Alcohol-Impaired Driving: Evaluating Its Impact on Urban Safety and Driver Behavior through Driving Simulator

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Introduction

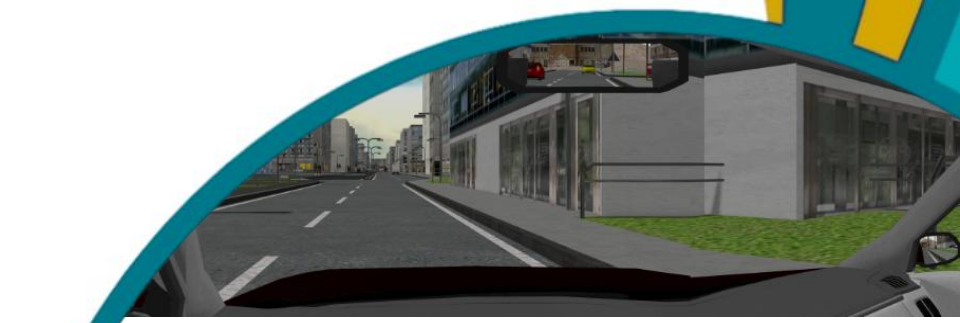
- Alcohol-impaired driving is a major road safety hazard, strongly increasing crash risk.
- Even low BAC levels (0.03%) impair reaction time, attention, and judgment.
- Urban environments increase risk due to high density, intersections, and vulnerable users.
- The study investigates how BAC affects headway distance, reaction time, and crash probability in urban driving.

Study Aim & Contribution

- To quantify the effects of alcohol consumption on driver behavior under urban traffic conditions.
- To assess dose-response relationships across four BAC levels: 0%, 0.03%, 0.06%, 0.09%.
- To explore behavioral and demographic moderators, including gender, tolerance, and drinking habits.
- To provide evidence for policies and targeted interventions addressing drunk driving in cities.

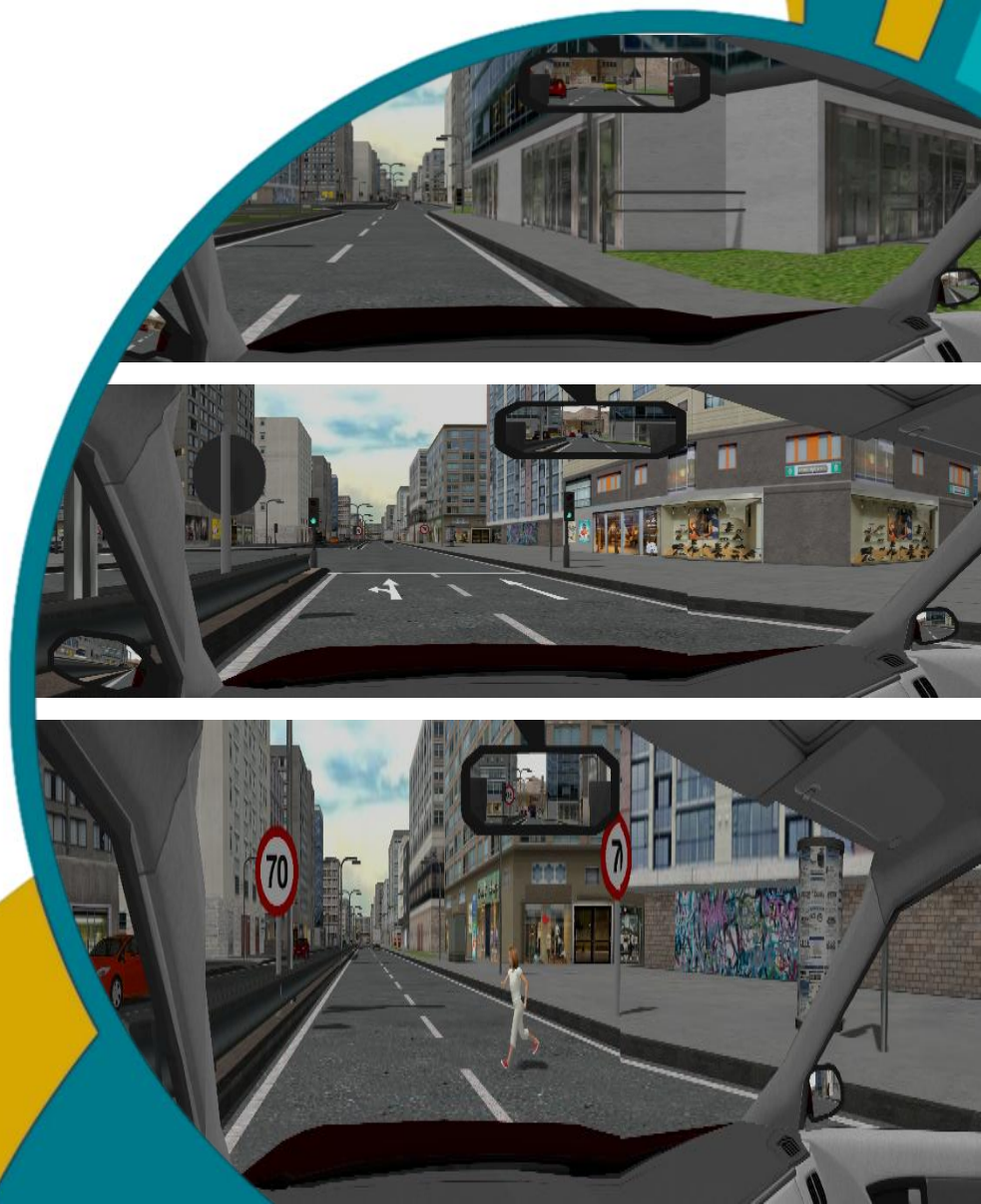
Experiment & Participants

- The study used the FOERST driving simulator to replicate an urban road environment.
- 35 drivers aged 19–32 (21 male, 14 female) participated.
- Questionnaire data collected demographics, drinking habits, and attitudes toward drink-driving.



Scenarios & Data

- Scenario included urban roads with intersections, crossings, parked vehicles, and traffic.
- Each completed four identical urban simulator drives at randomized BAC simulated levels.
- Unexpected events (e.g., pedestrians, sudden braking) introduced to test responsiveness.
- Continuous logging of speed, headway, braking, TTC, lane deviation, reaction time, etc.



Modeling Approach

- **Linear regression** used for headway distance and reaction times.
- **Binary logistic regression** applied to crash probability estimation.
- **Statistical significance** set at $p < 0.05$, R^2 for linear, accuracy for logistic.
- **Elasticity analysis** used to assess relative variable influence.

Results – Headway Distance

- Higher BAC levels reduced headway distance, showing riskier following behavior.
- Male drivers kept longer distances compared to females.
- Frequent urban drivers maintained shorter headways, reflecting risky familiarity.
- Underestimation of alcohol tolerance further shortened distances.

Independent Variables	βi	Std. Error	t Value	p-Value	e	e*
(Constant)	109.201	9.729	11.224	0.000 ***		
Discrete variables						
Scenario_No	-7.102	1.504	-4.722	0.000 ***	-0.07	2.52
Gender	10.115	3.540	2.857	0.005 ***	0.10	-3.60
Days_perweek_urban	-2.813	0.747	-3.763	0.000 ***	-0.03	1.00
Beer_limit	-5.951	2.256	2.683	0.009 **	-0.06	2.12
R^2 = 0.29 Adjusted R^2 = 0.26						

Results – Reaction Time

- BAC increase significantly delayed reaction times, confirming a dose-dependent impairment effect.
- Higher self-reported alcohol consumption linked to slower responses.
- Perceived tolerance bias worsened performance under alcohol.
- Drivers avoiding drink-driving in real life reacted faster, showing protective behavioral traits.

Independent Variables	βi	Std. Error	t Value	p-Value	e	e*
(Constant)	1.021	0.173	5.898	0.000 ***		
Discrete variables						
Scenario_No	0.108	0.031	3.429	0.000 ***	0.07	1.00
Average_alcohol_quantity	0.2041	0.053	3.883	0.000 ***	0.13	1.89
Beer_limit	0.1283	0.046	2.819	0.006 **	0.08	1.19
Returning_home_scenario	-0.14	0.062	-2.270	0.025 *	0.09	1.30
R^2 = 0.20						
Adjusted R^2 = 0.17						

Results – Crash Probability

$$Crash\ Probability = \frac{e^{NumOfCrashesAverage}}{e^{NumOfCrashesAverage}+1}$$

- Crash likelihood rose sharply with higher BAC levels, strongest predictor in the model.
- Past violations showed reduced simulated crash risk, possibly due to self-regulation under observation.
- Lower income correlated with higher crash risk.
- The model reached 78.6% prediction accuracy, confirming strong robustness.

Independent Variables	βi	Std. Error	z Value	p-Value	e	e*
(Constant)	-2.419	0.789	-3.065	0.002 **		
Discrete variables						
Scenario_No	1.724	0.285	6.049	0.000 ***	0.972	-5475.88
Annual_family_income	-0.582	0.344	-1.694	0.090 .	-0.002	1.00
Continuous variables						
Exceeded_breathalyzer_limit	-0.002	0.0006	-3.399	0.000 ***	-0.232	1304.3
Times_driven_intoxicated_last_year	-0.147	0.061	-2.424	0.015 *	-0.059	333.10
Accuracy = 78.57%						

Discussion

- **Alcohol impairs safe urban driving** at all tested levels, reducing headway and slowing reaction times.
- **Crash probability** rises sharply with BAC, with alcohol level the strongest predictor in the model.
- **Behavioral traits and risk perception** matter, including tolerance beliefs and avoidance strategies.

Conclusions

- Even moderate alcohol consumption impairs urban driving safety, elevating crash probability.
- Headway distance, reaction time, and crash involvement all deteriorated with rising BAC.
- Beliefs about tolerance and self-control are misleading, leading to unsafe behavior.
- Alcohol-impaired driving remains a critical policy target, requiring combined enforcement and education.

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