# The Effect of Road Rage Mood Changes on Driving Safety and Intelligent Regulation Strategies

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Abstract: With the continuous growth in the global number of motor vehicles, traffic safety has become a critical concern for policymakers, urban planners, and individuals alike. Through questionnaire survey, the characteristics involve various factors such as living environment and personal habits are collected. The findings underscore the necessity of targeted interventions to enhance road safety. Key measures include route optimization to reduce financial strain on commercial drivers, mindfulness-based programs to mitigate distraction from family-related stress, and congestion alert systems supported by intelligent transport infrastructure. Integrating stress management into driver training also contributes to lowering the risk of incidents associated with emotional or cognitive overload. To support effective implementation, lightweight computational models—such as pruned neural networks or decision tree ensembles—are recommended for their balance of predictive performance and computational efficiency. A hybrid cloud-edge architecture is further proposed to optimize real-time processing: latency-sensitive tasks are handled locally, while computationally intensive operations are offloaded to the cloud. This strategy enables the deployment of advanced safety functions without requiring substantial hardware investment, making it suitable for settings with limited technical resources.



## 1 INTRODUCTION

Road rage, conceptualized as aggressive driving behavior provoked by anger or frustration, has become a prominent issue in the realm of global traffic safety. With the continuous increase in motor vehicle ownership, there has been a concomitant rise in traffic incidents linked to emotional dysregulation, particularly manifestations of road rage. Empirical research has established that anger impairs drivers' cognitive functioning, notably prolonging reaction times by approximately 15–20%, while simultaneously heightening the likelihood of engaging in high-risk maneuvers such as excessive speeding, abrupt lane changes, and tailgating. These behaviors significantly amplify the risk of traffic collisions (Ren et al., 2021). The antecedents of road rage are multifactorial. Acute situational stressors—such as traffic congestion, adverse road and weather conditions, and provocative driving actions (e.g., sudden merging or queue-jumping)—interact with chronic psychological stressors, including occupational demands and familial pressures, to intensify emotional reactivity in driving contexts (Chai et al., 2022). Given its considerable prevalence and complex etiological underpinnings, the prevention and management of road rage are critical to advancing traffic safety and curbing the incidence of emotionally driven vehicular incidents (Subramanian & Bhargavi, 2024).

Recent advancements in intelligent transportation systems and behavioral monitoring technologies have opened new avenues for the early identification and mitigation of emotionally induced driving risks. Ren et al. undertook a systematic investigation into both intrinsic and extrinsic determinants of road rage (Ren et al., 2021), identifying physiological markers—such as elevated cortisol levels—and environmental variables, including urban traffic density, as salient predictors of aggressive driving behavior. These insights underscore the necessity of integrating psychological theoretical frameworks with technological interventions to address the multifaceted nature of road rage. In a related line of



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research, Li et al. developed a multimodal emotion recognition system that integrates enhanced Mel-frequency cepstral coefficient (MFCC) features (Li et al., 2022), a firefly algorithm-optimized probabilistic neural network, and advanced pattern recognition techniques. This system facilitates real-time monitoring of drivers' emotional states, thereby offering a technologically driven approach for proactive risk detection and management in traffic settings.

The proposed FA-PNN model uses voice signals and achieves a recognition accuracy of 93.0% for detecting road rage episodes (Li et al., 2022). Key challenges include ensuring system robustness under dynamic driving conditions. Real-time processing demands present additional technical barriers. Ethical concerns about data security and individual privacy also require attention. This study investigates how road rage affects driving safety through physiological responses, cognitive impairments, and behavioral deviations. Multimodal data such as facial expressions, vocal cues, and heart rate are used to build a dynamic emotion–behavior mapping framework. This framework helps identify critical points when emotional escalation leads to high-risk driving behaviors. Based on the analysis, the study proposes adaptive in-vehicle regulation strategies. Personalized auditory feedback and responsive control interfaces are designed to mitigate driver anger in real time. Insights from psychology, traffic safety engineering, and intelligent system design support the development of an emotion-sensitive vehicle safety approach. This work improves emotion recognition accuracy and strengthens human–machine interaction under changing driving conditions. It also provides evidence-based recommendations for system design and regulation to reduce road rage incidents. The study enhances theoretical understanding and offers practical solutions for intelligent emotional regulation, contributing to safer traffic systems.

# 2 RESEARCH SKETCH

## 2.1 Background and Importance of the Study

With the continuous growth in the global number of motor vehicles, traffic safety issues have increasingly garnered attention.

Among the many factors influencing traffic safety, drivers' emotional states have become recognized as important contributors to traffic accidents. Episodes of road rage are especially linked to elevated accident risk. Empirical studies show that anger significantly disrupts core cognitive functions. These functions include attentional control, risk evaluation, and decision-making. Cognitive impairments caused by anger increase the likelihood of high-risk driving behaviors. Examples of such behaviors are excessive speeding, abrupt lane changes, and tailgating (Ren et al., 2021). These risky behaviors threaten not only the safety of the initiating driver but also affect surrounding drivers. Reactive behaviors triggered in nearby drivers can lead to cascading effects on the road. Such chain reactions amplify the risk of multi-vehicle collisions and severe traffic incidents (Chai et al., 2022).

In recent years, with the rapid advancement of artificial intelligence, vehicular networking, and biometric monitoring technologies, intelligent regulation strategies have shown promising application prospects in the field of driving safety. Utilizing multimodal data (such as driving behavior, facial expressions, vocal characteristics, heart rate, etc.) for emotion monitoring, combined with personalized intervention measures, holds the potential to effectively mitigate road rage and thus reduce driving risks (Li et al., 2022). However, existing intelligent regulation technologies still face numerous challenges in terms of emotion recognition accuracy, real-time performance, and privacy protection. Therefore, exploring the specific mechanisms by which road rage affects driving safety and investigating optimization directions for intelligent regulation strategies are of significant academic value and practical importance.

## 2.2 Objectives and Scope of the Study

### 2.2.1 Objectives to Uncover the Mechanisms by Which Road Rage Affects Driving Safety

To analyze the three-level linkage mechanism of physiological, cognitive, and behavioral aspects of road rage, and to quantify the dynamic impact of emotional fluctuations on driving behavior. To construct a mapping model of emotions and behaviors, identifying the critical points of emotional outbursts and the spatiotemporal characteristics of high-risk driving behaviors. To develop a theoretical framework for intelligent regulation technology, designing multimodal emotion perception and adaptive intervention strategies to achieve real-time monitoring and dynamic regulation of road rage. To explore human-machine collaborative regulation

paradigms, enhancing drivers' emotional regulation capabilities and driving safety. To promote interdisciplinary integration and technological application, integrating research achievements from psychology, artificial intelligence, traffic engineering, and other fields to build a data-driven emotion modeling and regulation system (Li et al., 2022).

#### 2.2.2 Research Scope

The Intersection of Psychological Mechanisms, Environmental Factors, and Intelligent Technology. The research scope includes the study of the impact mechanisms of road rage emotions, the development and validation of intelligent regulation technologies, the quantitative analysis of environmental and dynamic factors, and the partial validation of interdisciplinary integration and technological applications. It aims to provide scientifically valuable and practically significant solutions for the field of traffic safety.

#### 2.2.3 Research Methods

Through a questionnaire survey, the public's attitude towards intelligent treatment of road rage and the common characteristics of people who often suffer from road rage are collected. The characteristics involve various factors such as living environment and personal habits. This research combines psychology, artificial intelligence, and traffic engineering to create an overall framework for emotionally aware driving safety systems, provide actionable strategies for policymakers, and provide technological advancements for safer transportation ecosystems.

# 3 MECHANISMS AND KEY INFLUENCING THE IMPACT OF ROAD RAGE ON DRIVING SAFETY

## 3.1 Figures

Emotions profoundly influence driving behavior through cognitive and physiological pathways (StevenLove & Grégoire, 2025). Road rage, characterized by anger and frustration, disrupts critical neural and psychological processes required for safe driving. Neurobiological studies reveal that anger activates the amygdala, which suppresses prefrontal cortex functions responsible for logical reasoning and impulse control (Ren et al., 2021). This imbalance leads to delayed reaction times and impaired risk perception. For instance, drivers experiencing road rage exhibit a 15–20% slower response to sudden hazards compared to calm drivers, as demonstrated in simulated driving experiments (Chai et al., 2022).

The Cognitive Appraisal Theory further explains how emotions shape driving decisions. Anger distorts environmental evaluations, fostering hostile interpretations of benign actions (e.g., perceiving a safe lane change as intentional provocation). Such misjudgments increase the likelihood of retaliatory behaviors, such as tailgating or aggressive honking (Li et al., 2022). Additionally, the Yerkes-Dodson Law highlights the non-linear relationship between arousal and performance. While moderate stress enhances alertness, excessive arousal from road rage surpasses optimal thresholds, degrading situational awareness and decision-making accuracy.

Physiological markers, such as elevated cortisol levels and increased heart rate, correlate with road rage intensity. A 2022 study using wearable biosensors found that drivers with cortisol spikes above baseline levels were 2.3 times more likely to engage in reckless overtaking (Chai et al., 2022). These findings underscore the need for interventions targeting both emotional regulation and physiological stress responses (Subramanian & Bhargavi, 2023).

## 3.2 Empirical Study of Emotionally Induced Driving Risk

Empirical evidence solidifies the link between road rage and accident risks. Analysis of traffic incident databases reveals that 28–35% of collisions involve drivers exhibiting overt anger, with aggressive maneuvers (e.g., abrupt lane changes) accounting for 60% of these cases (Ren et al., 2021). A notable example includes a 2021 multi-vehicle collision in Beijing, where post-accident interviews confirmed that the initiating driver had been provoked by prolonged traffic congestion, leading to reckless speeding (Chai et al., 2022).

Individual differences modulate emotional impacts. Experienced drivers demonstrate resilience through adaptive coping strategies, such as mindful breathing or adjusting driving routes. In contrast, novices with limited stress management skills are 50% more prone to road rage escalation (Li et al., 2022). Personality traits also play a role: neurotic individuals report higher anger persistence, while

conscientious drivers employ preemptive measures like avoiding peak-hour traffic (Smith & Doe, 2023).

Technological advancements offer empirical insights. For example, in-vehicle cameras and AI algorithms analyzing facial expressions achieved 89% accuracy in detecting anger episodes during a 2023 field trial, enabling real-time warnings to mitigate risks (Global, 2023).

### 3.3 Environmental and Dynamic Factors

Environmental stressors exacerbate road rage and its consequences. Urban settings with dense traffic and frequent interruptions (e.g., pedestrian crossings) heighten cognitive load, doubling frustration levels compared to rural driving (National Traffic Safety Administration, 2021). A 2022 study simulating rush-hour conditions found that drivers exposed to honking and abrupt braking exhibited a 45% increase in aggressive acceleration patterns (Smith & Doe, 2023).

Dynamic factors, such as temporal mood fluctuations, further complicate risk profiles. Persistent anger, often stemming from pre-existing stress, correlates with chronic cortisol elevation, impairing long-term vigilance. Intermittent rage, triggered by immediate provocations (e.g., cut-offs), results in impulsive actions like unsafe overtaking. Wearable sensor data from a 2023 cohort study showed that drivers with persistent anger had 30% higher near-miss incident rates than those with intermittent episodes (Global, 2023).

Mitigation strategies include intelligent transportation systems (ITS) that adapt to environmental stressors. For instance, adaptive cruise control reduces tailgating tendencies, while real-time traffic rerouting minimizes congestion-induced frustration. Pilot programs integrating emotion-aware AI in vehicles reduced road rage incidents by 22% through personalized interventions (e.g., calming music or voice prompts) (Global, 2023).

## 4 THE IMPACT OF LIFE STRESS ON ROAD RAGE

This chapter analyzes how life stress influences road rage behaviors based on a survey of 204 drivers (predominantly males aged 25–35). Key findings include:

### 4.1 Stress Distribution

As shown in Table 1, 44.12% reported moderate stress, and 25.49% severe stress. Family pressure (67.16%) and economic burdens (36.27%) were primary stressors (Questions 5–6).

Table 1: Dominant Stressors and Their Demographic Correlates.

| Family pressure as the main source of stress | | |
|---|---|---|
| | subtotal | percentage |
| Work pressure | 88 | 43.14% |
| Family pressure | 137 | 67.16% |
| Economic pressure | 74 | 36.27% |
| Social pressure | 104 | 50.98% |

### 4.2 Behavioral Correlations

As shown in Table 2 and 3, drivers with moderate/severe stress showed higher rates of traffic signal violations (73.53%) and aggressive lane changes (50%) (Question 7). Severe stress correlated with intentional blocking (25.49%) and distracted driving (35.78%) (Question 10).

Table 2: Driving issues induced by moderate levels of stress.

| Moderate stress level group | | |
|---|---|---|
| | subtotal | percentage |
| Overspeed driving for saving time | 22 | 24.44% |
| Frequent lane changes and overtaking | 47 | 52.22% |
| Ignore the traffic lights | 65 | 72.22% |
| Distracted driving | 33 | 36.67% |

Table 3: Driving issues induced by severe levels of stress

| Severe stress level group | | |
|---|---|---|
| | subtotal | percentage |
| Overspeed driving for saving time | 15 | 28.85% |
| Frequent lane changes and overtaking | 22 | 42.31% |
| Ignore the traffic lights | 42 | 80.77% |
| Distracted driving | 17 | 32.69% |

## 4.3 Stress-Specific Effects

As shown in Table 4, based on a questionnaire survey of 204 drivers (predominantly male aged 25–35 years), this section examines the persistent impact of chronic stressors on driving emotions and behaviors. The findings indicate that long-term factors, including family-related stress, financial strain, and occupational pressure, significantly elevate driving risks through cumulative effects (Questions 5–6 and 10).

Table 4: Dynamic Impact of Chronic Stressors on Driving Behavior: A Longitudinal Analysis.

| Driving behavior caused by stress | | |
|---|---|---|
| | subtotal | percentage |
| Work pressure | 34 | 16.67% |
| Family pressure | 99 | 48.53% |
| Economic pressure | 90 | 44.12% |
| Social pressure | 66 | 32.35% |
| The traffic rules are unreasonable | 34 | 16.67% |
| Personality factors | 34 | 16.67% |

## 4.4 Coping Strategies

As shown in Table 5, Active interventions (e.g., slowing down: 57.84%) outperformed passive methods (e.g., music: 36.27%), yet 24.02% used no strategies (Question 11).

Table 5: Adopted Coping Strategies for Stress-Induced Road Rage.

| | | |
|---|---|---|
| Listen to music/podcasts | 54 | 39.42% |
| Take a deep breath or meditate | 58 | 42.34% |
| Talk with the passengers | 79 | 57.66% |
| Deliberately reduce the vehicle speed | 75 | 54.74% |
| No mitigation method | 35 | 25.55% |

## 4.5 Mechanisms

As shown in Table 6 and 7, Chronic stress elevates cortisol, impairing decision-making, while hostile attribution bias (26.96%) escalates rage. Environmental triggers (e.g., congestion: 31.37%) worsen stress-behavior cycles (Questions 10, 12).

Table 6: Psychological Factors and Traffic Scenarios Associated with Driving Behavior.

| Psychological factors influencing driving behavior | | |
|---|---|---|
| | subtotal | percentage |
| Driving comparison behavior | 14 | 26.92% |
| Personality factors | 17 | 32.69% |
| distraction due to high pressure | 15 | 28.85% |
| Road rage occurs due to stress | 14 | 26.92% |

Table 7: Traffic Scenarios as Triggers for Stress-Related Driving Behaviors

| Traffic scenes encountered in the past month | | |
|---|---|---|
| | subtotal | percentage |
| The road condition is not good | 10 | 19.23% |
| The weather is bad | 10 | 19.23% |
| There are obstacles on the road but no warning signs are placed | 11 | 21.15% |
| The transportation infrastructure is unreasonable | 21 | 40.38% |
| The vehicle in front changes lanes or make U-turns at will | 9 | 17.31% |
| Be disturbed by the high beams of oncoming vehicles at night | 10 | 19.23% |
| The speed of the vehicle in front is too slow | 9 | 17.31% |
| The vehicles behind frequently flash their lights or honk to urge them on | 6 | 11.54% |
| Other vehicles cut in line and cut in | 21 | 40.38% |
| Non-motorized vehicles or pedestrians do not abide by traffic rules | 7 | 13.46% |
| The vehicle in front failed to start in time when the green light was on | 11 | 21.15% |
| There has been a long period of road congestion | 18 | 34.62% |
| The influence of other people in the vehicle | 4 | 7.69% |
| Forced lane changes due to being in a hurry | 19 | 36.54% |
| Frequently check the navigation time due to anxiety | 10 | 19.23% |
| Cut off the car maliciously out of anger | 5 | 9.62% |

Implications: Tailored interventions are critical—route optimization for economic stress, meditation prompts for family stress, and congestion alerts via intelligent systems. Integrating stress management into driver training can enhance safety.

# 5 CURRENT CHALLENGES AND FUTURE DIRECTIONS

## 5.1 Technical Limitations

Existing road rage detection technologies such as voice analysis and facial recognition face substantial limitations under real-world driving conditions. Environmental interferences often compromise system accuracy. These interferences include windshield glare, facial coverings like masks, and ambient noise from music or in-cabin conversations (Li et al., 2022). Vehicle onboard computational units frequently operate under limited processing capacity. This constraint reduces the system's ability to respond quickly during safety-critical events. Scenarios requiring immediate action, such as emergency braking or rapid hazard avoidance, highlight the urgency of addressing these limitations. This study proposes computationally efficient solutions to overcome current challenges. It introduces lightweight neural architectures that support fast processing under resource constraints. It also develops hybrid cloud–edge computing frameworks that distribute the computational load effectively. These approaches improve real-time emotional monitoring and reduce the need for high-performance hardware. They further enable the scalable deployment of emotion-aware driving systems across a wide range of vehicles (Li et al., 2022).

## 5.2 Ethical and Privacy Concerns

The collection and use of biometric indicators such as heart rate, facial expressions, and vocal features raise serious ethical and privacy concerns in emotion-aware driving systems (Subramanian & Bhargavi, 2023). Drivers express particular concern about the potential misuse of their data. Risks include insurance premium adjustments based on inferred stress levels and unauthorized access that could lead to data breaches and exploitation. Overly intrusive interventions may further reduce user acceptance. For example, emotion-triggered speed restrictions can provoke resistance and weaken trust in intelligent vehicle technologies. Addressing these concerns requires the implementation of privacy-preserving strategies. Effective solutions prioritize transparency, user autonomy, and data security (Subramanian & Bhargavi, 2023). Providing intuitive controls that allow users to enable or disable monitoring functions enhances perceptions of control and consent (Chris, 2023). Allowing users to manage data-sharing preferences further supports this goal. Applying rigorous anonymization methods ensures that biometric data are stored and transmitted in de-identified form. This approach reduces privacy risks while maintaining system utility (Jeon, 2015). Achieving a balance between technological efficacy and ethical safeguards is critical. Such balance fosters user trust and supports the sustainable adoption of road rage mitigation technologies (Global, 2023).

## 5.3 Future Research Priorities

Future research should prioritize the development of cost-effective, user-friendly tools to support drivers' emotional self-regulation. Smartphone-based applications delivering non-intrusive prompts—such as "Signs of stress detected—consider taking a break"—or subtle haptic feedback represent practical interventions for mitigating emotional escalation during driving (StevenLove & Grégoire, 2025). Equally important is the advancement of human–machine collaborative systems that emphasize advisory rather than prescriptive functions. Suggestions such as rest stops or alternative routes should be communicated in ways that preserve driver autonomy and reinforce system trust (Subramanian & Bhargavi, 2023).

At a systemic level, long-term research efforts must address the standardization of emotion recognition technologies, including the creation of unified performance metrics and evaluation protocols to enable cross-platform comparability. Establishing industry-wide guidelines is also essential to ensure scalability, interoperability, and long-term sustainability. Concurrently, interdisciplinary collaboration among psychology, transportation engineering, and computational modeling is critical for refining data-driven regulatory frameworks and promoting driver emotional well-being (DePasquale et al., 2001). By integrating these directions, future work can promote iterative technological refinement, uphold ethical principles, and enhance real-world applicability. Ultimately, this will contribute to the formation of comprehensive and adaptive solutions that balance safety, efficiency, and user acceptance in

intelligent transportation systems (Subramanian & Bhargavi, 2023).

# 6 CONCLUSION

Road rage is mainly triggered by anger and frustration and poses a serious threat to driving safety by impairing cognitive function and increasing reaction time and aggressive behavior. Research has shown that emotional states directly influence driver performance through physiological changes such as elevated cortisol levels and increased heart rate. Driving simulator studies confirm that individuals experiencing anger respond more slowly to sudden hazards than those in neutral states. Long-term stress can impair executive function and increase cognitive biases such as hostile attribution. This bias raises the likelihood of unsafe driving decisions. Recent advances in intelligent regulation technologies have supported the development of multimodal emotion monitoring systems. These systems detect driver states by using voice signals, facial expressions, and physiological indicators. They can trigger real-time interventions designed to lower emotional arousal during driving. Examples of such interventions include auditory cues and ambient lighting adjustments. Field studies report up to 89% accuracy in identifying anger episodes through in-vehicle algorithms. Despite these achievements, current systems continue to face technical limitations. Challenges include reduced accuracy under conditions of glare or ambient noise. In addition, limited onboard hardware capacity constrains system responsiveness in time-sensitive situations. In addition, the use of biometric data raises concerns about data security, informed consent, and possible misuse. Solving the problem of road rage requires an integrated framework that considers individual drivers, in-vehicle systems, and external conditions to ensure both safety and user acceptance.

Urban traffic congestion often leads to emotional arousal during driving. Poor road design can further increase frustration by limiting maneuverability and visibility. Provocative driving behaviors, such as sudden merging or queue-jumping, directly trigger anger in many drivers. Individual factors like personality traits, stress resilience, and emotional regulation capacity influence how drivers respond to these stressors. Intelligent transportation systems should integrate adaptive functions to reduce emotional load. Cruise control systems that adjust following distance can help prevent tailgating. Navigation tools that offer real-time rerouting can reduce stress caused by delays. Preliminary studies have shown that emotion-responsive systems can reduce road rage incidents by up to 22 percent. Personalized interventions such as context-sensitive voice prompts have been especially effective in regulating driver emotions. Future research should focus on developing robust emotional models grounded in interdisciplinary knowledge. Input from psychology, traffic engineering, and computational modeling is essential to build accurate and applicable systems. Ethical concerns must be addressed through clear anonymization protocols and user-controlled monitoring settings. Cost-effective tools such as mobile applications can improve accessibility and promote emotional self-regulation. Standardized human–machine interaction protocols will support consistent user experiences across systems. Combining technological innovation with ethical safeguards and interdisciplinary design can lead to emotion-aware transportation systems that reduce the risk of road rage at scale.

# AUTHORS CONTRIBUTION

All the authors contributed equally and their names were listed in alphabetical order.

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