



Research article

The role of anger rumination as a mediator in the relationship between driver moral disengagement and driving angry

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ABSTRACT

Background: Road rage is a common phenomenon during driving, which not only affects the psychological health of drivers but also may increase the risk of traffic accidents. This article explores the impact of moral disengagement and anger rumination on road rage through two studies.

Method: This research combined experimental studies with survey questionnaires. Study one used a driving simulator to investigate whether moral disengagement and anger rumination are psychological triggers of road rage in real-time driving, and whether there are differences in the main psychological triggers of road rage under different road scenarios. Building on the first study, study two employed a survey questionnaire to analyze the relationship between moral disengagement, anger rumination, and road rage. Participants in both studies were drivers with certain driving ages and experience. Data were processed and analyzed using descriptive statistics, factor analysis, reliability and validity tests, and multiple regression analysis.

Results: The findings indicated: (1) There were significant differences in the anger induction rate across different road scenarios, $\chi^2 = 35.73$, $p < 0.01$, effect size = 0.29. Significant differences in average anger levels were observed in scenarios involving oncoming vehicles, lane-cutting, sudden stops by the vehicle ahead, pedestrians crossing the road, and traffic congestion ($F = 20.41$, $p < 0.01$, $\eta^2 = 0.36$), with anger rumination playing a major role in the formation of road rage; (2) Moral disengagement significantly predicted road rage ($\beta = 0.25$, $t = 3.85$, $p < 0.01$). The predictive effect of moral disengagement on anger rumination was significant ($\beta = 0.39$, $t = 6.17$, $p < 0.01$), as was the predictive effect of anger rumination on road rage ($\beta = 0.43$, $t = 6.3$, $p < 0.01$). The direct effect of moral disengagement on road rage included 0 in the bootstrap 95% confidence interval, while the mediating effect of anger rumination did not include 0 in the bootstrap 95% confidence interval, indicating that anger rumination fully mediated the relationship between moral disengagement and road rage.

1. Introduction

Driving anger is defined as a driver's intense emotional response, resulting from stress or frustration while driving cars [1]. This emotional state may manifest alongside aggressive actions directed towards fellow drivers, passengers, or pedestrians. According to prior research, individuals experiencing intense anger while driving tend to make quicker decisions when considering lane changes,

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which in turn elevates the likelihood of causing accidents [2,3]. The phenomenon of road rage, encompassing both verbal and physical expressions of anger, has witnessed a surge in occurrence across numerous countries. This worrisome trend further exacerbates road safety issues stemming from such behavior [4,5]. It is evident that the presence of irate drivers and the subsequent aggressive driving conduct triggered by driving anger are detrimental to the overall safety of road travel and can substantially contribute to traffic accidents [6]. Consequently, traffic psychologists have extensively examined the underlying factors that contribute to the emergence of driving rage. Their comprehensive efforts aim to diminish the frequency of such incidents and effectively mitigate the occurrence of road rage behaviors.

Traffic road scenarios are the primary instigator of driving rage and a fundamental factor leading to aggressive conduct, as proposed by Soole et al.'s [7] comprehensive model of driving behavior. The mere presence of traffic police, sluggish traffic flow, and congestion frequently trigger driving rage, potentially culminating in aberrant driving actions like exceeding speed limits and disregarding traffic signals [8]. Furthermore, in the context of self-driving vehicles, irate drivers exhibit a heightened tendency to assume manual control of the vehicle, particularly in congested road conditions [9]. Drawing from Ref. [10] findings, individuals have been observed to channel their anger through three primary avenues: verbal expressions, physical gestures, and vehicular actions. Another dimension identified is adaptive constructive aggression. Furthermore, it's worth noting that a driver's own display of rage can potentially trigger anger in fellow drivers too [11].

However, when confronted with traffic situations that could potentially elicit anger, the intensity of drivers' provoked anger and the methods through which they manifest this anger exhibit substantial variability, influenced by individual factors. When faced with circumstances potentially triggering anger, male drivers have been noted to encounter a higher frequency of stimuli in comparison to their female counterparts [12,13]. While Hashmi et al.'s [14] investigation revealed a paradoxical pattern where female drivers exhibited elevated driving anger scores yet scored lower in terms of traffic infractions when compared to their male counterparts. This incongruity might be attributed to the subjective nature of the questionnaire employed. Nonetheless, it remains evident that male drivers tend to exhibit a more overtly aggressive expression of anger than their female counterparts [15]. Contrasting senior drivers, those younger and less experienced drivers tend to exhibit a greater inclination of reporting instances of driving anger, often influenced by a predisposition towards aggressive thought patterns [16,17]. Drivers who engage in risky driving behaviors frequently find themselves susceptible to heightened driving anger, are contrast to individuals embodying more altruistic or responsible driving tendencies, typically showcasing a lower intensity of anger or anger expression [18,19]. Furthermore, compared to private drivers, professional drivers who routinely break the law while driving for work are more prone to become enraged and drive aggressively, and taxi drivers exhibit higher levels of aggressive anger while driving than truck and bus drivers [1,20]. Previous research indicates that negative emotions and aggressive behaviors may be present not only in immediate traffic congestion but also on non-congested roads following congestion [21–23]. This research [24] utilized dashcams to record facial expressions across different road scenarios, finding that various road conditions elicited different degrees of negative or other emotions. Addressing this gap, the study selected five specific road scenarios that are most likely to provoke driver anger, based on a review of the literature. Through simulated driving, it explores whether there are differences in the psychological triggers that primarily influence driving anger in different road scenarios.

Although, the studies mentioned provide valuable insights into comprehending driving rage, implementing driving anger therapies that center around these characteristics can prove challenging and less effective due to the immutability and diversity of individual disparities, coupled with the intricate nature of road traffic conditions. Conversely, intervening in the cognitive evaluation process is comparatively more feasible and also a crucial step in addressing the genesis of driving rage.

Two frequently employed cognitive assessments in the investigation of rage encompass anger rumination and moral justifications. Anger rumination, delineated by four distinct dimensions—namely, anger post-incident, recollection of angry episodes, thoughts of revenge, and understanding causation—represents an ineffective cognitive approach that inclines individuals to fixate on and brood over their angry emotions and encounters, along with their triggers and outcomes [25,26]. Notably, Suhr et al. [27] established a correlation between scores on the anger rumination scale and self-reported risky driving behaviors, encompassing hazardous, aggressive, and perilous driving actions. Meanwhile, Stephens et al. [28] found the act of anger rumination holds significant sway over the transition from trait anger to aggressive driving. Elevated levels of anger rumination amplify the probability of drivers manifesting aggressive anger expression, while diminished levels heighten the likelihood of adaptive expressions. Subsequent to recollecting past instances of anger, individuals exhibit a noticeable surge in their emotional state [29]. And employing a positive attributional approach has the effect of mitigating both the magnitude and expression of anger, whereas a hostile attribution bias fuels anger rumination, thereby contributing to aggressive behaviors [28,30,31]. Besides, the relationship between self-compassion and anger expression is also mediated by anger rumination, with self-compassion indirectly impacting the expression of aggressive and adaptive anger through anger rumination or certain of its characteristics [32].

On the other hand, moral disengagement refers to a series of cognitive processes that allows one to dissociate their actions from their inherent moral principles, enabling them to act immorally without experiencing any negative consequences [33,34]. By affecting the control of negative emotions and consequently high-risk behaviors, moral disengagement can be a predictor of aggressive behavior [35]. In their study on driving moral disengagement, Swann et al. [36] found that drivers with higher scores on the driving moral disengagement scale tend to exhibit a greater propensity for engaging in aggressive driving behaviors. This was viewed by drivers as a belief that their actions would end the other person's transgression, despite the fact that their own actions were wrong and might have been driven by their own level of animosity [37].

Assessing whether anger rumination and moral justifications reliably predict driving anger in real-world driving situations poses a challenge, primarily because investigations into anger rumination and driving anger, as well as studies on moral justifications linked to aggressive driving, have predominantly relied on questionnaire-based methodologies. As this limitation and the effectiveness of driving simulators in eliciting anger [11,38], the present study adopted five traffic scenarios simulated by driving simulators—a traffic

jam, pedestrian crossing, sudden halt by the vehicle in front, opposing vehicle reversing direction, and another vehicle abruptly entering the road—as means to provoke driving anger. The study's objective was to ascertain whether moral disengagement and anger rumination serve as principal psychological triggers for driving anger, and hypothesized that there are differences in the psychological triggers that play a major role in driving anger in different road situations (Hypothesis 1). As the same time, the correlation among driving anger, anger rumination, and moral excuses remains elusive, adding complexity to the challenge of directing cognitive interventions aimed at mitigating the extent to which driving anger is triggered across various road scenarios, although previous research has identified the combined impact of moral justifications and anger rumination on aggressive driving behaviors [26], the interplay between these factors is not entirely understood. To address this conundrum, we employed a questionnaire-based approach to explore the interrelation between moral justifications, anger rumination, and driving anger (Study 2). In line with this, we hypothesized that the link between moral justifications and driving anger is mediated by the presence of anger rumination (Hypothesis 2).

2. Study 1: effects of driver moral pushback and anger regurgitation on driving anger in different road scenarios

2.1. Method

2.1.1. Participants

To ensure good consistency, 38 drivers were randomly recruited to take this test in Dalian. Among them, 21 were female subjects and 17 were male subjects. The age range of the subjects was 19–33 years, the driving experience range was 0.5–6 years, and the education level of all subjects was university degree or above. The experiment was approved by the Academic Ethics Committee of Liaoning Normal University. Ethics review number: LL2023082.

2.1.2. Research tools

2.1.2.1. Driving rage test platform. Driving simulators were employed in this study due to their safety and their close association with driving-related risks. The experiment utilized City car driving, a PC-based program designed to simulate urban road conditions and replicate realistic traffic flow. The program was chosen to stimulate participants and elicit driving anger by introducing unexpected road scenarios such as pedestrians crossing the road. To enhance the immersive experience, a Logitech G29 steering wheel and three 17-inch monitors were utilized, allowing participants to operate the vehicle within the simulator, see Fig. 1.

2.1.2.2. High definition (HD) cameras. A Microsoft LifeCam HD camera was placed in front of the subjects in order to post-calibrate rage and analyze anger triggers. The subject's behavior and facial expressions in response to the road scene stimuli were captured on camera.

2.1.2.3. Emotional self-rating scales. Individual driver variances can lead to different emotional responses to the same road scenario. Therefore, this study employed an empirical sampling strategy to collect data, where participants were required to promptly inform the investigator about their emotional state following an unexpected traffic event. To simplify the process, the study utilized Sigman's six basic emotions framework, including happiness, anger, sorrow, fear, surprise, and disgust. However, for the purpose of this study, the focus was on the three negative emotions of anger, fear, and disgust. An emotion self-rating scale was developed using these three emotion adjectives to reduce the participants' workload [39]. Anger, including driving anger, was one of the emotions rated on a scale of 0–5, with 0 representing minimal or unproductive anger and 5 indicating extremely intense anger. In the experiment, participants had the option to respond with “no” if they were not experiencing any of the three specified emotions during the debriefing. The primary focus of this study was on anger as the target emotion. To determine the probability of the road event eliciting anger, the



Fig. 1. Driving simulator platform.

frequency of participants experiencing anger during the road event was divided by the frequency of participants experiencing all other emotions during the same event. Higher values indicate a greater level of anger provoked by the traffic incident.

2.1.2.4. Moral excuses scale. The Chinese version of the Civic Moral Pushback Questionnaire, consisting of 32 items, was assessed using a 5-point Likert scale [40] made modifications to this questionnaire. Higher scores on the scale indicated higher levels of moral pushback. The questionnaire dimensions demonstrated strong internal consistency, with all coefficients above 0.90, and split-half reliability coefficients exceeding 0.80. The pre-survey conducted with 70 participants in this study revealed a significant positive association between moral pushback and driving anger ($r = 0.35, p < 0.01$). Further analysis of the correlations between the dimensions of moral pushback and driving anger indicated that the dimensions of favorable comparison, transfer of responsibility, and dehumanization were significantly correlated with driving anger ($r = 0.36, p < 0.05$; $r = 0.40, p < 0.01$; $r = 0.47, p < 0.01$) and were found to be more sensitive predictors of driving anger.

2.1.2.5. Anger regurgitation scale. The anger rumination scale of Sukhodolsky et al. [25] was selected, with a total of 19 items, including four dimensions: post-event anger, vengeful thoughts, anger memory and understanding the reason. This scale is scored on a 4-point scale of “never, sometimes, often, always”, whose consistency coefficient of the scale is 0.93

2.1.3. Materials

The experiment was carried out on an urban road with an unpredictable traffic flow, with a length of 10 km, consisting of 12 intersections, 2 roundabouts and 20 pedestrian crossings. Each participant was instructed to follow the same route while operating the vehicle with the assistance of the software’s route navigation feature. During the course of driving, participants encountered five randomly selected unexpected road situations. The first situation was a high traffic flow leading to a traffic jam, which was defined according to the “Road Traffic Congestion and Evaluation Method” (GA 115-1995) published by the Ministry of Public Security in China. In this situation, a vehicle would have to wait for three green lights at a traffic signal before being able to cross the intersection, as shown in Fig. 2. Seven subjects in this study did not meet this condition when they experienced the traffic jam scenario and were therefore not included in the statistics. The remaining 31 subjects experienced an average of one traffic jam scenario during the experiment. The second situation is pedestrians suddenly crossed the road from 50 m in front of the vehicle, as shown in Fig. 3. Each subject encountered this scenario 2.7 times on average in the experiment. The third situation is vehicles behind suddenly accelerated and jumped the road in front of the subject’s vehicle, with each subject encountering this scenario 3.6 times on average in the experiment, as shown in Fig. 4. The fourth situation is vehicles in front of the subject stopped sharply, with each subject encountered this scenario 1.9 times on average in the experiment, as shown in Fig. 5. The fifth situation is vehicles in the opposite lane went against the road and caused obstruction to the normal movement of the subject’s vehicle, whose average number of times each subject encountered this scenario in the experiment was 2.3, as shown in Fig. 6.

2.1.4. Experimental design

The study utilized a one-way within-subjects experimental design, incorporating five levels of independent variables, which corresponded to five different road scenarios. These scenarios included traffic congestion, pedestrian crossings, vehicles swerving into the path of traffic, abrupt stopping of cars in front, and vehicles in the opposite lane moving in the opposite direction. The dependent variable focused on three emotions: anger, fear, and disgust, which were measured using a six-point emotion scale. Participants were asked to report their subjective emotional state at irregular intervals, based on an experience sampling approach. If a participant was not experiencing any emotion at the time of reporting or feeling an emotion other than anger, fear, or disgust, they had the option to respond with “none.” Besides, the effects of extraneous variables are excluded, such as the location of the experiment, the light intensity of the experimental site, and the appearance and expression of the subject on the results of the experiment.



Fig. 2. Traffic jam.



Fig. 3. Pedestrians crossing the road.



Fig. 4. Other vehicles jumping the road.



Fig. 5. Emergency stop of the front vehicle.

2.1.5. Experimental procedure

Prior to the start of the experiment, the participants were informed about the task requirements, which involved completing a round trip on a predetermined route within a 40-min time frame while obeying traffic laws. The experimenter provided an explanation of how the driving simulator operated, allowing the participants to practice adaptive driving for 10 min to familiarize themselves with the driving style of the simulator. During the formal experiment, data were collected using an experience sampling method. In this method, the experimenter directly questioned the participants about their emotional state whenever they encountered a specific road scenario, and recorded the participants' responses. While the participants in the study expressed their emotional states using simple and direct terminology, such as "anger 1" and "disgust 2", to minimize the potential influence of their stated emotions on their driving behavior. After the experiment, the participants completed the driving anger scale, the anger rumination scale, and the moral excuses



Fig. 6. Opposite direction traffic in reverse.

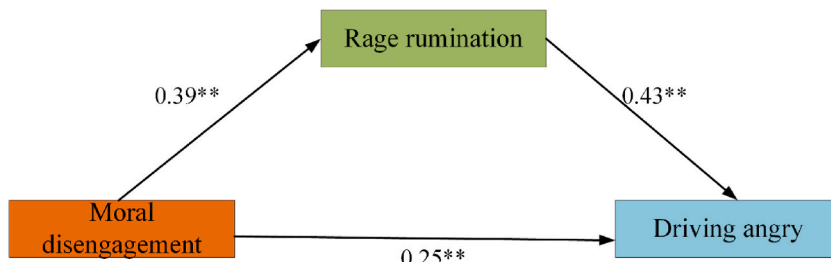


Fig. 7. Intermediary effects model.

scale. The experimenter recorded the participants’ responses and findings from these scales for further analysis.

2.1.6. Analysis of data

This study aims to examine drivers’ emotional responses under five different road scenarios: vehicles driving in the wrong direction, lane cutting, sudden stops by the car ahead, pedestrians crossing the road unexpectedly, and traffic congestion. It records instances of anger, disgust, fear, and no emotion, along with the rate of anger induction. The normality of the data is tested using the Kolmogorov-Smirnov test. Differences in anger induction rates across different road scenarios are analyzed using the chi-square test. Pairwise comparisons between scenarios are made to identify significant differences in anger induction rates. A repeated measures ANOVA, followed by LSD multiple comparisons, is used to analyze differences in anger levels across scenarios. Regression analysis explores the impact of anger rumination on driving anger, with the average anger levels under different scenarios as the dependent variable and dimensions of anger rumination as predictors. Demographic variables (age, gender) are controlled in a regression analysis to explore the impact of anger rumination dimensions on anger levels. The explanatory power of each variable on anger levels is interpreted from the regression model’s coefficient of determination. All statistical analyses are performed using SPSS 22.

Table 1
Skewness, kurtosis, and standard deviation of the sample distribution.

		Emergency stop of the front vehicle	Other vehicles jumping the road	Opposite direction traffic in reverse	Pedestrians crossing the road	Pedestrians crossing the road
Number of cases	Valid	38	38	38	38	38
	Missing	0	0	0	0	0
Skewness		0.791	-0.587	-0.353	0.860	2.846
Standard error of skewness		0.383	0.383	0.383	0.383	0.383
Kurtosis		-1.105	-1.108	-1.456	-0.974	7.203
Standard error of kurtosis		0.750	0.750	0.750	0.750	0.750

2.2. Results and analysis

2.2.1. Anger-evoking effects of five road scenarios

2.2.1.1. Anger triggering rates for different road scenarios. From Tables 1 Considering significance, these five variables are skewed distributions. Since this is a type of social behavior, it is common to see skewed distributions. However, with more than 30 valid subjects, it is possible to approximate a normal distribution for statistical analysis. From Tables 2 and 3, it can be seen that subjects reported emotions a total of 433 times in the occurrence of the particular road scenario, with an anger induction rate of 40%. A chi-square test analysis of the anger induced by different road scenarios, revealed a significant difference in the rate of anger induced by different road scenarios, $\chi^2 = 35.73, p < 0.01$, effect size = 0.29. A further two-by-two chi-square comparison of the data revealed that subjects were significantly more likely to produce anger in the scenario of going against traffic than a car stopping sharply, pedestrian crossing and the traffic jam ($\chi^2 = 10.38, p < 0.01$, effect size = 0.26; $\chi^2 = 16.3, p < 0.01$, effect size = 0.29; $\chi^2 = 13.7, p < 0.01$, effect size = 0.34). Subjects were significantly more likely to produce anger in the lane grabbing scenario than the car in front of them stopping sharply, pedestrians crossing the road and the traffic jam ($\chi^2 = 10.17, p < 0.01$, effect size = 0.22; $\chi^2 = 16.91, p < 0.01$, effect size = 0.26; $\chi^2 = 13.27, p < 0.01$, effect size = 0.28). There was no difference in the subjects' probability of generating anger between backtracking and lane jumping, and no difference in the three scenarios of stopping sharply in front of a car, pedestrians crossing the road and traffic jams.

2.2.1.2. Analysis of anger levels induced by different road scenarios. There were significant differences in the subjects' mean anger levels in the five scenarios of other vehicles traveling against the road, other vehicles jumping the road, the car in front of them abruptly stopping, pedestrians crossing the road, and traffic jams ($F = 20.41, p < 0.01$, effect size = 0.36). The results of repeated measures ANOVA on the mean anger levels of the subjects in the different road scenarios are shown in Table 4.

The results of the LSD post-hoc multiple comparisons indicated that subjects' mean anger level in the front-end rush stop scenario was greater than the traffic jam ($p < 0.01$); the lane grabbing scenario was greater than the front-end rush stop, traffic jam and pedestrian crossing scenarios ($p < 0.01$; $p < 0.01$; $p < 0.01$); the retrograde scenario was greater than the front-end rush stop, traffic jam and pedestrian crossing scenarios ($p < 0.01$; $p < 0.01$; $p < 0.01$) and the pedestrian crossing scenario was greater than the mean anger level in the traffic jam ($p < 0.01$).

2.2.2. Regression analysis of driver anger regurgitation, moral pushback and driving anger in different road scenarios

2.2.2.1. Regression analysis of driver anger regurgitation on driving anger in different road scenarios. The mean anger rating of the subjects in the five scenarios of opposite vehicle reversal, other vehicle lane jumping, emergency stop in front of the vehicle, pedestrian crossing, and traffic jam were used as dependent variables, and the subjects' scores on each dimension of anger ruminant were used as predictor variables. Regression analyses were conducted controlling for two demographic variables, age and gender of the subjects.

The regression analysis results in Table 5, reveals significant effects of certain factors on the anger levels of the subjects in different scenarios. Specifically, hindsight anger showed a significant effect on anger levels when encountering scenarios such as the car in front stopping sharply and the opposite vehicle going against traffic ($\beta = 0.35, p < 0.05$; $\beta = 0.48, p < 0.01$). Revenge thoughts had a significant impact on anger levels in the lane grabbing scenario ($\beta = 0.33, p < 0.05$), while anger memory had a significant influence on anger levels in the pedestrian crossing scenario ($\beta = 0.71, p < 0.01$). It is worth noting that anger memory also had a significant effect on anger levels in the pedestrian crossing scenario ($\beta = 0.71, p < 0.01$). The regression model coefficients provide clear evidence that driver's anger after an incident significantly and positively predicts their anger level towards the vehicle in front of them abruptly stopping and the vehicle traveling in the opposite direction, explaining 27% of the variance. Furthermore, driver's revenge thoughts positively predict their anger towards other vehicles for lane jumping, explaining 10% of the variance. Lastly, driver's anger memory positively predicts their anger towards pedestrians crossing the road, explaining 30% of the variance.

2.2.2.2. Regression analysis of driver moral pushback and anger regurgitation on driving anger in lane grabbing scenarios. To predict subjects' mean anger ratings in other vehicle lane jumping scenarios, hierarchical regressions were employed. At the first level, gender and age were introduced using the ENTER method, while subjects' scores on favorable comparison and revenge thoughts were introduced at the second level using the STEPWISE method. The results revealed significant correlations between subjects' mean anger

Table 2

Anger triggering rates for five road events.

	Angry	Aversion	Fear	No emotion	Total	Induced anger rate
Opposite direction traffic in reverse	47	16	22	1	86	55%
Other vehicles jumping the road	73	24	41	2	140	52%
Emergency stop of the front vehicle	21	15	31	5	72	30%
Pedestrians crossing the road	27	20	45	12	104	26%
Traffic jam	5	20	1	5	31	16%
Total	173	95	140	25	433	40%
Opposite direction traffic in reverse	47	16	22	1	86	55%

Table 3
Chi-square test for anger triggering rates for different road scenarios.

	χ^2	df	p
Pearson's chi-square	35.73 ^a	4	<0.001
Likelihood ratio	36.94	4	<0.001
Linear association	32.23	1	<0.001
Number of valid cases	433		

a.0 cells (0.0%) Expected count is less than 5. The lower limit of expected count is 12.39

Table 4
Results of analysis of differences in mean anger levels generated by subjects in different road scenarios.

Dependent variables	M	SD	F	p	ηp^2
Stopping in front of a car anger level	1.21	1.63	20.41	<0.001**	0.36
Lane jumping anger level	2.68	1.77			
Anger level for going against traffic	2.71	1.98			
Traffic jam anger level	0.34	0.97			
Pedestrian crossing anger rating	1.1	1.53			

Note: **p < 0.01.

Table 5
Results of regression analysis of the dimensions of anger rumination on subjects' anger ratings.

Dependent variable	Independent variable	R	R ²	ΔR^2	F	β	t
Stopping in front of a car anger level		0.57	0.33	0.27	5.58*		
	Age					-0.16	-1.06
	Gender					0.19	1.21
Lane jumping anger level	Anger after the fact	0.42	0.17	0.1	2.37	0.35	2.3*
	Age					0.01	0.03
	Gender					0.23	1.45
	Retaliation ideas					0.33	2.12*
Anger level for going against traffic		0.58	0.33	0.27	5.63*		
	Age					-0.27	-1.89
	Gender					0.27	1.88
Pedestrian Crossing Anger Rating	Anger after the fact	0.61	0.38	0.3	4.95*	0.48	3.35**
	Age					0.3	2.11
	Gender					0.21	1.51
	Angry Memories					0.71	3.67**

Note: *p<0.05, **p<0.01, same below.

ratings and their scores on favorable comparison and revenge thoughts in the other vehicle lane jumping scenarios. Based on the regression analysis findings presented in Table 6, it was observed that the favorable comparison propensity in the lane-grabbing scenario had a significant impact on participants' rage ratings ($\beta = -0.42, p < 0.01$). The coefficient of determination for the regression model indicated that the participants' favorable comparison inclinations negatively predicted their rage ratings towards lane snatching, explaining 17% of the variance. Furthermore, after incorporating the subjects' scores on ideas of retribution, the

Table 6
Results of regression analysis of mean anger levels for lane grabbing.

Variables		Average anger level at traffic jams					
		Model 1		Model 2		Model 3	
		β	SE	β	SE	β	SE
Step 1	Control variables						
	Gender	-0.04	0.58	-0.01	0.53	0.04	0.5
	Age	0.25	0.12	0.19	0.11	0.17	0.1
Step 2	Predictor variables						
	Favorable comparisons			-0.42**	0.12	-0.45**	0.11
Step 3	Predictor variables						
	Retaliation ideas					0.37*	0.11
	F	1.19		3.5*		4.83**	
	R ²	0.06		0.24		0.37	
	ΔR^2	0.01		0.17		0.29	

model's explanatory power improved to 29%, allowing for a more accurate prediction of participants' anger ratings towards lane snatching.

3. Study 2: the relationship between driver moral pushback and driving anger: the mediating role of anger regurgitation

3.1. Method

3.1.1. Participant

The questionnaires for this study were distributed online, and a random selection of drivers from across the nation was invited to participate. A total of 245 questionnaires were collected initially. However, 45 questionnaires were identified as incorrect due to factors such as repetitive options. After removing these 45 questionnaires, 200 genuine surveys remained, resulting in an efficiency rate of 81.63%. The sample size was calculated using G*Power with parameters set for a medium effect size ($f = 0.3$), power $(1-\beta) = 0.95$, $\alpha = 0.05$, and a two-tailed test. The calculation indicates that a sample size of 134 participants is required. The current sample size meets the statistical requirements for publication.

Table 7 presents the demographic data of the survey respondents. In this table, the driving frequency variable is coded on a scale of 1–5, while the education variable is coded on a scale of 1–6. The research procedures and data collection methods were approved by the Research Ethics Committee of Liaoning Normal University. All the participants were provided with an informed consent form.

3.1.2. Research tools

3.1.2.1. Moral excuses scale. In the same study 1, the Chinese version of the revised civic moral pushback questionnaire by Wang et al. [40] was chosen to retain the three dimensions of favorable comparison, transfer of responsibility and dehumanization for testing the relationship between moral pushback and driving anger.

3.1.2.2. Anger rumination scale. As in Study 1, the anger rumination scale developed by Sukhodolsky et al. [25] was chosen to test four dimensions of anger afterwards, thoughts of revenge, anger memory and understanding the cause.

3.1.2.3. Driving anger scale. The Chinese version of the driving anger scale revised by Guo et al. [21] was used, with 22 items, divided into four dimensions: hostile gestures, slow driving, unreasonable driving and traffic congestion. The internal consistency coefficient of the scale was 0.84, and the internal consistency coefficient and split-half reliability coefficient of each dimension were above 0.70.

3.1.3. Research methodology

The research methodology employed in this study involved the use of a questionnaire to recruit drivers online and invite them to participate in the trial. The recruited subjects were then asked to complete several scales, including the basic demographic information form, the driving anger scale, the anger regurgitation scale, and the moral excuses scale. Prior to filling out these scales, the participants were provided with information about the objectives and purpose of the study.

Table 7
Frequency analysis of demographic variables.

Variables	Category	N	Frequency
Sex	Men	96	48%
	Women	104	52%
Age	Under 20 years old	3	2%
	21–30 years old	75	38%
	31–40 years	63	32%
	41–50 years old	49	25%
	51 years and above	10	5%
Driving experience	Less than 5 years	106	54%
	6–10 years	57	29%
	11 years or more	37	19%
Education level	Primary	4	2%
	Junior High School	46	23%
	College/University	44	22%
	Undergraduate	92	46%
	Postgraduate and above	14	7%
Driving frequency	Drive every day	57	29%
	4–6 days a week	63	32%
	1–3 days a week	48	24%
	1 time in half a month	13	7%
	1 time a month	8	4%
	Less than 1 time a month	11	6%

3.1.4. Analysis of data

After the questionnaires were collected, invalid questionnaires were excluded and the valid questionnaires were entered into SPSS 22 for statistical analysis. The normality of the data was assessed using the Kolmogorov-Smirnov test. To evaluate the potential for common method bias, Harman's single-factor test was employed. Subsequently, Pearson correlation analysis was conducted to examine the relationships the variables. This was followed by a detailed analysis of the interrelationships between the three variables and their association with demographic variables. Finally, mediation models were tested using Model 4 in the SPSS macro developed by Hayes (2012), with gender and age as control variables."

3.2. Results and analysis

3.2.1. Common method bias test

The normality of the data was assessed using the Kolmogorov-Smirnov test. Based on Table 8, the skewness and kurtosis at three levels indicate that the sample is approximately normally distributed. This study used the Harman single factor test to test for homophily bias and the results showed that there was no serious problem of homophily bias as 12 factors with eigenvalues greater than 1 were obtained using unrotated principal component factor analysis and the variance explained by the first factor was 27.15%, which was less than the critical criterion of 40% (see Table 9).

3.2.2. Correlation analysis of driving anger, anger rumination, moral pushback and demographic variables

Pearson's correlation analysis was conducted on the driver's driving anger, anger rage, moral pushback and demographic variables and the results are shown in Table 9. The correlations between driving anger, anger rumination and moral pushback were significant ($r = 0.52, p < 0.01$; $r = 0.28, p < 0.01$; $r = 0.42, p < 0.01$). Driving anger was negatively correlated with age and driving age ($r = -0.38, p < 0.01$; $r = -0.29, p < 0.01$), while driving anger was positively correlated with educational attainment and driving frequency ($r = 0.35, p < 0.01$; $r = 0.17, p < 0.05$). Furthermore, anger rumination was negatively correlated with age and driving age ($r = -0.32, p < 0.01$; $r = -0.26, p < 0.01$), while anger rumination was positively correlated with education and driving frequency ($r = 0.25, p < 0.01$; $r = 0.23, p < 0.01$). However, the correlations between moral pushback and age, driving age, education, and driving frequency were not significant ($r = -0.12, r = -0.10, r = -0.07, r = -0.03, r = 0.07$).

3.2.3. Correlation analysis of moral pushback, anger regurgitation and driving anger

3.2.3.1. Correlation between driving anger and anger ruminant. Driving anger was positively correlated with anger ruminant ($r = 0.52, p < 0.01$) and its' three dimensions of anger ruminant: post-event anger, anger memory and understanding the cause ($r = 0.17, r = 0.25, r = 0.22$), but was not significantly correlated with thoughts of revenge ($r = 0.11$). And anger ruminant was positively correlated with the three dimensions of driving anger: hostile gestures, slow driving and traffic congestion were positively correlated ($r = 0.15, r = 0.19, r = 0.25$), but were not significantly correlated with irrational driving ($r = 0.12$), see Table 10.

3.2.3.2. Correlations between driving anger and moral pushback. Driving anger was positively correlated with moral pushback ($r = 0.28, p < 0.01$), but not correlated with its dimensions, involving favorable comparisons, blame shifting and dehumanization ($r = 0.02, r = 0.05, r = -0.08$). Meanwhile moral pushback was positively correlated with slow driving ($r = 0.15$), while insignificantly correlated with hostile gestures, unreasonable driving and traffic congestion ($r = 0.10, r = 0.07, r = 0.08$), see Table 11.

3.2.3.3. Correlation between anger ruminant and moral pushback. Anger rumination was positively correlated with moral pushback ($r = 0.42, p < 0.01$), yet correlations between anger rumination and three dimensions of moral pushback were not significant for favorable comparisons, blame shifting and dehumanization ($r = 0.06, r = 0.07, r = 0.10$). At the same time, moral pushback was positively correlated with three dimensions of anger rumination, post-incident anger, anger memory and revenge thoughts ($r = 0.16, r = 0.17, r = 0.14$), whereas non-significant correlation with understanding reasons ($r = 0.12$), see Table 12.

3.2.4. Analysis of the mediating effect of anger rumination between moral pushback and driving anger

The mediating effect of anger rumination in the relationship between moral pushback and driving anger was tested according to the test procedure proposed by Wen and Ye [41], using Model 4 (simple mediation model) in the SPSS macro developed by Hayes (2012), controlling for gender and age. The results indicated (see Tables 13 and 14) that moral pushback was a significant predictor of driving

Table

8Skewness, kurtosis, and standard deviation of the sample distribution.

		Moral disengagement	Anger rumination	Driving angry
Number of cases	Valid	38	38	38
	Missing	0	0	0
Skewness		0.427	0.513	-0.464
Standard error of skewness		0.383	0.383	0.383
Kurtosis		-0.593	0.419	0.220
Standard error of kurtosis		0.750	0.750	0.750

Table 9
Correlation analysis of driving anger, anger regurgitation, moral pushback and demographic variables.

	<i>M</i>	<i>SD</i>	Driving Anger	Rage Regurgitation	Moral pushback	Age	Driving experience	Education level	Frequency of driving
Driving Anger	56.49	16.45	1						
Rage Regurgitation	34.21	9.90	0.52**	1					
Moral pushback	21.56	7.33	0.28**	0.42**	1				
Age	35.05	9.40	-0.38**	-0.32**	-0.10	1			
Driving experience	7.36	7.20	-0.29**	-0.26**	-0.07	0.42**	1		
Education level	3.33	0.97	0.35**	0.25**	-0.03	-0.49**	-0.27**	1	
Frequency of driving	2.43	1.36	0.17*	0.23**	0.07	-0.13	-0.42**	0.12	1

Note: * $p < 0.05$, ** $p < 0.01$, same below.

Table 10
Correlation between driving anger and anger regurgitation.

	Driving Anger	Rage Regurgitation	Hostile gestures	Slow driving	Unreasonable driving	Traffic congestion	Post-incident anger	Angry memories	Thoughts of revenge	Understanding the cause
Driving Anger	1									
Rage Regurgitation	0.52**	1								
Hostile gestures	0.41**	0.15*	1							
Slow driving	0.44**	0.19**	0.69**	1						
Unreasonable driving	0.42**	0.12	0.75**	0.69**	1					
Traffic congestion	0.47**	0.25**	0.68**	0.71**	0.62**	1				
Post-incident anger	0.17*	0.50**	0.42**	0.45**	0.42**	0.45**	1			
Angry memories	0.25**	0.52**	0.46**	0.46**	0.39**	0.51**	0.83**	1		
Thoughts of revenge	0.11	0.46**	0.33**	0.30**	0.25**	0.35**	0.73**	0.69**	1	
Understanding the cause	0.22**	0.49**	0.44**	0.44**	0.43**	0.44**	0.78**	0.70**	0.56**	1

Table 11
Correlation between driving anger and moral excuses.

	Driving Rage	Ethical pushback	Hostile gestures	Slow Driving	Unreasonable Driving	Traffic Congestion	Favorable comparison	Transfer of responsibility	Dehumanization
Driving Rage	1								
Ethical pushback	0.28**	1							
Hostile gestures	0.41**	0.10	1						
Slow Driving	0.44**	0.15*	0.69**	1					
Unreasonable Driving	0.42**	0.07	0.75**	0.69**	1				
Traffic Congestion	0.47**	0.08	0.68**	0.71**	0.62**	1			
Favorable comparison	0.02	0.34**	0.27**	0.21**	0.24**	0.22**	1		
Transfer of responsibility	0.06	0.40**	0.15*	0.22**	0.15*	0.19**	0.70**	1	
Dehumanization	-0.08	0.29**	0.27**	0.26**	0.18*	0.20**	0.63**	0.62**	1

Table 12

Correlation between anger regurgitation and moral excuses.

	Regurgitation of anger	Moral excuses	Anger after the fact	Anger memory	Thoughts of revenge	Understanding the cause	Favorable comparison	Transfer of responsibility	Dehumanization
Regurgitation of anger	1								
Moral excuses	0.42**	1							
Anger after the fact	0.50**	0.16*	1						
Anger memory	0.52**	0.16*	0.83**	1					
Thoughts of revenge	0.46**	0.14*	0.73**	0.69**	1				
Understanding the cause	0.49**	0.12	0.78**	0.70**	0.56**	1			
Favorable comparison	0.06	0.34**	0.29**	0.27**	0.29**	0.30**	1		
Transfer of responsibility	0.07	0.40**	0.27**	0.25**	0.32**	0.24**	0.70**	1	
Dehumanization	0.10	0.29**	0.43**	0.37**	0.52**	0.31**	0.63**	0.62**	1

Table 13
Mediating model tests for anger rumination.

Regression equation (N = 200)		Fitted indicators			Coefficient Significance	
Dependent Variables	Independent Variables	R	R ²	F (df)	β	t
Driving angry	Gender	0.43	0.19	15.22**	0.02	0.23
	Age				-0.33	-4.97**
	Moral excuses				0.25	3.85**
Rage Regurgitation	Gender	0.50	0.25	22.21**	-0.28	-1.7
	Age				-0.11	-4.36**
	Moral excuses				0.39	6.17**
Driving angry	Gender	0.57	0.33	23.59**	0.06	1.01
	Age				-0.21	-3.32**
	Rage Regurgitation				0.43	6.3**
	Moral excuses				0.09	1.32

Note: ** $p < 0.01$, same below.

Table 14
Total effect, direct effect and intermediate effect breakdown table.

	Effect	Boot SD	Boot lower	Boot upper
Total effect	0.56	0.15	0.28	0.85
Direct effect	0.19	0.14	-0.09	0.47
Mediating effect	0.37	0.09	0.21	0.57

anger ($\beta = 0.25$, $t = 3.85$, $p < 0.01$). Moral pushback was a significant predictor of anger ruminant ($\beta = 0.39$, $t = 6.17$, $p < 0.01$) and anger ruminant was a significant predictor of driving anger ($\beta = 0.43$, $t = 6.3$, $p < 0.01$). The direct effect of moral pushback on the effect of driving anger contained 0 at both the upper and lower limits of the bootstrap 95% confidence interval, while the mediating effect of anger rumination did not contain 0 at both the upper and lower limits of the bootstrap 95% confidence interval, indicating that moral pushback predicted driving anger through the mediating effect of anger rumination. [Figure 7](#)

4. General discussion

This study aimed to explore whether moral avoidance and anger rumination are the main psychological causes of driving anger in real-time driving situations, and the connection between anger rumination, moral pushback, and driving anger. To achieve this, a simulator was utilized to analyze the psychological triggers that have a significant impact on driving anger across five different road scenarios. Subsequently, participants completed a questionnaire consisting of the driving anger scale, the moral pushback scale, and the anger rumination scale. It is important that we verified that anger rumination and moral avoidance are the psychological causes of driving anger through an empirical study. The results of the study supported the hypothesis that anger rumination plays a significant role in the manifestation of driving rage in three traffic scenarios: vehicle reversal, stopping in front of a vehicle, and pedestrian crossing. Furthermore, the study also found that moral pushback and anger rumination collectively predict driving rage in scenarios involving lane grabbing. And the relationship between moral pushback and driving rage was mediated by anger rumination was proved, too.

4.1. Psychological triggers that play a major role in driving anger in different road scenarios

Questionnaire-based studies have previously confirmed that moral disengagement and anger rumination are psychological triggers for driving anger or aggressive driving [32,36]. However, there has been no prior research to demonstrate whether anger rumination and moral disengagement can influence driving anger during actual driving experiences. Consequently, attributing driving anger solely to anger rumination and moral disengagement has remained challenging.

This study induced driving anger through driving simulator scenarios and found that, after controlling for gender and age, anger rumination primarily contributes to driving anger in three traffic scenarios: oncoming vehicles engaging in misbehavior, sudden braking by preceding vehicles, and pedestrians crossing the road. In the road aggression scenario, both moral disengagement and anger rumination play a role. While the analysis did not cover the traffic congestion scenario due to its lowest rates of anger induction and average anger levels. It can be seen that this study fills the gap in empirical research regarding the impact of anger rumination and moral disengagement on driving anger. Furthermore, the identification of differences in the primary psychological triggers for driving anger across four distinct road scenarios confirms our hypothesis 1.

It is worth mentioning that the differences in psychological triggers and their intensity may objectively lead to variations in the rates of anger induction and average anger levels across different road scenarios. Oncoming vehicles engaging in misbehavior

represent a relatively rare traffic situation, but once it occurs, can significantly impact driving safety, strongly eliciting driver anger rumination. Thus, this scenario has the highest rates of anger induction and average anger levels [42]. Other vehicles cutting into lanes are a common traffic scenario in driving simulator studies, although rule violations are absent. Drivers tend to employ moral disengagement to rationalize their behavior, expressing driving anger through anger rumination. Consequently, the rates of anger induction and average anger levels are relatively high in such scenarios [38,43]. In contrast to the above two scenarios, sudden braking by preceding vehicles and pedestrians crossing the road incidents are mostly random events with relatively low potential threats. Drivers exhibit higher acceptance of these situations, leading to lower proportions of anger rumination. Therefore, driving anger only occurs in a few scenarios in these cases [44].

In general, in situations where there is a potential threat to drivers and rule violations, anger rumination serves as an effective indicator for predicting driving anger. On the other hand, in scenarios where no rule violations occur but there is still a potential threat to drivers, moral disengagement plays a dominant role in driving anger.

4.2. The relationship between moral disengagement and road rage: the mediating role of anger rumination

Moral disengagement can positively predict aggressive driving behavior [36] and can also moderate the relationship between anger rumination and aggression, as well as the relationship between trait anger and aggression [26]. Furthermore, individuals with higher scores on anger rumination tend to exhibit higher levels of road rage [28]. Additionally, road rage often leads to aggressive driving behaviors [45]. However, no researchers have explored the relationship between road rage, moral disengagement, and anger rumination, making it challenging to develop psychological interventions aimed at reducing road rage triggers and subsequently decreasing the occurrence of aggressive driving behaviors.

In this study, we examined the relationships between moral disengagement and road rage, anger rumination and road rage, as well as the mediating role of anger rumination in the relationships between moral disengagement and road rage. We found that anger rumination fully mediated the relationship between moral disengagement and road rage, confirming the hypothesis 2. Specifically, moral disengagement predicts driving anger indirectly by influencing anger rumination, thus validating the mediating role of emotion regulation in the relationship between moral disengagement and risky behaviors [35]. On one hand, moral disengagement significantly predicted road rage. Individuals with higher levels of moral disengagement tended to perceive their aggressive driving behaviors such as overtaking and cutting off other vehicles in response to violations by other vehicles as a means to assert their own road rights, overlooking the potential dangers of their own road rage [36]. Conversely, individuals with lower levels of moral disengagement were more likely to acknowledge the impropriety of their behavior, leading to fewer instances of aggressive driving. On the other hand, the study also found that anger rumination could positively predict road rage. Engaging in repetitive thoughts and recollections of anger made individuals more susceptible to experiencing road rage in potentially anger-inducing traffic situations [46].

Research related to the aggression theory suggests that moral disengagement combines with negative emotions, forming a negative emotion-cognition system disruption. Individuals with higher moral standards are more susceptible to the influence of negative emotions, leading to cognitive dissonance, which may result in attributing ambiguous information in a hostile manner and an increased likelihood of road rage [47–49]. In contrast, individuals with lower levels of moral disengagement are less influenced by negative emotions, enabling them to view their behavior more objectively, resulting in less anger rumination and fewer instances of road rage. The mediating effect of anger rumination suggests the importance of identifying the cognitive processes that play a primary role in road rage and targeting interventions accordingly in order to effectively reduce road rage manifestations and the occurrence of aggressive driving behaviors.

All in all, this study explored the predictive roles of real-time anger rumination and moral disengagement in driving anger within driving simulation scenarios. It clarified the differences in psychological triggers for driving anger in various road scenarios, filling an empirical research gap on the impact of anger rumination and moral disengagement on driving anger. Furthermore, this study established anger rumination as a mediating variable in the relationship between moral disengagement and driving anger, providing insights for cognitive interventions to reduce traffic accidents caused by driving anger.

However, this study has some limitations. Firstly, it did not differentiate groups of drivers, making it impossible to understand the differences between professional and non-professional drivers. Future research could consider analyzing these groups separately. Secondly, subjective self-report methods were used to measure anger induction in this study, which may have relatively low precision. Future research could incorporate objective measures such as EEG, ECG, and skin conductance to make anger induction measurements more precise. Thirdly, There are numerous other road conditions that can provoke extreme emotions in drivers, such as minor collisions or being hit by another vehicle, drivers making mocking faces, errors or confusion due to navigation mishaps, environmental factors, and penalties for traffic violations. The list of road conditions provided here is not exhaustive; rather, we have selected some of the most significant situations or scenarios mentioned in the majority of studies for discussion.

5. Conclusion

This study, conducted through different traffic scenarios in a driving simulator, has found that moral disengagement and anger rumination serve as psychological triggers for real-time driving anger. Specifically, in scenarios involving vehicles driving in the wrong direction, sudden stops by preceding vehicles, and pedestrians crossing the road, anger rumination plays a primary role in the development of driving anger. While in situations involving lane-cutting, both moral disengagement and anger rumination jointly predict driving anger. Building on these findings, the study further explored the relationships between driving anger, moral disengagement, and anger rumination, revealing that anger rumination acts as a complete mediator in the relationship between moral

disengagement and driving anger.

Ethics statement

The research procedure and data collection method were approved by the research ethics committee in the Liaoning Normal University.

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Informed consent statement

Informed consent was obtained from all subjects involved in the study.

CRedit authorship contribution statement

Renjie Lv: Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization, Project administration, Writing – review & editing. **Yusong Wang:** Writing – review & editing, Writing – original draft, Conceptualization. **Chao Zhang:** Investigation, Data curation. **Jinfei Ma:** Conceptualization, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Driving anger scale

Hello, driver! Your answers to this survey are completely anonymous, and we will keep all of your personal information in the strictest confidence. Based on your own driving experience, please select the appropriate number at the end of the question and be as honest as possible when indicating whether you feel furious when driving in the scenarios detailed in the question.

Subject	Not angry	Little angry	Angry	Very angry	Strongly very angry
1. The driver in front of you nearly rear-ended you when he abruptly braked to answer his phone.	1	2	3	4	5
2. Automobiles in front of you that are traveling slowly obstruct traffic	1	2	3	4	5
3. On the highway, someone unexpectedly passes you on the right.	1	2	3	4	5
4. You've been waiting for someone to pull into the parking space when suddenly they do.	1	2	3	4	5
5. Someone driving slowly in fast traffic	1	2	3	4	5
6. A car traveling slowly on a mountain road doesn't pull over to let you pass	1	2	3	4	5
7. You saw police cars monitoring the traffic from a hidden position.	1	2	3	4	5
8. Someone's backing up in front of you without looking where they're going.	1	2	3	4	5
9. The vehicle in front of you on the side suddenly merges without a turn signal and nearly collides with you	1	2	3	4	5
10. Someone driving behind you at night with high beams on	1	2	3	4	5
11. Some people park very slowly and impede traffic	1	2	3	4	5
12. You get stuck in a traffic jam	1	2	3	4	5
13. There's a long line in the driveway, you've been waiting for a long time, and a car suddenly pulls out from behind to try and squeeze in front of you	1	2	3	4	5
14. Drivers of other vehicles make obscene gestures or spit at you while driving	1	2	3	4	5
15. A police car is approaching you	1	2	3	4	5
16. You're driving behind a truck with a wobbly load	1	2	3	4	5
17. Someone is yelling or swearing at you	1	2	3	4	5
18. A cyclist was driving in the middle of the road and blocking traffic	1	2	3	4	5
19. You are driving in an alley with a single lane, and there is a car ready to enter, and you have sounded your horn to give way, but the other person does not pay any attention	1	2	3	4	5
20. You are driving behind a vehicle that is heavily smoking and emitting diesel fumes	1	2	3	4	5
21. A truck kicked up sand onto your car	1	2	3	4	5
22. You can't see the road around you because a big truck is moving ahead	1	2	3	4	5

Appendix B. Anger rumination scale

Please read each of the following items carefully and choose the corresponding number according to your degree. There are no right or wrong answers, so make a quick choice based on your first feeling after reading each sentence.

Subject	Never	Sometimes	Often	Always
1. I kept thinking about my past experiences with anger	1	2	3	4
2. I reflected on the injustice that had happened to me	1	2	3	4
3. I'd be thinking about something that made me angry for a long time	1	2	3	4
4. When the conflict was over, I had persistent fantasies of revenge	1	2	3	4
5. It makes me angry to remember something from a long time ago	1	2	3	4
6. It's hard for me to forgive people who hurt me	1	2	3	4
7. When the argument is over, I continue to imagine arguing with this person in my mind	1	2	3	4
8. Agitated memories pop into my head before I go to sleep	1	2	3	4
9. Whenever I feel angry, I think about it for a while	1	2	3	4
10. I've had times where I can't stop thinking about a particular conflict	1	2	3	4
11. I analyze the events that make me angry	1	2	3	4
12. I think about the reasons why people treat me badly	1	2	3	4
13. I have violent imaginings and fantasies	1	2	3	4
14. I would recreate it in my head after a fit of anger	1	2	3	4
15. I'm angry about something in my life	1	2	3	4
16. When someone annoys me, I can't stop thinking about how to fight back	1	2	3	4
17. When someone messes with me, I keep thinking why is this happening to me	1	2	3	4
18. Even the memory of small troubles will haunt me for a long time	1	2	3	4
19. When something makes me angry, I run it over and over in my head	1	2	3	4

Appendix C. Moral disengagement scale

Here are some ways of doing things in life, please choose the corresponding number according to how much you agree with these ways of doing things. There are no right or wrong answers, so make a quick choice based on your first impression after reading each sentence.

Subject	Rating scale: 1 = "Totally disagree", 2 = "Strongly disagree", 3 = "not sure", 4 = "Strongly agree", 5 = "Totally agree"				
1. When there are no effective garbage disposal facilities, people should not be condemned for littering the streets	1	2	3	4	5
2. Some people just don't deserve to be alive	1	2	3	4	5
3. There is no reason to punish those who write graffiti on walls, as opposed to other people who commit more serious acts such as vandalism	1	2	3	4	5
4. When the whole traffic is moving fast, a driver should not be penalized for speeding to maintain distance	1	2	3	4	5
5. Treat those who behave rudely in the same way as they do in the same way	1	2	3	4	5
6. If a person loses control in an argument, then he is not solely responsible for the consequences of his actions	1	2	3	4	5
7. Compared with the huge pollution caused by industry, littering on the street should not be punished	1	2	3	4	5
8. Given the increasing prevalence of corruption in society, it is inevitable that one person will take advantage of others	1	2	3	4	5
9. Since cars are built for speed, speeding is not the driver's fault	1	2	3	4	5
10. In contrast to adult drug abuse, teenage smoking is not to blame	1	2	3	4	5
11. Humiliating and abusing competitors is the way to go	1	2	3	4	5
12. You can only force someone to work like a cow or a horse	1	2	3	4	5

Appendix D. Emotional self-rating scale

	None	Slightly	Weakly	Moderately	strongly	Very strongly
Angry	0	1	2	3	4	5
Fear	0	1	2	3	4	5
Disgust	0	1	2	3	4	5

During the experiment, when the experimenter asks you about your emotional state, please choose the answer that fits your situation according to the three emotions in the table below and the number representing the different intensity of their response. Give

short answers such as “Anger 1” or “Fear 3”. If you have no emotion at the time of reporting or the emotion is not one of the above three, you can answer “no”.

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