of those driven by the drivers whose sex and age are written horizontally.

Table 6. Number of rear-end collisions which occurred on State and U.S. routes in the State of Washington in 1982.

	Male, Y	Male, M	Male, 0	Female, Y	Female, M	Female, 0	Else	Total
Male, Y	132	128	146	99	91	111	68	775
Male, M	71	79	109	50	48	90	54	501
Male, 0	79	86	141	63	64	119	70	622
Female, Y	52	70	88	46	46	67	38	407
Female, M	39	51	54	46	45	56	25	316
Female, 0	48	40	74	45	39	68	41	355
Else	61	84	144	64	81	88	17	539
Total	482	538	756	413	414	599	313	3515

Y : 16 to 24 years old ; M : 25 to 34 years old ; 0 : 35 years or older
Else : Drivers whose sex or age is unknown or age is below 16.

Table 7. Number of rear-end collisions which occurred on State and U.S. routes in the State of Washington in 1983.

	Male, Y	Male, M	Male, 0	Female, Y	Female, M	Female, 0	Else	Total
Male, Y	121	103	135	85	80	117	51	692
Male, M	70	64	114	61	48	66	47	470
Male, 0	69	95	165	57	66	125	57	634
Female, Y	67	56	104	61	50	81	26	445
Female, M	32	52	67	33	50	56	30	320
Female, 0	30	51	69	43	49	92	26	360
Else	55	83	126	58	61	105	21	509
Total	444	504	780	398	404	642	258	3430

Y : 16 to 24 years old ; M : 25 to 34 years old ; 0 : 35 years or older
Else : Drivers whose sex or age is unknown or age is below 16.

Table 8. Number of rear-end collisions which occurred on State and U.S. routes in the State of Washington in 1984.

	Male, Y	Male, M	Male, 0	Female, Y	Female, M	Female, 0	Else	Total
Male, Y	135	131	178	92	98	136	59	829
Male, M	66	89	127	61	71	79	51	544
Male, 0	91	95	173	75	71	123	62	690
Female, Y	66	70	115	74	60	107	37	529
Female, M	42	37	79	41	52	69	31	351
Female, 0	53	54	109	41	50	86	34	427
Else	69	74	135	62	82	116	18	556
Total	522	550	916	446	484	716	292	3926

Y : 16 to 24 years old ; M : 25 to 34 years old ; 0 : 35 years or older
Else : Drivers whose sex or age is unknown or age is below 16.

Table 9. The results of a weighted analysis of variance by analyzing 1n Rs in terms of driver sex and age effect, and sex and age main effect only.

Source	Degrees of Freedom	Sum of Squares	F Value	P-Value	R-Square
Model	3	1.56	209.39	0.0001	0.98
Error	14	0.03			
Corrected total	17	1.59			
Source	Degrees of Freedom	Sum of Squares	F Value	P-Value	
Sex	1	0.32	127.21	0.0001	
Age	2	1.24	250.48	0.0001	