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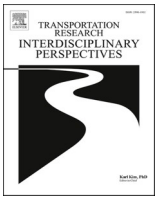

Understanding the role of cognitive appraisal and mindfulness in driving-related anger among Chinese drivers

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ABSTRACT

Cognitive appraisal plays an important role in driving anger, but it is unclear how drivers evaluate different anger-provoking situations. Also, mindfulness is regarded as a promising emotional regulation strategy, but its associations with state driving anger and non-adaptive anger expression are not well-understood. This study, therefore, examined the relationships between driving-related anger, trait mindfulness, and cognitive appraisal undertaken across diverse anger-provoking driving situations.

An online survey was conducted with 559 Chinese drivers, who completed the short form of the Driving Anger Scale (DAS), the short form of the Driving Anger Expression Inventory (DAX), and the Mindfulness Awareness Attention Scale (MAAS). Participants also responded to questions related to state driving anger and cognitive appraisal in Safety Blocking (SB), Travel Blocking (TB), and Hostile Aggression (HA) situations.

The structural equation models showed that all pathways among the driving-related anger variables were positive and significant, except for the link between state driving anger and non-adaptive anger expression in the TB situation. Furthermore, trait mindfulness mitigated trait driving anger and non-adaptive anger expression but not state driving anger.

The investigation of appraisal patterns showed that drivers with higher trait driving anger consistently emphasised "goal relevance", "goal incongruence", and "other responsibility" in all anger-provoking situations. They also exhibited high "problem-focused coping potential" in SB and TB situations, while "emotion-focused coping potential" was salient in the HA situations, and both coping capacities were associated with state driving anger. Overall, the present study provides valuable insights for both theoretical understanding and policy implications by integrating the psychological mechanism of driving anger with road safety.

1. Introduction

Driving anger is widely considered as an important motivator of unsafe driving behaviours, which further contributes to traffic crashes and injuries (Bogdan et al., 2016; Zhang and Chan, 2016). In China, rapidly growing numbers of vehicles and an increasingly dense road user population have created a highly demanding and competitive driving environment. Within this context, automobile-involved crashes resulted in 43,413 fatalities and 157,157 injuries in 2019 (National Bureau of Statistics, 2020). Among these crashes, aggressive and risky driving behaviours have been identified as major contributors (The Traffic Management Bureau of the Ministry of Public Security of China, 2020). Notably, driving anger has been frequently reported on Chinese roads (Suo et al., 2017; Wu et al., 2018), indicating the essential need to reduce unsafe driving through anger management.

It is well acknowledged that driving anger has two modalities: trait driving anger and state driving anger. Trait driving anger refers to a driver's propensity to become angry in a range of driving situations, while state driving anger is a transitory emotional state in response to an anger-arousing situation (Deffenbacher et al., 2001). Over the past decades, plenty of researchers have focused on trait driving anger, including studies comparing individual differences, and examining its relationship with driving behaviours and driving outcomes, e.g., crash involvement (Deffenbacher et al., 2016; Xi et al., 2024).

Designing effective interventions and road safety policies depends on a comprehensive understanding of driving anger. However, focusing extensively on trait driving anger may not be sufficient. Specifically, drivers not only possess a predisposition to anger but also experience

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and express it in non-adaptive ways while driving (e.g., "Swearing at other road users"). Importantly, how to express anger while driving has been found to be more predictive of driving outcomes, as compared to anger propensity (Demir et al., 2016). These insights underscore the essential need to control anger and regulate its expression to improve road safety.

1.1. Literature review

1.1.1. Measuring driving anger using self-reported instruments

Researchers have used self-reported data to understand differences among drivers when confronted with various anger-provoking situations. One of the most widely used instruments is the Driving Anger Scale (DAS; Deffenbacher et al., 1994), which originally included 33 anger-provoking scenarios into six broad categories: slow driving; discourtesy from other drivers; hostility from other drivers; police presence; illegal driving; and traffic obstructions. This factor structure has been confirmed by some other studies (Cantini et al., 2015; Brandenburg and Oehl, 2021). A shorter form of DAS has also been developed, which contains 14 items and shows a high correlation with the 33 item DAS (Deffenbacher et al., 1994). However, its factorial structure has shown inconsistency, despite studies conducted within the same cultural context (Ge et al., 2017; Zhang et al., 2018; Zhai and Xi, 2023).

Researchers have raised concerns about redundancy within the original 33-item DAS, as strong correlations between some subscales have been reported, e.g., traffic obstructions and slow driving (Li et al., 2014; Brandenburg and Oehl, 2021). Deffenbacher et al. (2016) also noted this issue, suggesting that a three-factor structure may be more appropriate for the DAS: 1) driving progress impediment, suggesting driving progress was blocked (e.g., traffic obstruction or slow driving); 2) driving being put at risk, referring to danger or risk caused by other drivers' risky behaviours (e.g., speeding and dangerous overtaking); 3) hostility received while driving, reflecting discourtesy or rude manners from other drivers (e.g., aggressive honking performed by other drivers). In addition to these structural issues, concerns have also been raised regarding the representativeness of DAS items. For instance, several studies have shown that situations involving police presence evoke the least amount of anger among drivers (Sullman et al., 2017b; Brandenburg and Oehl, 2021). Collectively, these findings suggest that the DAS may not fully capture anger propensity in the modern traffic contexts, highlighting the need for refinement and updating (Stephens et al., 2019).

To fill this gap, the Measure for Angry Drivers (MAD) was developed to assess drivers' anger proneness across three types of driving situations: 1) Travel delays (e.g., "You are stuck in a traffic jam."), 2) Danger posed by others (e.g., "Someone cuts right in front of you forcing you to brake."), and 3) Hostility from other drivers (e.g., "Someone beeps at you without reason."). These categories closely align with the conceptual framework proposed by Deffenbacher et al. (2016). Recent studies have applied the MAD, demonstrating its validity for capturing anger responses in contemporary traffic environments and its applicability across cultures (Öztürk et al., 2024; Zhai and Öztürk, 2025).

In addition to measuring anger disposition, researchers have also aimed to understand how drivers express anger while driving. Deffenbacher et al. (2002) developed the Driving Anger Expression Inventory (DAX), a 49-item scale with four factors: verbal expression (e.g., "Yell at the other driver."), physical expression (e.g., "Shake my fist."), use of the vehicle to express anger (e.g., "Drive right up on the other driver's bumper.") and adaptive/constructive expression (e.g., "Not stoop to their level."). However, the length of the DAX limits its practicality for use alongside other driving behaviour measures (Stephens and Sullman, 2014). To overcome this, a short version with 15 items was developed, retaining the same factorial structure and showing high correlations with the full version. This short form provides a more efficient balance between measurement precision and succinctness. More recently, studies have validated the short DAX in different contexts (Zhai et al., 2023; Öztürk et al., 2024), showing its international applicability.

1.1.2. Cognitive appraisal and driving-related anger

Cognition has been recognised as a necessary antecedent of emotions, which arise from the cognitive appraisal of situations in relation to personal goals, desires, and well-being (Lazarus, 1991). In other words, cognitive appraisal connects emotions to external contexts by comparing discrepancies between expected and actual outcomes (Uusberg et al., 2019). Drawing on such a perspective, Smith and Lazarus (1993) developed the Cognitive Appraisal Theory (CAT), which comprises two simultaneous processes, *primary and secondary appraisal*, that jointly determine whether and how emotions are experienced by individuals (see Fig. 1).

The primary appraisal evaluates whether and how external contexts (e.g., traffic events) are related to personal concerns such as well-being, goals, or desires (Smith and Lazarus, 1993). It consists of two components: **goal relevance** (to what extent the external contexts are relevant to personal concerns) and **goal incongruence** (to what extent the external contexts are incongruent with personal concerns).

The secondary appraisal reflects an assessment regarding attribution and coping potential with the triggers. It involves four components: **self/other responsibility** (whether there is an obvious target of blame to receive the credit for the outcomes of external contexts), **problem-focused coping potential** (the evaluation of the perceived ability to act directly on situations to achieve goals), **emotion-focused coping potential** (perceived ability to cope by psychologically adjusting one's interpretation of personal concerns) and **future expectancy** (the extent to which the situation is expected to improve in line with personal concerns, either practically or psychologically). It is worth noting that the secondary appraisal is indispensable for the generation of emotion, as it not only concerns how harm or benefit is involved, while also identifying individuals' coping options and prospects that provide the cognitive foundation for subsequent coping and behavioural responses (Lazarus, 1991).

Within this framework, emotions differ depending on how appraisal components are combined (Lazarus, 1991). Specifically, anger is likely to arise if an event is evaluated as personally relevant but incongruent with individual goals, blamed on others, and perceived as controllable through one's coping resources (e.g., Kuppens et al., 2003). When driving, personal goals/desires often include safe travel, timely arrival, and courtesy from others. Thus, driving anger is likely to occur when another road user is judged as responsible for obstructing goal attainment. For example (see Fig. 2), driver A may become angry when confronted with high-beam headlights from an oncoming vehicle B. The situation could be appraised as threatening personal safety and courtesy (goal relevance and incongruence) and caused by driver B (other responsibility). Driver A also evaluate their ability to cope (coping potential, e.g., honking) and whether the situation could be improved (future expectancy). This outlines general conditions under which anger is elicited.

Cognitive appraisal plays an important role in driving, with previous studies showing that drivers tend to perform speed-related behaviours (e.g., rapid acceleration or hard braking) when they evaluate driving situations as anger-relevant (Stephens and Groeger, 2009). As a result, Møller and Haustein (2018) have suggested that interventions targeting driving anger should consider drivers' cognitive processes. Despite these insights, the understanding of appraisal in driving anger remains insufficient (Siagian and Andangsari, 2021; Bjureberg and Gross, 2021).

To date, only a few studies have applied the CAT to the domain of driving anger (Parkinson, 2001; Stephens et al., 2016a; Albentosa et al., 2018), with most focusing mainly on the link between trait and state driving anger. For example, when Parkinson (2001) asked participants to recall an anger-provoking event and rate the anger intensity they experienced, it was found that the CAT explained 25 % of the variance in state driving anger. However, trait driving anger was not included in the regression models alongside appraisal components, leaving it unclear

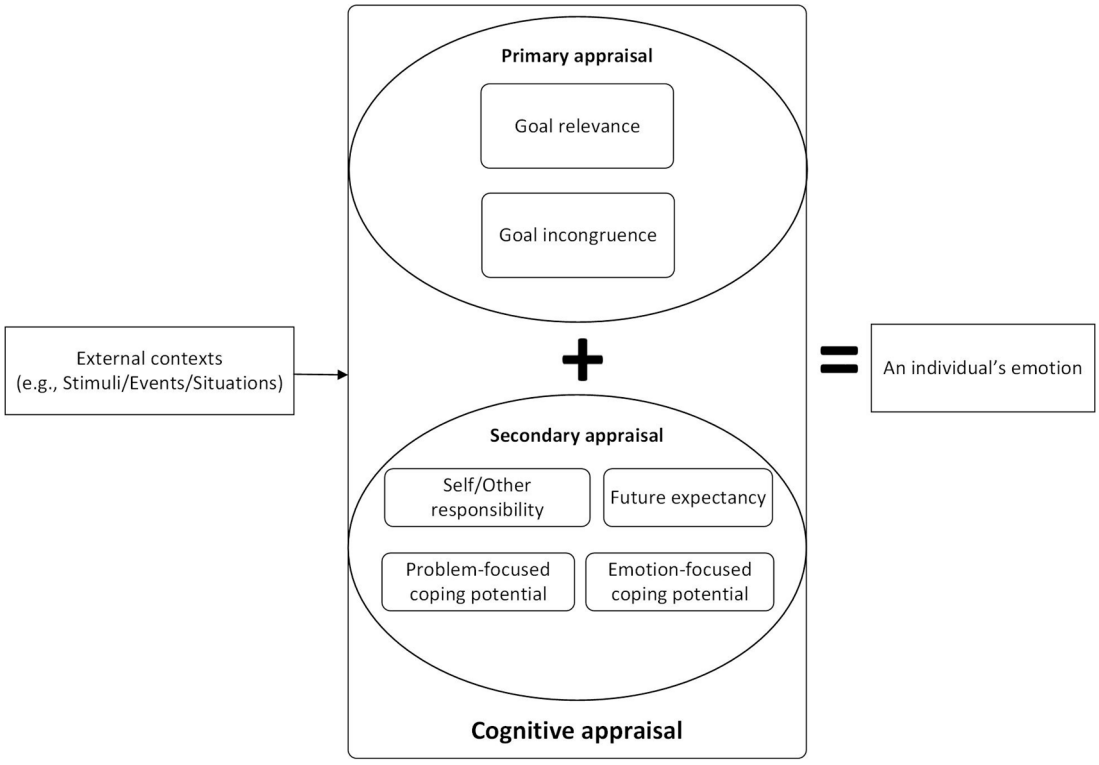

Fig. 1. The framework of cognitive appraisal adapted from Stephens et al. (2016).

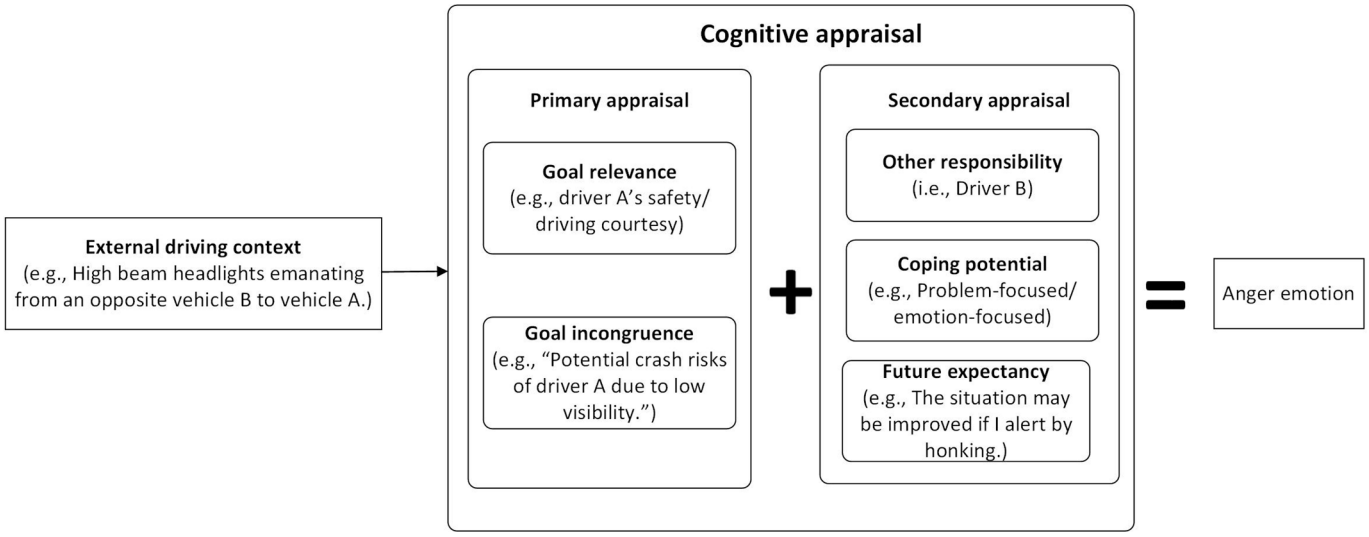

Fig. 2. A diagram of cognitive appraisal process in a specific anger-provoking driving context.

whether anger disposition could predict state anger significantly. Subsequent studies addressed this limitation but produced inconsistent findings. Specifically, Albentosa et al. (2018) reported that trait driving anger was directly or indirectly associated with anger (partially mediated by cognitive appraisal), whereas Stephens et al. (2016a) found no direct relationship between trait driving anger and state driving anger when appraisal was considered.

It is also noteworthy that several limitations exist in the above-mentioned studies. First, all studies relied on the event recall approach to activate participants' "angry memories", but the emotional intensity might be inaccurate if some participants are unable to retrieve such a scenario. Second, none of these studies systematically examined how drivers' appraisal varies across different categories of anger-provoking situations. For instance, both Stephens et al. (2016a) and Albentosa et al. (2018) have identified goal relevance, goal incongruence, and other responsibility as salient components in anger appraisal. However, their findings regarding coping potential were inconsistent, and both studies reported that future expectancy was generally irrelevant to situational appraisal within the driving context. These mixed findings may indicate that drivers could deploy different coping strategies and expectations depending on the driving context. On the other hand, these inconsistencies may also be due to the reliance on open-ended self-report questions, which restricts the systematic categorisation of anger-provoking situations and limits the investigation of

appraisal patterns across driving contexts.

Consequently, our understanding of context-dependent cognitive components in anger situations remains incomplete, hindering the development of clear and testable hypotheses. Therefore, no specific hypotheses regarding Chinese drivers' coping potential and future expectancy were proposed. Instead, we hypothesised that:

- *H1: Goal relevance, goal incongruence, and other responsibility show significant loading value in cognitive appraisal in all types of anger-provoking situations among Chinese drivers.*

An additional aspect warranting further attention is the inclusion of driving anger expression when examining drivers' cognitive appraisal and anger responses. While trait driving anger has been extensively studied over the past decade, anger expression may have a more direct link to driving outcomes than underlying cognitive beliefs (Trung Bui et al., 2022). It is therefore important to clarify the associations among trait driving anger, state driving anger, and non-adaptive anger expression, especially given the mixed findings reported in previous studies. Considering appraisal is an essential antecedent of emotional responses, and anger disposition predisposes drivers to experience state anger, which could in turn increase non-adaptive anger expression. Hence, we hypothesised that:

- *H2a (mediated by cognitive appraisal): Trait and state driving anger are significantly and positively related through cognitive appraisal in all types of anger-provoking situations among Chinese drivers.*
- *H2b (direct path): Trait and state driving anger are significantly, positively, and directly related in all types of anger-provoking situations among Chinese drivers.*
- *H3: Trait driving anger is significantly, positively, and directly related to non-adaptive anger expression while driving in all types of anger-provoking situations among Chinese drivers.*
- *H4: State driving anger is significantly, positively, and directly related to non-adaptive anger expression while driving in all types of anger-provoking situations among Chinese drivers.*

1.1.3. Mindfulness and driving-related anger

Mindfulness refers to an act of paying attention to what is happening at present or in daily activities (Kabat-Zinn, 1994). Researchers have conceptualised mindfulness either as a dispositional trait or as a transient state (Sutcliffe et al., 2016). Trait mindfulness reflects an individual's capacity to maintain heightened and receptive attention and awareness of present experiences (Brown and Ryan, 2003). This definition, which emphasises attention and awareness as crucial characteristics of mindfulness (King et al., 2011), has been widely adopted in road safety research (Koppel et al., 2019).

Increased trait mindfulness encourages people to focus on the present and not react to any pre-existing negative thoughts or experiences, thereby reducing hostility and emotional reactivity (Baer et al., 2006; Stephens et al., 2018). Although mindful people might still experience anger, they tend to recognise physiological signs of emotional arousal (e.g., increased heart rate) and regulate their responses proactively to prevent escalation into aggressive behaviours. In this regard, mindfulness training has been proposed as an emotion regulation strategy that promotes desensitisation and enhances emotional awareness (Arch and Craske, 2006; Chambers et al., 2009). However, most mindfulness-based interventions in driving research have mainly focused on distracted driving (Koppel et al., 2019). For example, drivers who received mindfulness-based training reported enhanced situational awareness and reduced mobile phone use while driving (Feldman et al., 2011).

In contrast, the role of mindfulness in the field of driving anger has received little empirical attention. Existing evidence focuses mainly on trait driving anger, indicating that mindfulness reduces the likelihood to become angry while driving (Kazemeini et al., 2013; Stephes et al., 2018). Broader studies have also shown that mindfulness could reduce daily anger and aggression, or even crash involvement (Kuo et al., 2021; Kim et al., 2022; Ehsani et al., 2024). However, its specific relationship with state driving anger and non-adaptive anger expression remains largely under-investigated. This restricts our understanding of how mindfulness may facilitate anger regulation and reduce anger-motivated aggression in driving contexts. Therefore, the present study investigates whether mindfulness mitigates driving-related anger. Accordingly, we hypothesised that:

- *H5: Trait mindfulness is significantly and negatively related to trait driving anger in all types of anger-provoking situations among Chinese drivers.*
- *H6: Trait mindfulness is significantly and negatively related to state driving anger in all types of anger-provoking situations among Chinese drivers.*
- *H7: Trait mindfulness is significantly and negatively related to non-adaptive anger expression while driving in all types of anger-provoking situations among Chinese drivers.*

1.2. Study rationale, objectives, and proposed theoretical framework

Driving anger and unsafe driving are prevalent in China, reflecting both the challenges drivers face in regulating emotions and the limited effectiveness of existing enforcement in controlling aggressive driving behaviours. Emerging evidence shows the important role of cognitive appraisal and mindfulness in shaping driving-related anger, highlighting the need to investigate their underlying mechanisms to expand theoretical understanding and underpin the design of effective anger-reduction interventions.

Beyond these mechanisms, it is also essential to examine situational and individual differences in anger evoked while driving. Previous research on gender differences in trait driving anger has produced inconsistent findings, raising the question of whether similar patterns may also occur at the state level across different anger-provoking situations. Given these inconsistencies, no specific hypothesis was proposed regarding gender differences; however, exploring such patterns may still yield useful insights into how gender shapes situational anger, thereby supporting the development of targeted interventions. Moreover, although previous research has linked state anger to vehicle collisions (Zhang and Chan, 2016), its relationship with traffic violations remains unclear. Exploring whether anger differs between traffic-rule offenders and non-offenders across different driving contexts could inform more targeted enforcement approaches. This examination was conducted as an exploratory extension to generate preliminary insights in the present study; therefore, no specific hypothesis was proposed.

Overall, the present study investigates the mechanisms of driving-related anger by integrating psychological perspectives on cognitive appraisal and mindfulness with road safety research, aiming to expand theoretical understanding and inform practical implications for intervention design and policy enforcement.

In summary, four study objectives are listed below:

1) To compare differences in state driving anger across various anger-provoking situations and demographic background (gender and self-reported traffic penalty points).
2) To understand how Chinese drivers undertake cognitive appraisal when facing different types of anger-provoking situations.
3) To examine the relationships between trait driving anger, state driving anger and non-adaptive anger expression by considering cognitive appraisal in different types of anger-provoking situations.
4) To explore the effects of trait mindfulness on trait driving anger, state driving anger and non-adaptive anger expression in different types of anger-provoking situations.

Based on the proposed hypotheses regarding potential associations among variables (*H1-H7*), a theoretical framework was developed (see

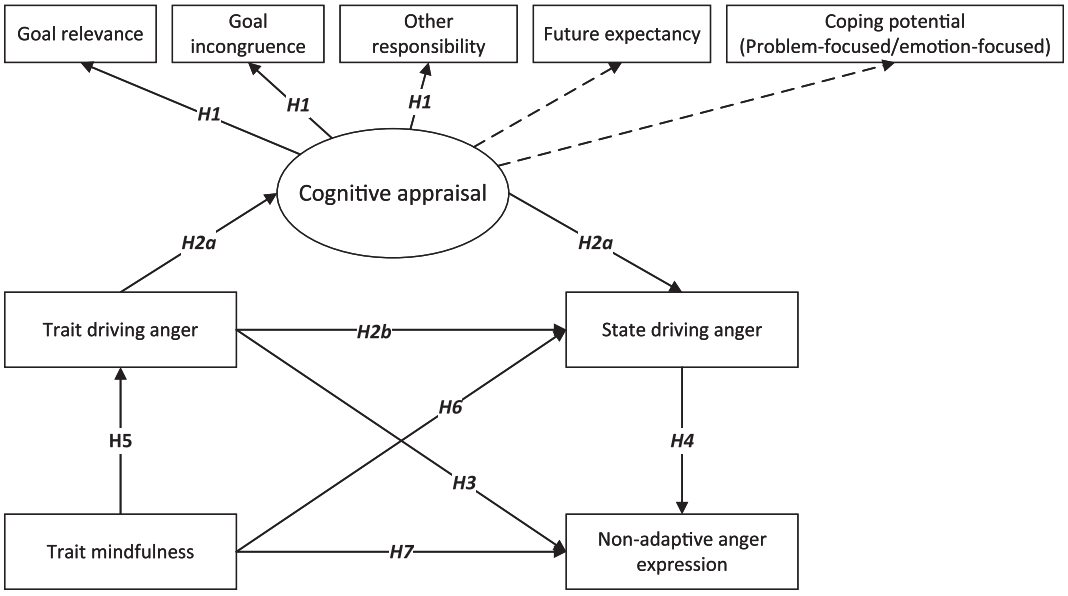

Fig. 3. Proposed theoretical framework of driving-related anger, cognitive appraisal, and trait mindfulness.

Fig. 3). Specifically, cognitive appraisal was regarded as an integrated latent construct, following the perspective of Stephens et al. (2016a) that combining appraisal components into a single latent factor is theoretically feasible. Meanwhile, cognitive appraisal was also used as a mediator between trait driving anger and state driving anger, according to previous studies (e.g., Albentosa et al., 2018). Although no explicit hypotheses were formulated regarding coping potential and future expectancy (as described in section 1.1.2), these elements remain theoretically relevant and warrant investigation. Herein, they were included in the model and represented by dotted lines. Furthermore, trait mindfulness was included to examine its potential effects on driving-related anger variables.

2. Method

2.1. Pilot survey

The DAS may be less suitable for exploring drivers' cognitive appraisal, due to its redundancy and inconsistent factor structure. Therefore, the present study used the MAD to investigate Chinese drivers' cognitive appraisal and state driving anger across different categories of anger-provoking situations. The MAD was translated into Chinese using a back-translation procedure to ensure both linguistic and conceptual equivalence.

Several modifications were made to some items in the MAD to better reflect the Chinese driving context, as driving behaviours could be influenced by cultural factors (Ersan et al., 2020; Öztürk et al., 2022). For instance, the item 7 ("A jaywalking pedestrian crosses in front of you forcing you to brake.") was revised to account for cyclists who also represent an important source of driving anger in China. Indeed, Chinese roads are often characterised by a high density of pedestrians and cyclists, leading to unpredictable encounters such as pedestrians running red lights and cyclists suddenly appearing or accelerating from the side (Yang et al., 2013; Zhang et al., 2019). Thus, item 7 was modified to "Jaywalking pedestrians/cyclists cross in front of you forcing you to brake". Also, the item 8 ("A driver fails to give way to you at a stop or give way sign when supposed to.") was modified, because its original description of a right-of-way scenario may not fully capture the Chinese driving context. For example, at most Chinese intersections, right-turning vehicles are not controlled by specific traffic lights, allowing drivers to turn at their own discretion (Liu et al., 2022). Such situations often give rise to traffic conflicts or congestion at intersections. To better reflect these common scenarios, item 8 was modified to "A driver fails to give way to you when they are supposed to (e.g., intersections, roadside stop, underground car park, at a give way sign, etc.").

It should be noted that the assessment of the factor structure of MAD is necessary before exploring appraisal patterns across anger-provoking situations, and the MAD has not been formally evaluated in China,[1] so Exploratory Factor Analysis (EFA) was performed. A total of 267 participants were recruited via the online survey platform *Wen Juan Xing*. Participants provided their age, gender, and rated their anger intensity in various driving scenarios on a 5-point scale (1= "Not angry at all" to 5= "Extremely angry"). Nine respondents were excluded because they selected the same score for all items.

The remaining 258 valid questionnaires ($M = 31.04 \pm 6.82$, 55% males) were subjected to a principal axis factoring approach with varimax rotation in SPSS 24.0, to extract common variance and identify the underlying factor structure. The Kaiser-Meyer-Olkin (KMO) value was 0.869, and Bartlett's test of sphericity was significant ($p < 0.001$), indicating the appropriateness of the scale for factorial analysis. According to Hair et al. (2019a), item loadings over 0.40 are sufficient if the sample size exceeds 350. Also, Ledesma et al. (2021) have noted that most traffic psychology studies use a threshold of 0.30 or 0.40. To ensure a more robust and non-redundant selection of anger-provoking scenarios, we adopted a factor loading threshold of 0.45. Seventeen items were retained, yielding a three-factor solution: Safety Blocking (SB), Travel Blocking (TB), and Hostile-Aggression (HA). The Corrected Item–Total Correlations of the retained items ranged from 0.399 to 0.579, indicating acceptable item–scale consistency and supporting the suitability of these items for measuring anger response in the driving context. Thus, this three-factor structure of the MAD was subsequently

[1] At the time this study was conducted, no formal validation of the Measure for Angry Drivers (MAD) in China had been published. A formal validation of MAD in the Chinese context was later reported in *Zhai, C. and Öztürk, İ. 2025. The Path to Driving Aggression and Crash Risk: The Role of Metacognition and Anger Rumination in Anger Expression Among Chinese Drivers. Aggressive Behavior. **51** (4), pe70041.*

implemented in the main survey of the present study. More detailed information on the factor structure of the MAD is provided in Zhai et al. (2024).

2.2. Participants

To explore the relationships among numerous variables in the proposed model (Fig. 3), data were collected through an online survey, considering the high internet penetration rate among the Chinese population. A Chinese survey company, *Wen Juan Xing* (www.sojump.com), administered the participant recruitment and survey nationwide in August 2022. In appreciation for participating in the survey, each participant received 20 RMB (approximately $3). The present study was approved by the ethics committee of the University of Leeds (AREA 21-123). In total, 601 respondents completed the survey, covering 91.2 % of the provinces in China. After data filtration (e.g., incorrect responses to attentional check questions, the same scores being selected for one or more scales, extreme completion time and illogical responses), 559 valid responses were retained, which remained broadly representative of the general Chinese driving population in terms of age and gender distribution (The Traffic Management Bureau of the Ministry of Public Security of China, 2021).

It should be noted that the recruitment of university students was limited, considering they may drive less frequently (Fayard, 2019). A significant age difference was identified between participants in the main survey ($M = 32.11 \pm 5.48$) and participants in the pilot study ($p < 0.05$), but they did not differ in gender ($p > 0.05$). More information about participants' demographic background in the main survey can be found in Table 1.

2.3. Measurements

2.3.1. Demographic information

Participants were required to report their personal details, including age, gender, years of driving license tenure, and the traffic penalty points they received in the last year. To note, crash involvement was not included, as it was beyond the scope of the present study and such data have been found to be less reliable when self-reported (af Wåhlberg and Dorn, 2015).

Table 1
Participants' demographic information (N = 559).

Variables	N	Proportion
Gender		
Male	272	48.7 %
Female	287	51.3 %
Age groups		
18–25 years old	23	4.1 %
26–36 years old	456	81.6 %
37–44 years old	57	10.2 %
Over 44 years old	23	4.1 %
Tenure of the driving license		
≤1 year	11	2.0 %
2–3 years	125	22.3 %
4–5 years	181	32.4 %
6–10 years	171	30.6 %
> 10 years	71	12.7 %
Traffic penalty points received in the last year		
0–1	287	51.3 %
2–4	165	29.5 %
5–8	95	17.0 %
9–12	12	2.1 %

2.3.2. Mindfulness Mttention Awareness Scale (MAAS)

The MAAS was originally developed for an assessment of an individual's self-reported trait mindfulness (Brown and Ryan, 2003). In the present study, the 15 item Chinese version of MAAS was used (Deng et al., 2012). This scale measures the degree of an individual's trait mindfulness by rating frequency on a range of activities related to mindful moments/activities on a 6-point scale (1= "Almost always" to 6= "Almost never"), e.g., "I find myself doing things without paying attention". Higher scores reflect a higher degree of trait mindfulness. The overall scale's Cronbach's α was 0.85, showing adequate reliability.

2.3.3. The short form of the Driving Anger Scale (DAS)

To measure trait driving anger while avoiding repetitive administration of the MAD, the short form of the Chinese version of the DAS was used (Zhang et al., 2015). This version comprises three factors that reflect three common sources of anger-provoking situations. Respondents need to rate their propensity to become angry when facing various driving situations on a 5-point scale (1= "Not at all" to 5= "Very much"). It showed sufficient convergent validity and reliability among three factors (i.e., Composite Reliability ranged from 0.72 to 0.84).

2.3.4. State anger and cognitive appraisal

For each of the three anger-provoking scenario categories, participants were required to select one scenario they frequently experienced while driving (i.e., choosing 1 of 7 scenarios in SB, 1 of 6 scenarios in TB, and 1 of 4 scenarios in HA) from the extracted three-factor structure of the MAD. To address the potential limitations of the event-recall approach, participants were asked to imagine encountering the selected event while driving and then respond to questions related to state anger and cognitive appraisal. This approach was chosen, because providing a detailed description of the scenarios for participants has been shown to be feasible and effective in inducing emotional responses (Popuşoi et al., 2018). Further details on these measurements were reported in Zhai et al. (2024). The Cronbach's α for cognitive appraisal was 0.79, showing acceptable reliability. Information regarding the participants' selection of anger-provoking situations can be found in Table 2.

2.3.5. The short form of the Driving Anger Expression Inventory (DAX)

To measure anger expression while driving, the present study used the Chinese version of the short form of the DAX (Zhai et al., 2023). This instrument comprised 11 items converged in three factors: Adaptive Expression (AE), Verbal Expression (VE), and Physical and Vehicle Expression (PVE). Participants rated how often they expressed anger expression while driving on a 4-point scale (1= "Almost never" to 5= "Almost always"). This Chinese short-form DAX demonstrated acceptable internal consistency (Cronbach's α ranging from 0.75 to 0.81) and convergent validity (item loading ranging from 0.61 to 0.84). In a more recent study, Zhai and Öztürk (2025) employed this scale in a Chinese sample, providing additional evidence for its suitability in the Chinese cultural context.

2.4. Data analysis

A preliminary check of the data was conducted in SPSS 24.0 prior to formal data analysis. Then, the issue of Common Method Bias (CMB)

Table 2
Participants' selection of anger scenarios in the main survey (N = 559).

Categories of anger-provoking situations	The percentage of drivers selecting each event
Safety Blocking (SB)	
Someone pulls out right in front of you without looking	6.4 %
Someone moves in front of you suddenly and without leaving enough room, forcing you to brake hard	26.8 %
Someone cuts in right in front of you forcing you to brake	28.8 %
When you are trying to overtake another driver he/she speeds up	6.9 %
When you are trying to merge, other drivers do not give way (preventing you merging)	5.0 %
Jaywalking pedestrians/cyclists cross in front of you forcing you to brake	17.0 %
A driver ahead of you is straddling two lanes	9.1 %
Travel Blocking (TB)	
You encounter road works and detours	10.4 %
Someone in front of you does not move off straight away when the light turns to green	19.7 %
You are driving behind a large vehicle and you cannot see around it	13.9 %
Someone pulls out right in front of you when there is no-one behind you	5.5 %
You are stuck in peak hour traffic	33.3 %
A driver fails to give way to you when they are supposed to (e.g., at intersections, roadside stop, underground car parks, at a give way sign, etc.)	17.2 %
Hostile Aggression (HA)	
Another driver indicates anger/hostility when you do a perfectly legal manoeuvre	26.7 %
Someone makes a rude gesture towards you about your driving	31.3 %
Someone shouts at you about your driving	20.8 %
Someone beeps at you without reason	21.2 %

Note: Percentage was rounded to one decimal place.

was assessed using Harman's single-factor analysis[2] (Kock, 2020). To detect if there were any potential associations among variables, Pearson correlational analysis was performed. Furthermore, to examine if there were any situational and individual differences in state driving anger, an Analysis of Covariance (ANCOVA) was carried out.

Lastly, Partial Least Squares Structural Equation Modelling (PLS-SEM) was used to assess the structure of the appraisal construct (*H1*), associations between driving-related anger and cognitive appraisal (*H2a, H2b, H3, and H4*), and relationships between trait mindfulness and driving-related anger variables (*H5, H6, and H7*). In contrast to Covariance-based SEM, PLS-SEM is more than confirmatory and is particularly appropriate when explaining complex path relationships with latent variables, hypothesis testing, and revealing potential causal mechanisms (Hair and Alamer, 2022). The PLS-SEM captures the total variance of the indicators and forms constructs as linear combinations of the indicators (i.e., items), making it well-equipped to handle measurement models that include single-item indicators (Hair et al., 2021b; Hair and Alamer, 2022). This is especially relevant in the present study, where certain appraisal dimensions were assessed using single-item measures based on the appraisal theory. The software Smart PLS 4.0 was used, and a bootstrapped sample was generated (Hair et al., 2017a). It is recommended to use 5000–10000 bootstrapped samples to get stable results (Sarstedt et al., 2022).

However, it has been suggested that model fit indices provide less value in the PLS-SEM context (Hair et al., 2017b; Rigdon et al., 2017), because the nature of the PLS-SEM does not minimise the divergence between observed and estimated covariance matrices (Hair et al., 2019b). Therefore, commonly used model fit indices in CB-SEM are not recommended for use in the context of PLS-SEM, and researchers advise against over-reliance on these indices to derive conclusions (Hair et al., 2019c; Hair et al., 2021a). Instead, evaluating the reliability, validity, and predictive power of the model is more appropriate for PLS-SEM (Hair and Alamer, 2022).

In the present study, Composite Reliability (CR) and the Average Variance Extracted (AVE) were used for assessing the internal consistency and convergent validity of the cognitive appraisal construct (Hair et al., 2019b). Generally, a CR over 0.70 and an AVE higher than 0.40 suggest acceptable reliability and convergent validity (Fornell and Larcker, 1981), but an AVE over 0.50 is better (Brown, 2015). In addition, the Variance Inflation Factor (VIF) was examined to assess multicollinearity, with VIF values below 3 indicating no collinearity issues (Hair and Alamer, 2022).

To evaluate the model's explanatory power (in-sample), R^2 was calculated for each endogenous variable, with values of 0.25, 0.50, and 0.75, respectively, reflecting weak, moderate, and substantial predictive power (Hair et al., 2019b). To assess the model's predictive relevance (an estimation of the model's out-of-sample predictive accuracy), Stone-Geisser's Q^2 was used (Hair et al., 2021b). This was obtained using the blindfolding procedure, which systematically omits and predicts data points to evaluate how well the model can reproduce the original values (Hair et al., 2021a). A Q^2 value greater than zero suggests that the model has predictive relevance (i.e., predictive accuracy), with values above 0.25 and 0.50, respectively, indicating medium and large predictive accuracy (Hair et al., 2019b).

3. Results

3.1. Selected of anger-provoking events

Table 2 shows the proportion of anger-provoking situations selected by drivers, categorised into three main types. In the SB category, events involving forced braking were the most reported, with 72.6 % of drivers indicating frequent experiences of abrupt vehicle cut-in or jaywalking by pedestrians or cyclists, forcing them to brake. In the TB category, traffic congestion was the most frequently selected event, reported by 33.3 % of drivers, indicating its prevalence in Chinese driving environments. Lastly, in the HA category, receiving aggressive gestures was identified as the most common event, with 31.3 % of participants reporting it as a regular occurrence, followed by showing hostility and aggressive honking.

3.2. Correlations between trait and state driving anger, non-adaptive anger expression and trait mindfulness

Results of correlational analysis between state anger evoked in three categories of anger-provoking situations, trait driving anger, non-adaptive anger expression, and trait mindfulness are presented in Table 3. Trait driving anger showed a positive correlation with state driving anger, with the strongest relationship in state anger provoked by safety blocking situations ($r_{SB} = 0.38, p < 0.01$). Also, SB state driving anger showed a greater and positive relationship with VE ($r = 0.32$,

[2] CMB is a common systematic measurement error, which could affect the reliability and validity of results and conclusions, which usually occurs when independent and dependent variables are collected at the same time via similar self-reported measurements. Harman's single-factor analysis is a commonly applied approach for detecting whether CMB is present (Kock, 2020). This approach is achieved by using EFA on all measured items/variables, if the variance of one factor is produced by an unrotated solution over 0.5, then indicating the existence of CMB (Fuller et al., 2016).

Table 3
Correlations between trait and state driving anger, non-adaptive anger expression and trait mindfulness.

Variables	1	2	3	4	5	6	7	8
1 SB state driving anger	1							
2 TB state driving anger	**0.37****	1						
3 HA state driving anger	**0.42****	**0.37****	1					
4 Trait driving anger	**0.38****	**0.34****	**0.34****	1				
5 VE	**0.32****	**0.24****	**0.30****	**0.32****	1			
6 PVE	**0.13****	**0.12****	**0.12****	**0.25****	**0.39****	1		
7 AE	**−0.17****	**−0.16****	**−0.14****	**−0.11****	**−0.39****	**−0.37****	1	
8 Trait mindfulness	−0.04	**−0.11***	**−0.11***	**−0.17****	**−0.21****	**−0.24****	**0.17****	1

Notes: * $p < 0.05$, ** $p < 0.01$, SB state driving anger = Safety Blocking state anger, TB state driving anger = Travel Blocking state anger, HA state driving anger = Hostile Aggression state anger, Trait driving anger = Total DAS score, VE = Verbal Expression, PVE = Physical and Vehicle expression, AE = Adaptive Expression

$p < 0.01$), showing a higher observed value compared to those evoked in the TB and HA situations. Moreover, trait mindfulness was negatively correlated with TB state driving anger ($r = -0.11, p < 0.05$) and HA state driving anger ($r = -0.11, p < 0.05$), but its effect on SB state driving anger was not significant ($r = -0.04, p > 0.1$).

3.3. Differences in state driving anger

Differences in state driving anger with respect to categories of anger-provoking situations, gender, and traffic penalty points were examined through several ANCOVAs, with age and years of driving licence tenure as covariates (see Fig. 4). Specifically, TB state driving anger was significantly lower ($F = 95.82, p < 0.001$) compared to SB state anger and HA state anger, while ratings of state driving anger in SB and HA were almost identical. Additionally, no significant gender differences were found in state driving anger across all anger-provoking categories ($F = 0.461, p = 0.497$). By contrast, a significant difference between traffic rules offenders and non-traffic rules offenders was detected, but only in TB situations ($F = 4.85, p < 0.05$).

3.4. The relationships between driving-related anger, cognitive appraisal, and mindfulness

The CMB is not a potential issue in the present study, as 13.8 % of the variance was explained by a single factor (Kock et al., 2021). The highest VIF value was 1.672 among all models, showing that no collinearity issues occurred. As suggested by Hair and Alamer (2022), path coefficients of PLS-SEM structural models (i.e., β) ranging from 0 to 0.1, 0.11–0.3, 0.31–0.5, and > 0.5 are respectively indicative for weak, modest, moderate, and strong effect size. Results are described for each of the three types of anger-provoking situations in the following subsections.

3.4.1. The role of cognitive appraisal and mindfulness in safety blocking anger-provoking situations

In SB situations (Fig. 5), state driving anger was significantly and positively associated with cognitive appraisal ($\beta = 0.34, p < 0.001$). Within the appraisal construct, goal relevance ($\beta = 0.65, p < 0.001$), goal incongruence ($\beta = 0.68, p < 0.001$), other responsibility ($\beta = 0.74, p < 0.001$), and problem-focused coping potential ($\beta = 0.54, p < 0.001$) were all significant. Future expectancy and emotion-focused coping potential were excluded due to low or non-significant loadings.

For the relationships among driving-related anger variables, trait driving anger was significantly, positively, and directly related to state driving anger ($\beta = 0.29, p < 0.001$) and non-adaptive anger expression ($\beta = 0.25, p < 0.001$). Moreover, cognitive appraisal partially mediated the relationship between trait driving anger and SB state driving anger,[3] with its direct effect on state driving anger being greater than that of trait driving anger. Furthermore, state driving anger was positively related to non-adaptive anger expression ($\beta = 0.12, p < 0.01$).

Additionally, trait mindfulness showed a significant and negative impact on trait driving anger ($\beta = -0.17, p < 0.001$) and non-adaptive anger expression ($\beta = -0.15, p < 0.001$), but its effect was not significant on state anger in SB driving situations ($\beta = -0.04, p > 0.1$). Overall, the model demonstrated low predictive relevance, explaining 25.3 % of the variance in state anger and 13.8 % in non-adaptive expression.

3.4.2. The role of cognitive appraisal and mindfulness in travel blocking anger-provoking situations

In TB situations (Fig. 6), state driving anger was significantly and positively related to cognitive appraisal ($\beta = 0.45, p < 0.001$). Within the appraisal construct, goal relevance ($\beta = 0.73, p < 0.001$), goal incongruence ($\beta = 0.64, p < 0.001$), other responsibility ($\beta = 0.67, p < 0.001$), problem-focused coping potential ($\beta = 0.65, p < 0.001$), and future expectancy ($\beta = 0.51, p < 0.001$) were significant. Emotion-focused coping potential was excluded due to lower loading.

As regards the associations among driving-related anger variables, trait driving anger was significantly, positively, and directly linked with both state driving anger ($\beta = 0.19, p < 0.001$) and non-adaptive anger expression ($\beta = 0.28, p < 0.001$). Similarly, cognitive appraisal partially mediated the relationship between trait driving anger and TB state driving anger,[4] but the direct link between state driving anger and non-adaptive anger expression was not significant ($\beta = 0.05, p > 0.1$).

Moreover, trait mindfulness exerted significant and negative effects on trait driving anger ($\beta = -0.17, p < 0.001$) and non-adaptive anger expression ($\beta = -0.14, p < 0.001$), instead of state driving anger ($\beta = -0.06, p > 0.1$). In general, the model showed low to medium predictive relevance, explaining 29.3 % of the variance in state anger and 12.8 % in non-adaptive expression.

3.4.3. The role of cognitive appraisal and mindfulness in hostile aggression anger-provoking situations

In HA situations (Fig. 7), state driving anger ($\beta = 0.41, p < 0.001$) was significantly and positively linked to cognitive appraisal. Within the appraisal construct, goal relevance ($\beta = 0.72, p < 0.001$), goal incongruence ($\beta = 0.73, p < 0.001$), other responsibility ($\beta = 0.74, p < 0.001$), emotion-focused coping potential ($\beta = 0.71, p < 0.001$), and future expectancy ($\beta = 0.58, p < 0.001$) were significant, whereas problem-focused coping potential was not.

With respect to the associations between driving-related anger variables, trait driving anger was significantly, positively, and directly associated with state driving anger ($\beta = 0.21, p < 0.001$) and non-adaptive anger expression ($\beta = 0.26, p < 0.001$). Also, cognitive

[3] Indirect effect (Trait driving anger→Cognitive appraisal→SB State driving anger) $\beta = 0.09, 95\%CIs[0.05, 0.12]$.

[4] Indirect effect (Trait driving anger→Cognitive appraisal→TB State driving anger) $\beta = 0.15, 95\%CIs[0.12, 0.19]$.

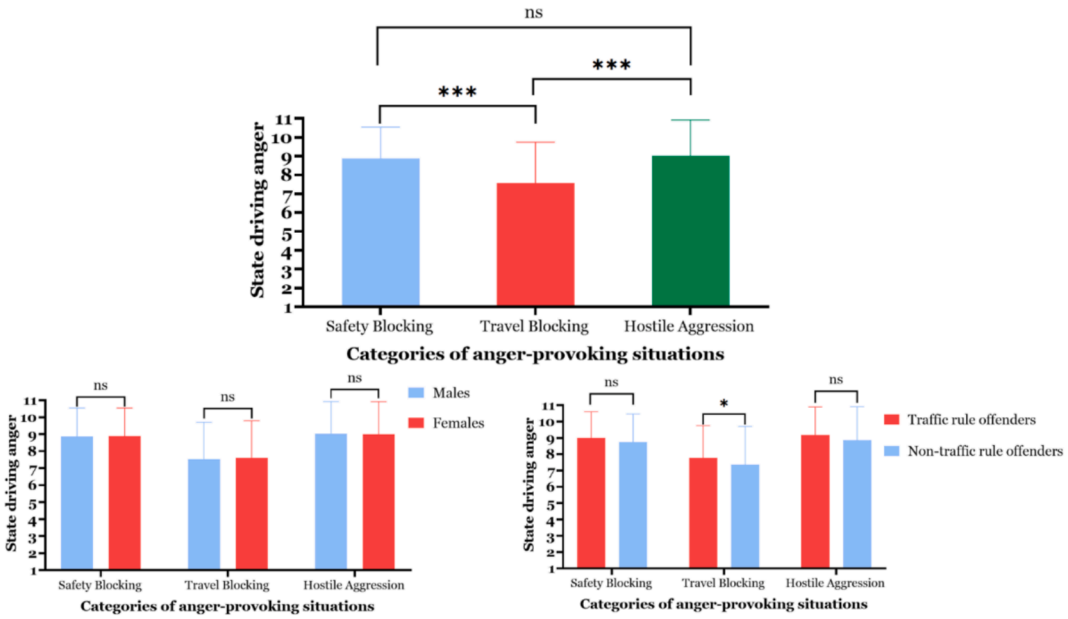

Fig. 4. Differences in state driving anger by driving situations, gender and traffic rule offenders/non-offenders.
Notes: * $p < 0.05$, *** $p < 0.001$, ns = not significant, error bars indicate the mean with standard deviation.

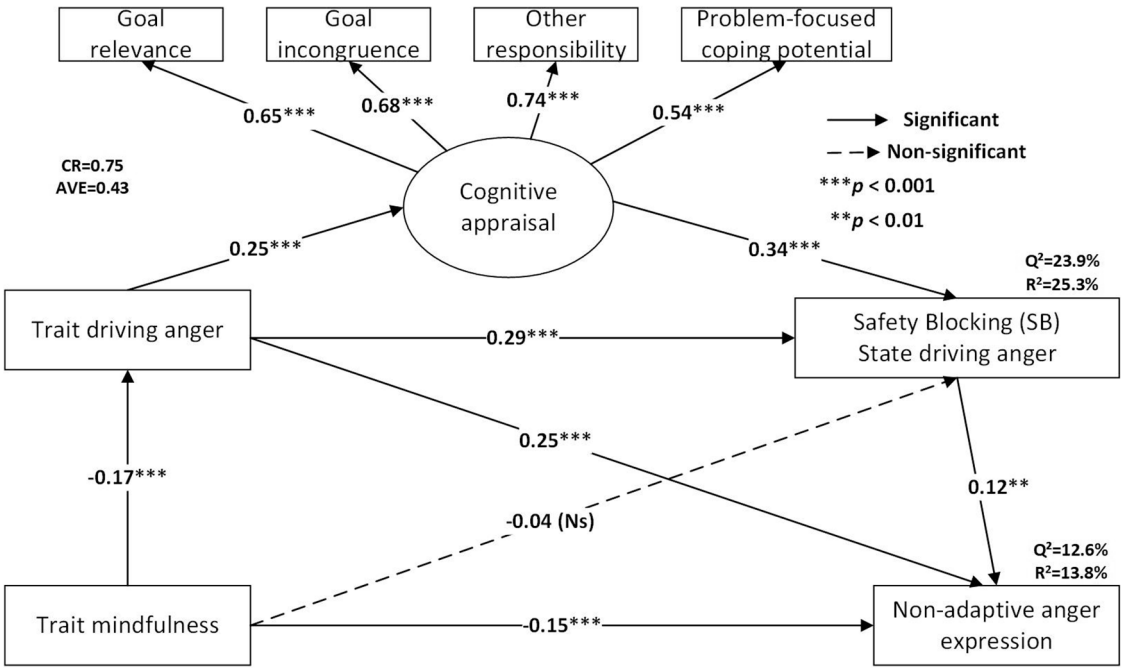

Fig. 5. The model of cognitive appraisal, driving-related anger, and trait mindfulness in Safety Blocking (SB) driving situations (standardised coefficients).

appraisal played a mediated role in the relationship between trait driving anger and state driving anger.[5] Moreover, state driving anger was positively related to non-adaptive anger expression ($\beta = 0.12, p < 0.001$).

As expected, trait mindfulness exhibited a significant reduction in trait driving anger ($\beta = -0.17, p < 0.001$) and non-adaptive anger expression ($\beta = -0.14, p < 0.001$). However, trait mindfulness did not diminish state driving anger evoked in HA situations ($\beta = -0.05$, $p > 0.1$). The model elucidated low to medium predictive relevance, explaining 27.1 % of the variance in state driving anger and 13.7 % in non-adaptive anger expression.

3.4.4. *Overview of hypothesis testing and measurement properties of the cognitive appraisal construct*

To provide a clear overview of the hypotheses tested in the present study and the measurement properties of the cognitive appraisal construct, the results are summarised in Tables 4 and 5, respectively. As shown in Table 4, most hypotheses were supported, but *H4* and *H6* were

[5] Indirect effect (Trait driving anger→Cognitive appraisal→HA State driving anger) $\beta = 0.12, 95\%CIs[0.08, 0.17]$.

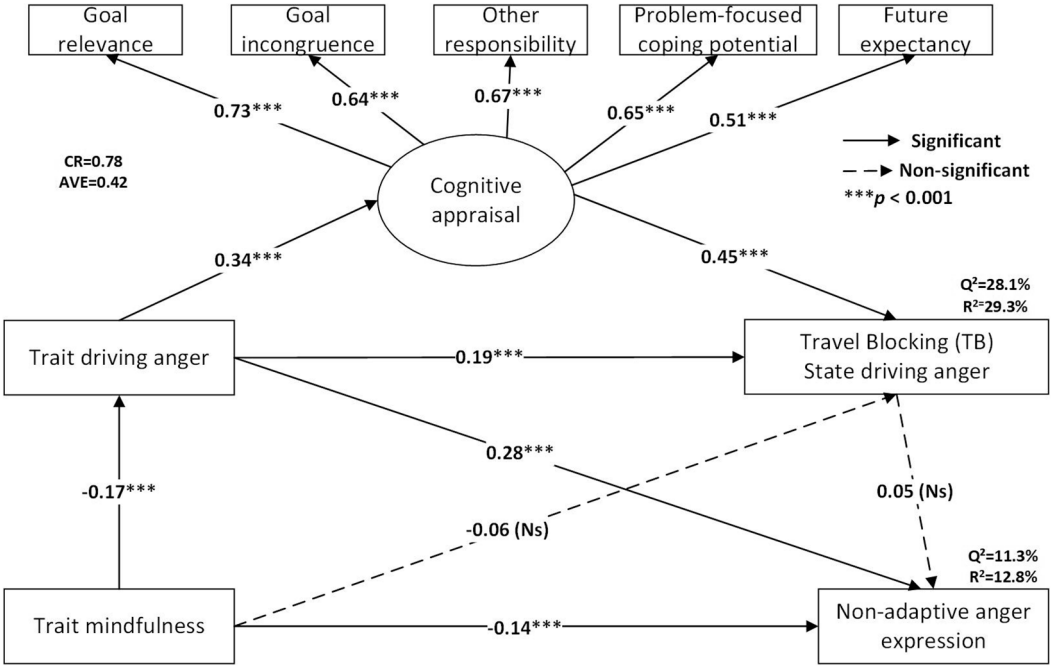

Fig. 6. The model of cognitive appraisal, driving-related anger, and trait mindfulness in Travel Blocking (TB) driving situations (standardised coefficients).

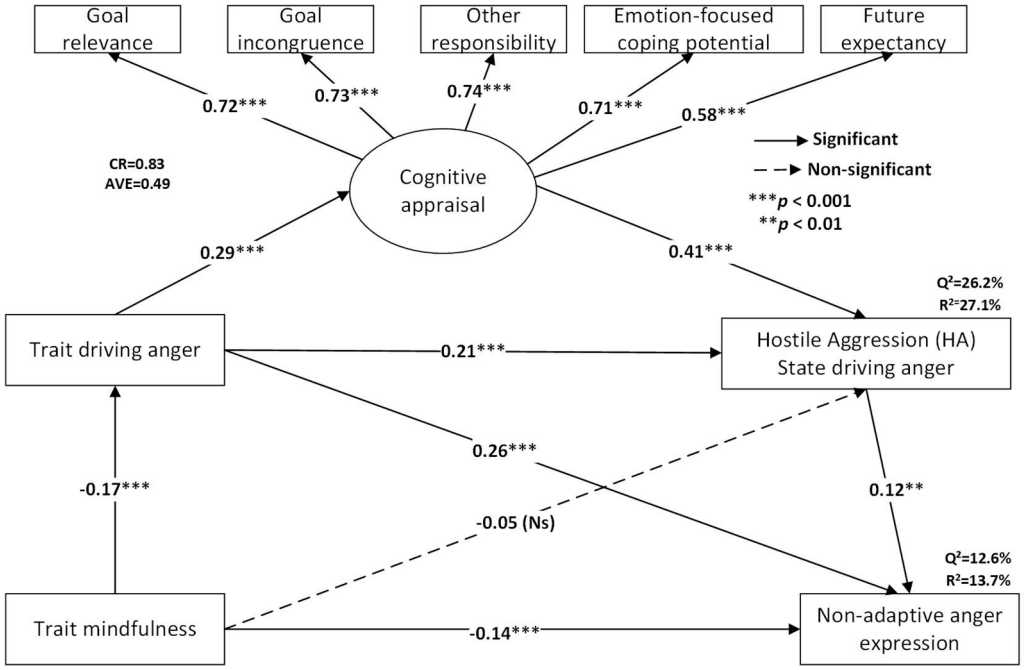

Fig. 7. The model of cognitive appraisal, driving-related anger, and trait mindfulness in Hostile Aggression (HA) driving situations (standardised coefficients).

not, because no association was found between state driving anger and non-adaptive anger expression in TB situations, as well as there being non-significant path relationships between trait mindfulness and state driving anger in all anger-provoking situations. Table 5 shows the indicator loading, CR, and AVE for the cognitive appraisal construct across three anger-provoking categories. These results suggest that the construct of cognitive appraisal demonstrates acceptable reliability and validity (Fornell and Larcker, 1981).

4. Discussion

The present study adopted an interdisciplinary framework by integrating the appraisal theory and mindfulness perspectives to examine how appraisal patterns vary across driving situations and whether mindfulness may contribute to the regulation of driving-related anger. Overall, the findings suggest that the integrated approach extends understanding of the mechanisms of driving-related anger and provides implications for potential intervention design and policy enforcement to improve road safety in China.

Table 4
Results of hypothesis testing.

Hypotheses	Structural paths	β (Standardised coefficients)			Remark
		Categories of anger-provoking situations			
		SB	TB	HA	
H1	Cognitive appraisal → Goal relevance	0.65***	0.73***	0.72***	Supported
	Cognitive appraisal → Goal incongruence	0.68***	0.64***	0.73***	
	Cognitive appraisal → Other responsibility	0.74***	0.67***	0.74***	
H2a	Trait driving anger → Cognitive Appraisal → State driving anger	0.09	0.15	0.12	Supported
H2b	Trait driving anger → State driving anger	0.29***	0.19***	0.21***	Supported
H3	Trait driving anger → Non-adaptive anger expression	0.25***	0.28***	0.26***	Supported
H4	State driving anger → Non-adaptive anger expression	0.12**	0.05 (Ns)	0.12**	*Not supported*
H5	Trait mindfulness → Trait driving anger	−0.17***	−0.17***	−0.17***	Supported
H6	Trait mindfulness → State driving anger	−0.04 (Ns)	−0.06 (Ns)	−0.05 (Ns)	*Not supported*
H7	Trait mindfulness → Non-adaptive anger expression	−0.15***	−0.14***	−0.14***	Supported

Notes: ** $p < 0.01$, *** $p < 0.001$, Ns = Non-significant, SB = Safety Blocking, TB = Travel Blocking, HA = Hostile Aggression

Table 5
Measurement properties of cognitive appraisal in different anger-provoking situations.

Components of cognitive appraisal	Indicator loadings (Standardised coefficients)		
	Categories of anger-provoking situations		
	SB	TB	HA
Goal relevance	0.65	0.73	0.72
Goal incongruence	0.68	0.64	0.73
Other responsibility	0.74	0.67	0.74
Problem-focused coping potential	0.54	0.65	Not applicable
Emotion-focused coping potential	Not applicable	Not applicable	0.71
Future expectancy	Not applicable	0.51	0.58
CR	0.75	0.78	0.83
AVE	0.43	0.42	0.49

Notes: CR = Composite Reliability, AVE = Average Variance Extracted, SB = Safety Blocking, TB = Travel Blocking, HA = Hostile Aggression

4.1. Drivers' selections of anger-provoking situations and differences in state driving anger

By specifying driving anger situations, the results revealed that safety blocking situations involving forced braking were the most reported (72.6 %). These incidents were mostly caused by other drivers' aberrant driving (55.6 %). Similar patterns have been observed in previous studies, which highlighted the prevalence of competitive driving in China (Li et al., 2016). In addition, encountering jaywalking by vulnerable road users was also reported (17.0 %), indicating drivers view such non-compliance as a safety threat. However, from the perspective of pedestrians and cyclists, car interference (e.g., failing to yield) has been identified as a significant source of anger (Herrero-Fernández et al., 2019; Huo et al., 2024). This reflects the confrontations of road-users in China, in which both drivers and vulnerable road users view each other as contributing to conflicts.

As expected, with the increasing number of vehicles on Chinese roads, traffic congestion has become a common experience for drivers. This finding is in agreement with a previous study that driving in China is "time-consuming" (Chu et al., 2019). Despite its prevalence, drivers reported the lowest levels of state anger in response to travel delay situations. This may reflect the impact of habituation to the high frequency of congestion in urban areas. In contrast, drivers showed heightened anger when experiencing different forms of discourtesy, suggesting that discourteous encounters while driving are more powerful stimuli for driving anger (Shamoa-Nir, 2023; Zhai and Öztürk, 2025). These circumstances could amplify emotional responses, as drivers may perceive such behaviours as deliberate provocation.

Although conventional Chinese culture emphasises restraint in displaying overt anger (Su, 2015), the frequent hostility observed on the roads may suggest a limited influence of cultural values in managing driving behaviours. One possible explanation is the anonymity of driving (Ellison-Potter et al., 2001). In other words, drivers are physically and psychologically shielded while driving, which creates a sense of anonymity (e.g., a subjective feeling of being hidden from social judgment). This diminished sense of perceived accountability and social visibility may weaken the role of social norms and self-regulation, thereby increasing the likelihood of anger and aggressive behaviours. Also, drivers may prioritise individual goals over cultural norms with the growing emphasis on efficiency and goal attainment, especially in the context of globalisation and a fast-paced lifestyle. These contextual factors may gradually reduce the influence of traditional cultural values, thus contributing to negative appraisal, emotional reactivity, and more frequent expressions of anger in competitive driving situations.

Moreover, traffic-rule offenders reported greater anger in response to travel-blocking situations, suggesting that they may have lower tolerance for obstructed traffic compared with non-offenders. Lastly, no significant gender differences were found in state driving anger. This lack of difference may reflect the influence of gender roles rather than biological sex, as individuals exhibiting higher levels of masculinity may be more prone to displaying elevated anger (Sullman et al., 2017a).

4.2. Drivers' cognitive appraisal of different anger-provoking situations

An important aim of this study was to understand drivers' cognitive appraisal in different anger-provoking situation categories. In general, our results support *hypothesis H1* and aligning with other studies (Stephens et al., 2016b; Albentosa et al., 2018), which reflects a broadly consistent appraisal pattern across different driving contexts, where anger is elicited by the obstruction of personal goals and the attribution of responsibility to others, while the specific theme of appraisals varies according to situational demands.

Specifically, SB situations were appraised as highly safety-relevant, with most drivers selecting scenarios involving "being forced to brake hard", indicating that being safe while driving should be the most crucial goal (Stephens et al., 2021). In TB situations, drivers emphasised punctuality-related goals and attributed responsibility to others for obstructing progress, such as during traffic congestion. This suggests that arriving on time is a universal driving goal (Summala, 2007), and repeated exposure to such traffic contexts may cultivate habitual appraisal tendencies that stress goal incongruence and attribution. Moreover, in HA contexts, drivers perceived others' behaviours as

deliberate and offensive (e.g., "Someone makes a rude gesture towards you about your driving"), reflecting threats to self-esteem or social respect. Such encounters evoke appraisals of intentional harm and interpersonal disrespect, which may reduce the likelihood of emotional regulation.

In contrast to drivers' consistent cognitive evaluation of goal relevance, goal incongruence, and other responsibility in all anger-provoking situations, their coping potential differed across situations. It was found that drivers with higher trait driving anger reported greater problem-focused coping potential when facing SB and TB contexts. This suggests that they tend to perceive these situations as controllable and feel capable of taking concrete actions to overcome negative outcomes (e.g., avoiding hazards and changing routes). When facing safety-threat driving contexts, such coping potential may reflect a heightened sense of control in addition to simply recognising the importance of safety goals. Similarly, drivers often attempt to mitigate travel delays through coping efforts (Summala, 2007; Ellison and Greaves, 2015).

However, an increased sense of control may not always be adaptive (Kong et al., 2020). In the present study, high problem-focused coping potential was associated with increased state driving anger, suggesting that anger-prone drivers may overestimate their coping capacity, resulting in an illusion of control (Thompson, 1999; Blankenship et al., 2013), which has been found to be positively related to angry driving style (Nees et al., 2021). Although such perceptions may reduce feelings of helplessness (Stephens and Ohtsuka, 2014), situations might not be efficiently improved. Instead, the mismatch between perceived capability and actual situational demands may intensify anger. For example, drivers may believe that honking will prevent another vehicle from merging or that changing lanes will improve travel efficiency and reduce congestion, but such actions may fail to alter the outcome and instead generate frustration and negative emotional responses.

Furthermore, drivers appeared to exhibit higher emotion-focused coping potential in HA situations. This pattern partly aligns with previous research showing that problem-focused coping is less prevalent in hostile aggression contexts (Shamoa-Nir, 2023), because discourteous behaviours from other drivers are generally perceived as uncontrollable, thereby promoting reliance on emotion-focused regulation. However, a heightened emotion-focused coping potential among anger-prone drivers may not lead to effective emotion management. One possible explanation is that such drivers tend to show poorer emotional regulation skills (Siagian and Andangsari, 2021), which may lead to ineffective emotion management, despite a perceived high coping capacity. In addition, cultural factors may also play a role. In China, outward anger is socially discouraged, and individuals mainly regulate anger by suppression and forbearance (Maxwell et al., 2009). Although these approaches may reduce overt expression, they could undermine well-being and regulatory effectiveness over time (Maxwell and Siu, 2008). Consequently, accumulated frustration may exceed drivers' perceived capacity to control, especially when the anonymity of driving creates a psychological shelter for anger and aggression.

Moreover, future expectancy also emerged as an important component of appraisal. It appeared alongside both problem-focused and emotion-focused coping potential, suggesting that drivers' appraisal of anger-provoking events involves not only evaluations of control and regulation but also anticipation of future outcomes. Previous studies have shown that coping behaviours depend on contextual demands, perceived coping ability, and outcome expectancy (Carver, 1997). Therefore, the occurrence of future expectancy may reflect an optimistic perception of situations, which may increase drivers' motivation to cope with frustration (De Raedt and Hooley, 2016). However, greater optimism bias has been linked to higher anger propensity (Stephens and Ohtsuka, 2014), suggesting that drivers who overemphasise positive outcomes may experience stronger anger when actual situations contradict their expectations. This finding suggests that the role of future expectancy may depend on the consistency between anticipated outcomes and realistic appraisal, while discrepancies between expectation and reality could reinforce cognitive inconsistency and amplify emotional intensity.

4.3. The associations between trait driving anger, state driving anger, and non-adaptive anger expression

The results suggested that Chinese drivers' trait driving anger and state driving anger were linked through cognitive appraisal across different categories of anger-provoking situations, supporting *H2a (mediated by cognitive appraisal)*. This indicates emotional reactions on the road are influenced by both dispositional and cognitive factors (Zhai et al., 2024). Besides, a direct relationship between trait and state driving anger was also observed regardless of driving anger situations, in line with hypothesis *H2b (direct path)*. This finding may be explained by the close association between state and dispositional measures of anger (Lance et al., 2021), suggesting that psychological assessments routinely capture both state and dispositional components of target variables (Steyer et al., 2015). In addition, cognitive appraisal appeared to exert a stronger direct influence on state anger than trait driving anger, indicating that situational appraisal may be more influential than dispositions in driving contexts.

Moreover, trait driving anger was found to be directly associated with non-adaptive anger expression, despite the type of anger-provoking scenarios, supporting hypothesis *H3*. More importantly, state driving anger was significantly associated with non-adaptive anger expression in anger-provoking situations, such as safety blocking or hostile aggression, but trait driving anger showed a greater direct effect on non-adaptive anger expression compared with state driving anger. These findings are in agreement with the results of previous studies (e.g., Brandenburg and Oehl, 2021), which suggest the dominant role of anger propensity in anger expression while driving.

Interestingly, state anger in TB situations was not significantly related to non-adaptive anger expression while driving, so *H4* was not supported. One possible explanation may be the presence of a mediator between state anger and non-adaptive anger expression. For example, Mohammadpour et al. (2022) found that the angry or aggressive thoughts triggered by traffic congestion predicted non-adaptive expression while driving. Possibly, such cognitions may serve as an antecedent of anger expression in travel blocking situations. Alternatively, some studies have shown that arriving at the destination on time is generally prioritised instead of engaging in conflict with other road users while getting involved in traffic congestion (Lajunen and Parker, 2001). Thus, these conditions might explain why state driving anger was not significantly related to non-adaptive anger expression while driving on crowded traffic roads.

4.4. The effects of trait mindfulness on trait driving anger, state driving anger, and non-adaptive anger expression

Trait mindfulness exerted a significant and negative impact on trait driving anger among Chinese drivers, supporting the proposed hypothesis *H5*. This replicates the finding of Stephens et al. (2018), suggesting the important role of facilitating attention and awareness in reducing anger proneness. However, although negative correlations were observed between trait mindfulness and state driving anger, the direct path relationship between them was not significant across all driving anger situations; thus, hypothesis *H6* was not supported. This may indicate variability in the influence of mindfulness on transient negative emotions, because a recent *meta-analysis* by Zangri et al. (2022) found that the overall impact of mindfulness training on negative emotions was weak and non-significant after removing outliers.

Beyond this empirical pattern, the finding may also reflect a conceptual mismatch between trait-level mindfulness and state emotional states. Trait mindfulness, as assessed by the MAAS, represents a general tendency toward attentional awareness over time, whereas state anger reflects a context-specific and short-term affective state. The regulatory

role of mindfulness may therefore be more effectively captured by state mindfulness. It is also possible that "daily mindfulness" may not fully capture the cognitive-affective demands related to driving situations, suggesting the potential relevance of driving-specific mindfulness constructs. Additionally, the MAAS focuses primarily on attentional awareness and does not include facets such as non-reactivity and non-judgement, which have been shown to be more directly associated with emotional states and their regulation (Carpenter et al., 2019).

Furthermore, some studies have reported that the influence of trait mindfulness on emotional responses may be mediated by personality traits (Valero-Mora et al., 2021; Banfi and Randall, 2022). Accordingly, mindfulness may shape emotional experiences indirectly through its association with stable dispositional factors such as Neuroticism and Emotionality. Taken together, while several explanations may account for the non-significant association between trait mindfulness and state driving anger, further investigation is warranted to clarify the pathways through which mindfulness operates in emotion regulation within the driving context.

Lastly, trait mindfulness was negatively related to non-adaptive anger expression while driving, supporting hypothesis *H7*. This finding supported recent studies, which found the mitigating role of mindfulness in unsafe driving behaviours (Ehsani et al., 2024; Qu et al., 2024). Possibly, a higher level of mindfulness could enhance drivers' attentional awareness and self-monitoring, enabling them to recognise emerging anger reactions and regulate behavioural tendencies.

5. Theoretical contributions, practical implications, limitations and future work

5.1. Theoretical contributions

The present study makes several key contributions to the theoretical understanding of driving-related anger and its underlying mechanisms.

First, this study provided new insights into cognitive appraisal in different driving contexts by illustrating how drivers evaluate anger-provoking situations across different categories: Safety Blocking (SB), Travel Blocking (TB), and Hostile Aggression (HA). The findings show that drivers with higher levels of trait driving anger consistently appraise situations in terms of goal relevance, goal incongruence, and other responsibility, but coping-related appraisals (coping potential and future expectancy) vary according to the situational demands of anger-provoking events. Importantly, considering the "cost-benefit" orientation of driving activity, cognitive interventions directly targeting appraisal, such as goal relevance and goal incongruence, may be challenging to implement, because these are tightly embedded in drivers' personal travel goals. Instead, the present findings suggest the potential utility in developing cognitive interventions from the perspective of responsibility attribution, coping potential, and future expectancy to regulate anger responses in different anger-provoking situations.

Second, the present study comprehensively examined the relationships between driving-related anger variables by integrating a cognitive appraisal framework. The relationships between trait driving anger and state driving anger, as well as between trait driving anger and non-adaptive anger expression, remain stable, aligning with previous studies that have consistently demonstrated such general associations. However, the link between state driving anger and non-adaptive anger expression appears to be context-dependent, because the relationship may become non-significant under specific anger-provoking situations, such as TB. This context-specific finding suggests that potential cognitive mediators (e.g., revenge beliefs), may shape the link between state anger and non-adaptive anger expression. By examining these variables within categorised anger-provoking situations and incorporating cognitive appraisal, this study extends prior research and provides a more nuanced understanding of the dynamic associations among driving-related anger variables.

Lastly, this study shows the role of trait mindfulness within the driving anger context, revealing its significant associations with reduced trait driving anger and non-adaptive anger expression. In contrast, its relationship with state driving anger was not significant, indicating that the regulatory effects of dispositional mindfulness may be more relevant to enduring anger proneness and behavioural tendencies as compared to emotional responses in the driving context.

5.2. Practical implications

Based on the current findings, some recommendations are proposed for both anger-reduction interventions and policy implementation.

First, cognitive interventions could help drivers interpret frustrating traffic events in a less hostile and blame-oriented manner, thereby mitigating excessive anger responses. For instance, drivers could be encouraged to adopt alternative appraisal (e.g., "Perhaps the driver is unfamiliar with this road section.") rather than immediately attributing blame. In addition, enhancing awareness of coping may also be critical, as perceived coping ability and expectancy of outcomes have been shown to influence anger intensity and vary across contexts. Interventions that target unrealistic appraisals of control (e.g., "Assuming that speeding will solve the problem") may help drivers regulate anger more effectively and reduce risk-taking tendencies on the road.

Second, mindfulness training may further reduce non-adaptive anger expression by enhancing drivers' moment-to-moment awareness and improving their capacity to manage negative emotional states (Lindsay and Creswell, 2017). Interestingly, traditional Chinese values rooted in Confucianism and Daoism emphasise emotional restraint, self-control, reflection, and the pursuit of internal harmony/peace, which are conceptually similar to certain elements of mindfulness (e.g., non-reactivity and acceptance). As such, we suggest that the application of mindfulness in the Chinese context requires careful cultural adaptation rather than arbitrary implementation, because the interaction between cultural norms and mindfulness-based interventions is complex and not yet fully understood. Future studies are required to explore how such interventions could be culturally tailored without reinforcing suppression or other maladaptive forms of emotional regulation (e.g., anger rumination).

Third, public safety campaigns could be used to encourage courteous driving and mutual respect between road users, as the current findings showed that hostile situations are important provocations which may induce safety blocking and travel blocking concerns. Such campaigns may include urban billboard slogans and short-form videos disseminated by official traffic police on social media platforms (e.g., WeChat Channels, Bilibili, and Douyin). These daily reminders may help shape social norms, reduce aggression-triggering interactions, as well as promote prosocial driving in competitive and frustrating traffic environments.

Lastly, management and policy enforcement strategies still need to be updated and strengthened to ensure comprehensive coverage. While current road safety regulations in China have covered a wide range of traffic violations (e.g., speeding, drink driving, and failure to yield), aggressive or hostile behaviours such as verbal insults, hostile gestures, and deliberate cutting-in and blocking are not always explicitly defined or penalised. Similar concerns have also been observed in some countries, e.g., Prakash Giri et al. (2024). This regulatory gap implies that numerous anger-provoking encounters and hostile aggression on the road may be unpunished, despite their strong potential to escalate into negative traffic outcomes. Thus, enforcement practices could be strengthened in three aspects: (1) clearly defining hostile provocations as punishable traffic violations, (2) applying stricter penalty measures such as higher fines, increased deduction of penalty points, or temporary license suspensions for repeat offenders, and (3) introducing corrective approaches, such as mandatory participation in anger management and road safety courses. These combined measures may reduce the likelihood of recurrent anger-related behaviours.

5.3. Limitations and future work

The data was collected through self-reported means. Although self-reported data have been considered reliable in driving behaviour research (Lajunen and Summala, 2003), potential social desirability bias cannot be ruled out. Moreover, the imagery-based method used to evoke anger, may have elicited relatively mild emotional responses. Future studies could consider using simulation-based approaches to induce stronger emotional arousal and improve ecological validity. Importantly, no baseline measures were used to assess pre-existing emotional states, making it difficult to know if there were changes in emotion over time. In this regard, the validity and reliability of anger induction and measurement should be treated with more caution. It is therefore recommended that laboratory-based designs incorporating physiological or behavioural indicators may allow for more dynamic assessment of state driving anger.

Another limitation concerns the use of MAD to induce anger. Although the EFA revealed three dimensions of anger-provoking situations, no Confirmatory Factor Analysis (CFA) was performed. Consequently, the stability and construct validity of this factor structure remain uncertain. Future studies could use CFA combined with Multidimensional Item Response Theory (MIRT) to provide stronger evidence for the psychometric robustness of the MAD among Chinese drivers. In addition, appraisal components were operationalised as single-item indicators based on the Lazarus' theoretical framework. While this theory-driven approach aligns with prior studies, e.g., Albentosa et al. (2018), reliance on single-item measures raises concerns regarding measurement uncertainty and construct validity. Thus, developing validated multi-item scales for each appraisal dimension would enhance measurement precision and strengthen the proposed theoretical model.

From a cross-cultural perspective, as the current results of cognitive appraisal patterns were identified among Chinese drivers, caution should be taken when generalising the findings to other populations or cultural contexts. Thus, cross-cultural investigations using similar methodology (e.g., examining appraisal patterns across categorised anger-provoking situations) would be valuable for clarifying whether the identified patterns are culture-specific or reflect more universal processes. Furthermore, while participants reported their intended coping strategies in driving scenarios, it remains unclear whether these strategies are enacted in real driving contexts. Future research could include follow-up assessments or naturalistic driving observations to capture coping behaviours more accurately.

Lastly, the present study relied solely on the MAAS to measure self-reported mindful disposition, which primarily captures attentional awareness. Hence, the relative contribution of specific mindfulness facets (e.g., non-reactivity and non-judgement) remains unclear. Future studies are recommended to consider using multifaceted mindfulness instruments, such as the Cognitive and Affective Mindfulness Scale (CAMS) or the Five Facet Mindfulness Questionnaire (FFMQ), to explore whether distinct dimensions of mindfulness differentially predict state anger and appraisal patterns in driving contexts. Likewise, driving experience was operationalised only by the number of years of licensure, which may not fully capture an individual's exposure on the road. Incorporating additional indicators such as total mileage and annual mileage driven could provide a more precise measure of driving experience in future research.

6. Conclusion

The present study investigated the relationships between driving-related anger (i.e., trait and state driving anger and non-adaptive expression), cognitive appraisal, and trait mindfulness among Chinese drivers. Findings showed that goal relevance, goal incongruence, and other responsibility were consistently evaluated in cognitive appraisal across anger-provoking contexts. Drivers also adopted different coping strategies depending on the situations, but overestimating coping potential and holding overly optimistic expectations may intensify anger. Importantly, trait mindfulness was found to mitigate anger proneness and non-adaptive expression but not state anger. Overall, this study highlights the value of integrating the perspectives of the appraisal theory and mindfulness in the investigation of driving anger, providing practical implications for driver education, anger-reduction interventions as well as the enhancement of policy implementation within the Chinese traffic context.

CRediT authorship contribution statement

Chenzhao Zhai: Writing – review & editing, Writing – original draft, Visualization, Software, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization, Investigation. **Samantha Jamson:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Zahara Batool:** Writing – review & editing, Supervision, Methodology, Conceptualization.

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.

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Data availability

Data will be made available on request.

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