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MAD-DAX: Anger and driver behaviours on the road

İbrahim Öztürk [a,*], Pınar Bıçaksız [b], Yeşim Üzümcüoğlu [c], Türker Özkan [d]

[a] Institute for Transport Studies, University of Leeds, United Kingdom
[b] Department of Psychology, American University in Dubai, Dubai, United Arab Emirates
[c] Department of Psychology, TOBB University of Economics and Technology, Turkey
[d] Department of Psychology, Middle East Technical University, Turkey

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ABSTRACT

Anger is a common emotion in everyday life, and in the context of driving, the experience of greater anger has been positively associated with aggressive behaviour, near-misses and crashes. Although the effect of anger on driver behaviour has been studied, the role of the source of anger and the perceived level of skill of the driver experiencing anger, based on self-reported behaviour, is not well understood. In this context, the aim of the current study was to investigate the relationships of trait anger and driving anger with driver behaviours in relation to driver skills. A total of 369 drivers aged 18–58 years ($M = 24.53$, $SD = 7.65$) completed a questionnaire consisting of the Trait Anger Scale (TAS), the Measure for Angry Drivers (MAD), the Driver Skills Inventory (DSI), the Driver Behaviours Questionnaire (DBQ), the Positive Driver Behaviour Scale (PDBS) and the Driving Anger Expression Inventory (DAX). The factor analyses for the Turkish adaptations of the MAD and DAX supported the original factorial structures. For less skilled drivers, experiencing more anger due to the behaviours of others was associated with more errors. For skilled drivers, higher levels of anger due to the behaviours of others were associated with more personal physical anger expression and positive behaviours. Similarly, for the same group of drivers, higher levels of anger due to traffic delays were associated with more errors. The findings revealed a complex relationship between driving-specific anger and driver behaviours based on different levels of driver skills, contrary to non-significant relations of trait anger. Anger provoked by the context/situation-based reason, as opposed to trait anger, was associated with more general driving style (i.e., errors and positive behaviours) through driver skills. For the first time in literature, the relationship between anger and driver behaviour has been addressed in this study within the context of driver skill. The results provided valuable information to better understand how different situations that can trigger anger may relate to different behaviours for drivers with different levels of perceived skills. The results may contribute to more targeted intervention programmes to reduce driving anger, aberrant behaviour, and associated outcomes.

1. Introduction

Road traffic crashes are one of the leading public health problems worldwide, causing material and human losses (World Health Organization, 2018). Of all road users, drivers are disproportionately more likely to be involved in road crashes (WHO, 2018) and to be a contributing factor to road crashes than other road users (e.g., Lewin, 1982; Thomas et al., 2013; Treat et al., 1977). Therefore,

* Corresponding author at: Institute for Transport Studies, University of Leeds, Leeds, UK.
E-mail address: i.ozturk@leeds.ac.uk (İ. Öztürk).

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studies of the driver population are of great importance for road safety. Models, such as the basic horizontal model (Özkan & Lajunen, 2015), conceptualise road user behaviours and relationships with driving outcomes at the individual level. It defines the associations starting from distal factors leading to proximal factors and ending with outcomes through interaction with exposure. Driver-related human factors (called *proximal factors* in this model) are differentiated into behaviours and skills. While the former is related to what drivers usually do while driving, the latter focuses on the capacities of drivers, indicating what drivers can do (Elander et al., 1993; Lajunen & Özkan, 2011; 2021). These proximal factors are affected by other more general factors, called *distal factors*, such as age and personality.

Anger, as one of the distal factors, has been studied in relation to many driving-related outcomes (Demir et al., 2016) and conceptualised as *trait anger* or *driving anger* in road safety studies. The former is defined as the global tendency to experience anger (Spielberger, 1999), and the latter refers to a personality trait, similar to trait anger, but more context-specific, defined as "*more frequent and intense anger while operating a motor vehicle*" (Deffenbacher et al., 1994; p. 84). In other words, driving anger is a trait and an emotion experienced in traffic, which is often conceptualised as the level of anger resulting from interactions and involvement in different traffic situations (Deffenbacher et al., 1994; Sullman & Stephens, 2021). In this regard, the present study investigated the relationships of trait anger and driving anger with driver behaviours by focusing on the role of driver skills in the proposed association. In the following sections, driver behaviours and skills are elaborated by highlighting the findings on trait anger and driving anger.

1.1. Driver behaviours and anger

In the literature, the most widely accepted conceptualisation focusing on unsafe behaviours, also known as aberrant behaviours, has differentiated these behaviours into violations and errors, according to the nature of the behaviour (Reason et al., 1990). While violations are defined as "*deliberate deviations from those practices believed necessary to maintain the safe operation of a potentially hazardous system*" and are therefore intentional behaviours in their nature (p. 1316), errors are defined as "*the failure of planned actions to achieve their intended consequences*" (p. 1315) and are therefore unintentional behaviours. A meta-analysis study, which focused on 174 studies using the DBQ, showed strong evidence for the distinction between errors and violations, as well as their relationships with crash involvement. Both errors and violations showed similar levels of positive association with self-reported crash involvement (de Winter & Dodou, 2010).

A set of driver behaviours that appears to be related to anger has been grouped to reflect the ways in which drivers express the anger they experience (Deffenbacher et al., 2002). Accordingly, drivers have been found to express anger by means of verbally aggressive expression, physically aggressive expression, using the vehicle to express anger, and adaptive/constructive anger expression. The first three types of behaviours are also referred to as aggressive anger expression. The measurement and conceptual differentiation of anger-related behaviours have been validated in different studies across countries (e.g., Eşiyok et al., 2007; Ge et al., 2015; Sullman et al., 2015; Villieux & Delhomme, 2010).

Previous studies have found strong associations between trait anger, driving anger and different forms of driver behaviours. For example, drivers with high-trait anger were more likely to engage in aberrant driver behaviours (Ge et al., 2017) and express their anger aggressively (e.g., Sullman, 2015; Sullman et al., 2015). Similarly, when focusing on the relationship between driving anger and aberrant driver behaviours, drivers experiencing higher levels of anger while driving also exhibited more aberrant driver behaviours (e.g., Ge et al., 2017; Li et al., 2021; Sullman et al., 2013; Zhang et al., 2015), as well as aggressive anger expression (e.g., Sullman, 2015; Sullman et al., 2015; Villieux & Delhomme, 2010). Similar to self-reported driver behaviours, a study using naturalistic driving data from the Strategic Highway Research Program (SHRP2) by Precht et al. (2017) reported that driving anger increased aggressive behaviour, but did not affect errors.

In contrast to aberrant and aggressive driver behaviours, trait anger (Brandenburg et al., 2019; Deffenbacher et al., 2001; Sullman, 2015; Sullman et al., 2017) and driving anger (e.g., Deffenbacher et al., 2001; Sullman, 2015; Sullman et al., 2017; Villieux & Delhomme, 2010) have been shown to be negatively related to behaviours associated with adaptive/constructive anger expression. Drivers experiencing higher anger (either trait anger or driving anger) expressed their anger in a less adaptive/constructive manner (Sullman et al., 2017).

Building on the classification of aberrant driver behaviours, Özkan and Lajunen (2005) later added another aspect to this behavioural conceptualisation, called positive behaviours. Positive behaviours, in contrast to aberrant behaviours, were defined as "*taking care of smooth traffic flow or paying attention to other road users*" (Özkan & Lajunen, 2005, p.359). There is a limited number of studies focusing on the relationship between anger and positive driver behaviours (e.g., Shen et al., 2018). Shen et al. (2018) found that drivers with higher levels of anger exhibited fewer positive behaviours. In another study, Matović et al. (2020) found that driving anger due to illegal and discourteous behaviours was positively, and driving anger due to slow driving and traffic obstructions was negatively, related to prosocial driving (careful and patient driver behaviours), behaviours that were conceptually relevant and highly correlated (Shen et al., 2018) with positive behaviours.

1.2. Driver skills and anger

Driver skills, the second aspect of driver-related human factors, are essential for safe driving. Information processing, and motor and safety skills represent driver performance, which reflects what drivers "*can*" do and can be improved with practice and training (Elander et al., 1993). Driver skills are usually studied in two dimensions: perceptual-motor skills and safety skills (Lajunen & Summala, 1995). Perceptual-motor skills rely on the information processing and motor skills required for handling the car (e.g., fluent car control). Safety skills can be described as the orientation of a driver for safe driving (Lajunen & Summala, 1995).

Driver skills are related to driver behaviours. For example, perceptual-motor skills and safety skills have been reported to show an asymmetric pattern with violations and tickets (Lajunen et al., 1998; Sümer et al., 2006). In other studies, higher safety skills have been associated with fewer violations and tickets (Xu et al., 2018), whereas higher perceptual-motor skills have been related to more violations (Martinussen et al., 2014).

Considering the relationship between driver skills and anger expression, Sümer et al. (2006) examined the role of driver skills on different aggressive behaviours: hostile aggression and revenge (e.g., intentionally hitting the other car), losing patience with others (e.g., other drivers or pedestrians sometimes makes me impatient and lose my nerve with their behaviour), and aggressive warnings (e.g., showing reaction by honking). Safety skills and the interaction of perceptual-motor skills and safety skills had significant effects on hostile aggression and revenge. Drivers with lower safety skills and either high or low perceptual-motor skills showed higher levels of losing patience with others or hostile aggression and revenge. However, the highest level of losing patience with others was reported by drivers with high perceptual-motor skills, whereas the highest level of hostile aggression and revenge was reported by drivers with low perceptual-motor skills.

Apart from aberrant and aggressive behaviours, the relationship between driver skills and positive driver behaviours has been relatively unexplored. The two aspects of driver skills, perceptual-motor skills and safety skills, have been shown to be positively correlated with positive behaviours (Öztürk & Özkan, 2018; Xu et al., 2018) and negatively related to errors and lapses (Xu et al., 2018). In other words, drivers who perceived their driver skills as high had a tendency to show more positive behaviours, and reported fewer errors.

1.3. *Rationale of the present study*

In this context, the aim of the current study was to examine the associations of trait anger with driver behaviours (the path indicated by the blue arrows numbered "1″ at the end of each arrow in Fig. 1) and driving anger expression (the path indicated by the orange arrows numbered "2" at the end of each arrow in Fig. 1) and driving anger with driver behaviours (the path indicated by the purple arrows numbered "3" at the end of each arrow in Fig. 1) and driving anger expression (the path indicated by the green arrows numbered "4" at the end of each arrow in Fig. 1) by addressing the moderating role of driver skills in these relationships between anger and behaviours (Fig. 1). In other words, the model of the current study focused on the moderation effect of perceptual-motor skills on the relationship between trait anger/driving anger and driver behaviours/anger expression while moderated by safety skills (three-way interaction between anger-related construct by perceptual-motor skills by safety skills).

As can be seen in Fig. 1, both trait anger and driving anger were included in the present study. Even though studies have provided positive correlations between trait anger and driving anger (e.g., Ge et al., 2017), the multidimensional structure of driving anger (e.g., Brandenburg et al., 2019; Villieux & Delhomme, 2010; Yasak & Esiyok, 2009; Zhang et al., 2015) and conceptual differences between trait anger and driving anger have presented significant contributions to the literature. Ge et al. (2017) investigated the role of trait anger and driving anger on risky driving behaviours, and reported that while trait anger and driving anger showed positive relations, trait anger continued to be a significant predictor of risky driver behaviours even after the introduction of driving anger to the model, which also positively predicted risky behaviours. In another study, Zhang et al. (2015) found that, in contrast to the hostile gestures and safety-blocking aspects of driver anger, arrival blocking was positively related to all forms of aberrant driver behaviour. Moreover, Brandenburg et al. (2019) found negative correlations between slow driving and adaptive/constructive anger expression, while other dimensions of driving anger showed non-significant relationships. Given these potential differences due to trait anger and different underlying factors leading to anger, and the limited body of research focusing on the relationships of anger (either trait anger or driving anger) with driver skills and positive driver behaviours, it was believed that studying trait anger and driving anger with different behavioural outcomes would provide crucial distinctions and insight into these relationships.

Furthermore, the interaction of perceptual-motor skills and safety skills may provide further insight into the skill orientation of drivers (Lajunen & Özkan, 2021). For example, due to self-enhancement bias, drivers might have a tendency to overestimate their own

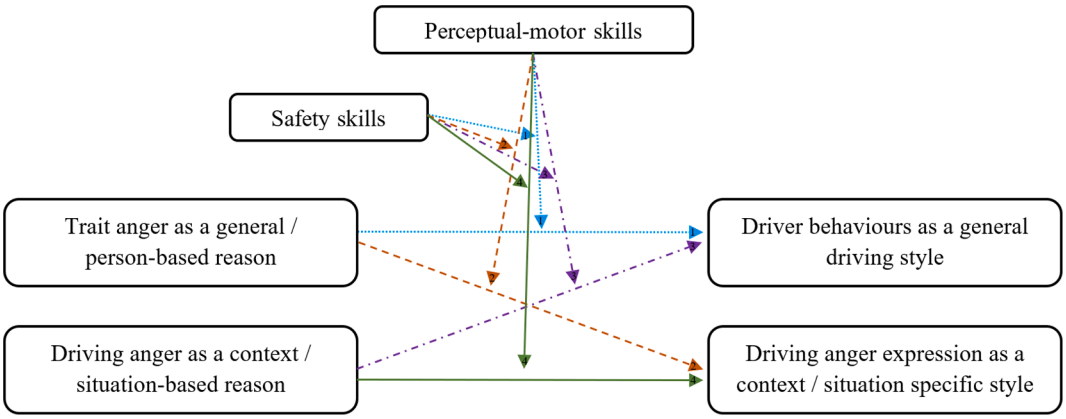

Fig. 1. Conceptual model tested in the current study.

driver skills and safety skills (Walton, 1999; Walton & Bathurst, 1998). The overestimation, especially for perceptual-motor skills, might cause more risky behaviours. However, safety skills might have a buffering role by making drivers more cautious, which would result in decreasing the negative effects of overestimation in perceptual-motor skills (Sümer et al., 2006). Therefore, in the present model, the two dimensions of skills were examined between anger (distal factors) and behaviours (proximal factors) as interaction effects.

The study model can be considered significant to the traffic and transportation psychology literature for the following reasons. First of all, the revised and adapted version of the DAX (Stephens & Sullman, 2014) and the newly developed MAD (Stephens et al., 2019) were adapted to Turkish for the first time in literature. While the use of the revised and adapted version of the DAX has the advantages of being up-to-date and reliable, the newly developed MAD was selected for this study because the measure examines driving anger with a revised item pool and categorisation of anger-provoking situations while driving. Secondly, the relationships between anger and behaviours were examined through both general trait anger (as a general/person-based cause) and driver-specific trait anger (as a context/situation-based cause), as well as general driver behaviours (as a general style) and anger expression-focused behaviours (as a context/situation-based style), including aberrant and aggressive behaviours on the one hand, and positive and adaptive behaviours on the other. In this way, it was possible to compare the directions and the strengths of the relationships of trait anger (paths 1 and 2 in Fig. 1) and driving anger (paths 3 and 4 in Fig. 1) with driver behaviour and to examine general driving style (paths 1 and 3 in Fig. 1) and anger-specific behaviours (paths 2 and 4 in Fig. 1) separately. Finally, the role of driving skills in the proposed relationship was revisited. The interaction between drivers' experience of anger and their perceived skills, as reflected in their behaviours, was examined for the first time in this study. As mentioned above, although the relationships between these variables have been examined directly in earlier studies, the interaction between the variables will provide more detailed information about the antecedents of different driver behaviours. With this in mind, three-way interaction effects were examined in the present study, and these were examined separately for the effects of both trait anger and driving anger on general driving style and anger-related driver behaviours. Due to the originality of the research approach, the final conceptual model was tested without a specific hypothesis for exploratory purposes.

2. Methods

2.1. Participants

The study was conducted with a total of 369 participants (194 females, 175 males) between the ages of 18 and 58 years ($M = 24.53$, $SD = 7.65$). The average time since obtaining a driving licence was 4.95 years ($SD = 6.38$). The average kilometres driven were 3832.52 km ($SD = 7618.31$) in the last year and 31413.48 km ($SD = 94083.44$) in lifetime.

2.2. Materials

2.2.1. Trait anger scale (TAS)

The general tendency of the participants to become angry (*Trait anger as a general / person-based reason* in Fig. 1) was measured using the TAS (Spielberger et al., 1983). The scale consists of 10 items (e.g., I am quick-tempered) with a single dimension. Participants were asked to rate anger-related statements on a 4-point Likert scale from 1 (never) to 4 (always), indicating their disposition to experience angry feelings. The Turkish version adapted by Özer (1994) was used in this study, and the Cronbach's alpha reliability of the scale was found to be 0.84.

2.2.2. The measure for angry drivers (MAD)

The drivers' tendency to get angry while driving (*Driving anger as a context / situation-based reason* in Fig. 1) was measured using the Measure for Angry Drivers (MAD) (Stephens et al., 2019). This scale consists of 23 items measuring three factors: danger posed by others with 12 items, aggression from others with seven items, and travel delays with four items. In the study, participants were asked to rate their level of anger experienced in particular situations (e.g., "someone pulls out right in front of you when there is no one behind you") in a 5-point Likert scale from 1 (not angry at all) to 5 (extremely angry). The scale was adapted to Turkish as a part of the current study. The factor structure and Cronbach's alpha reliability values of the dimensions are presented in section 3.1.1.

2.2.3. Driver skill inventory (DSI)

The drivers' self-reported driver skills were measured with the Driver Skill Inventory (DSI) (Lajunen & Summala, 1995). The DSI consists of 20 items measuring two different factors of driver skills; perceptual-motor skills (first moderator in Fig. 1; e.g., controlling the vehicle) and safety skills (second moderator in Fig. 1; e.g., keeping a sufficient following distance). While drivers' confidence in technical aspects of driving was measured with perceptual-motor skills items, safety motivation was measured with safety skills items. The drivers rated their skills on a 5-point Likert scale from 0 (definitely weak) to 4 (definitely strong). The Turkish version adapted by Lajunen and Özkan (2004) was used in the present study, and the Cronbach's alpha reliability values were determined to be 0.87 for perceptual-motor skills and 0.81 for safety skills.

2.2.4. Driver behaviour questionnaire (DBQ) and positive driver behaviour scale (PDBS)

The drivers' aberrant and positive driver behaviours (*Driver behaviours as a general driving style* in Fig. 1) were measured using the 19-item DBQ and PDBS battery, used as a part of the TraSaCu project (see Ersan et al., 2020; https://www.trasacu.eu/). Aberrant

driver behaviour items were selected from the DBQ (Reason et al., 1990) and the mini DBQ (Martinussen et al., 2013), representing two dimensions; errors with eight items and violations with seven items. Errors were defined as "*the failure of planned actions to achieve their intended consequence*" (p. 1315), and violations were defined as "*deliberate deviations from those practices believed necessary to maintain the safe operation of a potentially hazardous system*" (Reason et al., 1990, p. 1316). The four most representative items for positive driver behaviours were selected from the PDBS (Özkan & Lajunen, 2005), focusing on the behaviours of paying attention to the traffic environment, as well as other road users. The participants were requested to rate the frequency of the behaviours (e.g., attempt to drive away from traffic lights in third gear) on a 6-point Likert scale from 1 (never) to 6 (always). The 19-item short version has been validated in different countries. It represents the most common aberrant and positive behaviours (Ersan et al., 2020). The Cronbach's alpha reliability values were found to be 0.77 for errors, 0.78 for violations, and 0.86 for positive behaviours in the current study.

2.2.5. Driving anger expression inventory (DAX)

The drivers' anger expression was measured with a 15-item, short version of the DAX (*Driving anger expression as a context / situation specific style* in Fig. 1) developed by Stephens and Sullman (2014) based on the 49-item DAX (Deffenbacher et al., 2002). Stephens and Sullman (2014) found the same factor structure reported by Deffenbacher et al. (2002) with the revised version of the DAX corresponding to four ways of anger expression used by drivers (i.e., personal physical aggressive expression, verbal aggressive expression, use of the vehicle to express anger, and adaptive/constructive expression). The participants were asked to rate the frequency of various behaviours (e.g., try to get out and have a physical fight) as the reactions of instances when feeling angry while driving on a 4-point Likert scale from 1 (almost never) to 4 (almost always). The short revised DAX was adapted to Turkish as a part of the present study. The factor structure and reliability values are presented in section 3.1.2.

2.2.6. Demographic information form

This form elicited general demographic data (age, sex) and driving-related information (annual kilometres, total kilometres, licensing year).

2.3. Procedure

Before obtaining approval for the study from the Applied Ethics Research Center of Middle East Technical University (permission document number: 364-ODTU-2020), the MAD and DAX scales had been translated into Turkish by the three researchers who are fluent in English and Turkish, and have experience within this particular research field. The final translated version and back-translation were prepared with consensus. Data were collected using an online data collection platform (Qualtrics - qualtrics.com) through convenience and snowball sampling. The survey battery was distributed through social media channels and through instructors from different universities. Course credits were offered to some participants who voluntarily participated in the study. To protect the anonymity of the students participating in the study and to award course credits, the university's bonus point system was used. In this system, students who registered were given an anonymous unique ID. Students accessing the system with their ID were given the Qualtrics link to the study, and the bonus points were automatically processed by the system at the end of the research. All participants received an informed consent form highlighting their voluntary participation, rights to withdraw from the study anytime while answering questions, and the confidentiality and anonymity of their responses.

2.4. Analysis

Data obtained in the study were analysed using SPSS v.26 software. Respondents who only provided partial responses or had outlier values for age and kilometres driven in the last year (z scores > 3.5) were excluded from the study ($N = 49$). In the first step, the factor analyses for the MAD and DAX were conducted. Two principal component analyses with direct Oblimin as the rotation method were performed on the 23 items of the MAD and the 15 items of the DAX. An oblique rotation method (direct Oblimin) was used since the components were moderately correlated. Then, the bivariate correlations among study variables were reported. In the final step, 28 separate moderated moderation analyses (PROCESS Macro Model 3) were conducted to examine how the interaction between trait anger/driving anger and the perceived level of perceptual-motor skills differed across different levels of safety skills, by using the Hayes PROCESS tool (Hayes, 2022). Thus, three-way interactions were tested between trait anger/driving anger, perceptual-motor skills and safety skills. In each analysis, perceptual-motor skills were entered as the first moderator, and safety skills as the second moderator. In separate analyses, general trait anger and dimensions of driving anger were entered as the independent variables. Finally, analyses were performed separately for each dimension of driver behaviours (measured by the DBQ and PDBS) and driving anger expression (measured by the DAX). In all these analyses, age, gender and total mileage were entered as covariates.

3. Results

3.1. Factor analyses

Principal components analysis with oblique rotation (direct Oblimin) was used to test the factor structures of the Turkish translations of the MAD and DAX scales. The results of these analyses are presented below.

3.1.1. Factor structure of the MAD scale

For the MAD, Bartlett's test of sphericity yielded a significant result ($\chi^2(231) = 4091.05$, $p < .001$) and the Kaiser-Meyer-Olkin measure of sampling adequacy was 0.93, indicating that the correlation matrix produced by the scale items is factorable. The results yielded a three-factor solution by considering *the eigenvalues higher than 1* criterion (Reise et al., 2000) and scree test (for further discussion and guidelines for reporting, see Ledesma et al., 2021; Maskey et al., 2018). In the final solution, after eliminating one item (i.e., "A jaywalking pedestrian crosses in front of you forcing you to brake") due to very close cross-loading values, the total 22 items accounted for 56.29 % of the variance of the scale. Factor loadings and communality values of the scale items are presented in Table 1.

The first factor represents the *danger posed by others* factor of the original scale. One item (i.e., "A jaywalking pedestrian crosses in front of you forcing you to brake") loading on this factor in the original scale was deleted due to cross-loading, as mentioned above. Another item (i.e., "You have a green left turn arrow, but a driver ahead is travelling straight and blocking the turn") included in the *travel delays* factor of the original version, loaded on this – *danger posed by others* – factor in the Turkish version. The total 11 items making up this factor explained 40.16 % of the variance, with loadings ranging between 0.46 and 0.91. The internal consistency coefficient (Cronbach's Alpha) for these 11 items was 0.91.

The second factor represented the *travel delays* factor of the original scale. The remaining six items in the original version of the scale - except for one item mentioned above- loaded on this corresponding factor in the Turkish version. These six items explained 9.94 % of the variance, and factor loadings ranged between 0.56 and 0.79, with a Cronbach's Alpha value of 0.81.

The third factor included all of the four items of the *aggression from others* factor of the original scale, and one additional item (i.e. "When you are trying to merge, other drivers do not give way [preventing you merging]") was included in the *danger posed by others* factor of the original scale. These five items, in total, explained 6.01 % of the variance, with loadings ranging between 0.42 and 0.74. The Cronbach's Alpha value for these five items was 0.85.

3.1.2. Factor structure of the DAX-15 scale

For the DAX, Bartlett's test of sphericity yielded a significant result ($\chi^2(105) = 2400.56$, $p < .001$) and the Kaiser-Meyer-Olkin measure of sampling adequacy was 0.84, indicating that the correlation matrix produced by the scale items is factorable. The results yielded support for a four-factor solution by considering *the eigenvalues higher than 1* criterion (Reise et al., 2000) and scree test (for further discussion and guidelines for reporting, see Ledesma et al., 2021; Maskey et al., 2018). The four factors explained 66.61 % of the scale variance. Only one item loaded on a different factor than in the original version. Factor loadings and communality values of the scale items are presented in Table 2.

The first factor corresponds to the *use of vehicle to express anger* factor of the original scale. One item (i.e., "Try to scare the driver") loading on the *personal physical aggressive expression* factor in the original version of the scale loaded on this factor in the Turkish version of the scale. The four items loading on this factor explained 34.75 % of the variance, with loadings ranging between 0.51 and 0.83. The internal consistency coefficient (Cronbach's Alpha) for these four items was 0.74.

Table 1
Factor loadings of the MAD items.

Items	Component		
	Danger Posed by Others	Travel Delays	Aggression from Others
Someone does an illegal U turn in front of you, forcing you to brake hard	0.905		
Someone moves in front of you suddenly and without leaving enough room, forcing you to brake hard	0.897		
Someone cuts in right in front of you forcing you to brake	0.765		
Another driver causes a near miss with your vehicle	0.707		
Someone in front of you does not move off straight away when the light turns to green	0.652		
Someone pulls out right in front of you when there is no-one behind you	0.640		
A driver fails to give way to you at a stop or give way sign when supposed to	0.613		
Someone pulls out right in front of you without looking	0.601		
A driver ahead of you is straddling two lanes	0.593		
A driver fails to indicate at an intersection, roundabout, or when making a turn in front of you	0.557		
When you are trying to overtake another driver he/she speeds up	0.455		
You encounter road works and detours		0.787	
You are stuck in peak-hour traffic		0.737	
You see a flash and are unsure whether you have been photographed by a hidden speed camera		0.698	
Someone in front of you does not move off straight away when the light turns to green		0.686	
You are driving behind a large vehicle and you cannot see around it		0.620	
You have difficulty getting something you're using to help you drive to work properly or the way you want it to (e.g. Siri; phone directions)		0.561	
Someone makes a rude gesture towards you about your driving			-0.744
Someone shouts at you about your driving			-0.730
Another driver indicates anger/hostility when you do a perfectly legal manoeuvre			-0.687
Someone beeps at you without reason			-0.687
When you are trying to merge, other drivers do not give way (preventing you merging)			-0.418
Cronbach's Alpha	0.91	0.81	0.85
Variance explained	40.16 %	9.94 %	6.01 %

Table 2
Factor loadings of the DAX-15 items.

	Component			
Items	UoV	ACE	VAE	PAE
Try to scare the driver	0.825			
Do to drivers what they did to me	0.709			
Drive right up on the other driver's bumper	0.610			
Drive a lot faster	0.511			
Tell myself it's not worth getting involved		0.800		
Tell myself to ignore it		0.775		
Think of positive solutions to deal with the situation		0.690		
Tell myself it's not worth getting mad at		0.682		
Accept there are bad drivers on the road		0.661		
Make negative comments about the driver aloud			0.847	
Swear at the other driver aloud			0.796	
Yell at the other driver			0.663	
Try to get out of the car and tell the other driver off				-0.880
Try to get out and have a physical fight				-0.778
Roll down the window to communicate my anger				-0.766
Cronbach's Alpha	0.74	0.79	0.84	0.79
Variance explained	34.75 %	15.73 %	10.21 %	5.92 %

Note: UoV: Use of Vehicle to Express Anger, ACE: Adaptive/Constructive Expression, VAE: Verbal Aggressive Expression, PAE: Personal Physical Aggressive Expression.

The second factor represents the *adaptive/constructive expression* factor of the original scale. All of the five items in the original version of the scale loaded on this corresponding factor in the Turkish version. The factor loadings of the items ranged from 0.66 to 0.80. This factor accounted for 15.73 % of the scale variance and yielded a Cronbach's Alpha value of 0.79.

The third factor consists of items reflecting the *verbal aggressive expression* factor of the original scale. All three items in the original version of the scale loaded on this corresponding factor in the Turkish version. The factor loadings of the items ranged from 0.66 to 0.85. This factor accounted for 10.21 % of the scale variance and yielded a Cronbach's Alpha value of 0.84.

Finally, the fourth factor corresponds to the *personal physical aggressive expression* factor of the original scale. The items in the original version of the scale - except for one item mentioned above- loaded on this corresponding factor in the Turkish version. The factor loadings of these three items ranged from 0.77 to 0.88. This factor accounted for 5.92 % of the scale variance and yielded a Cronbach's Alpha value of 0.79.

3.2. Correlation coefficients

The bivariate correlation coefficients between study variables are presented in Table 3. Increased age was positively associated with self-reported skills, and more annual and lifetime kilometres were associated with higher perceptual-motor skills, higher violations, and a higher rate of expression of anger through verbal means and using the vehicle. In general, trait anger and the three dimensions of the MAD were positively correlated with each other, with violations, and verbal aggressive expression, and with the use of the vehicle to express anger. In terms of the relationship between driver skills and driver behaviour, safety skills were positively correlated with positive driver behaviour and adaptive/constructive anger expression, and negatively correlated with aberrant driver behaviour. Higher perceptual-motor skills were associated with more aberrant and positive behaviour and fewer errors. In addition, errors and violations were positively correlated with the forms of aggressive anger expression.

3.3. Three-way interactions

The moderated moderation analyses were performed using the Hayes PROCESS tool (Hayes, 2022). These analyses examined the three-way interactions between trait anger/driving anger, perceptual-motor skills, and safety skills on behaviours and yielded significant three-way interactions in seven of these models (out of 28), and the detailed findings are as follows. All of the significant interactions were with the dimensions of the MAD. Of the seven significant three-way interactions, three were with errors, two were with positive behaviour, and two were with physical aggressive expression. The figures presented findings focusing on two levels ("low" as one standard deviation (*SD*) below the mean and "high" as one SD above the mean) of each moderator (perceptual-motor skills as the first moderator and safety skills as the second moderator). The reason for selecting 1 SD below and above the mean in determining the moderator level of driver skills was that drivers were asked to compare themselves to an average driver when completing the questionnaire. Thus, drivers 1 SD above and below the sample mean reflect the definition of 'low' and 'high' levels of perceived driver skills (e.g., Sümer et al., 2006).

3.3.1. Driving anger and errors

Three significant three-way interaction effects were observed for the driving anger and errors relationship (the path indicated by the purple arrows numbered "3" at the end of each arrow in Fig. 1).

Table 3
Correlations between study variables.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.Age	1															
2.Annual km	0.19***	1														
3.Lifetime km	0.46***	0.55***	1													
4.Trait anger	0.05	0.07	0.14**	1												
5.Aggression from others	-0.09	-0.04	-0.01	0.42***	1											
6.Travel delays	-0.07	0.02	0.01	0.42***	0.48***	1										
7.Danger posed by others	-0.03	-0.01	0.04	0.43***	0.70***	0.48***	1									
8.Perceptual-motor skills	0.19***	0.34***	0.26***	0.05	0.08	0.04	0.20***	1								
9.Safety skills	0.10*	-0.03	0.01	-0.19***	0.04	-0.18***	0.17**	0.40***	1							
10.Errors	0.06	0.07	0.05	0.36***	0.11*	0.30***	0.02	-0.20***	-0.22***	1						
11.Violations	0.03	0.27***	0.17**	0.48***	0.26***	0.34***	0.26***	0.35***	-0.22***	0.44***	1					
12.Positive behaviours	0.09	0.08	0.05	-0.02	0.19***	-0.09	0.33***	0.30***	0.39***	-0.25***	0.02	1				
13.Personal physical aggressive expression	0.02	0.07	0.06	0.36***	0.12*	0.27***	0.06	0.13*	-0.12*	0.40***	0.41***	-0.18***	1			
14.Verbal aggressive expression	0.03	0.21***	0.13*	0.55***	0.33***	0.19***	0.34***	0.22***	-0.10	0.22***	0.55***	0.08	0.40***	1		
15.Use of the vehicle to express anger	0.03	0.23***	0.12*	0.42***	0.18***	0.36***	0.16**	0.27***	-0.26***	0.34***	0.61***	-0.13*	0.60***	0.49***	1	
16.Adaptive constructive expression	0.03	-0.12*	-0.05	-0.28***	-0.17**	-0.19***	-0.07	0.05	0.44***	-0.10	-0.32***	0.25***	-0.17**	-0.36***	-0.31***	1
M	24.53	3832.52	31413.48	19.40	3.07	2.21	3.33	3.38	3.87	1.66	1.97	4.90	1.18	1.86	1.37	3.00
SD	7.65	7618.31	94083.44	5.04	0.84	0.74	0.70	0.70	0.56	0.55	0.72	1.10	0.44	0.79	0.46	0.60

Note: * p <.05, ** p <.01, *** p <.001.

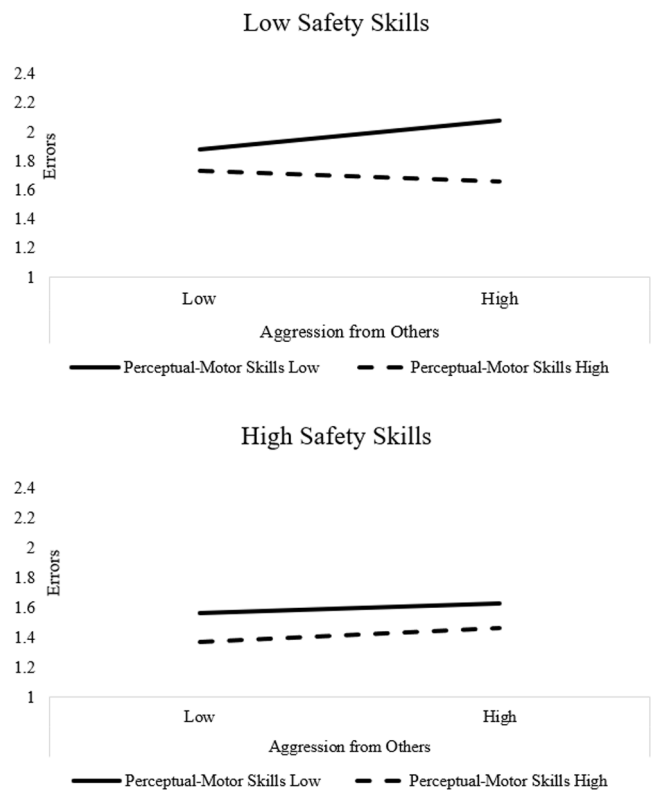

Fig. 2. Interaction between aggression from others and perceptual-motor skills for low and high levels of safety skills in predicting errors.

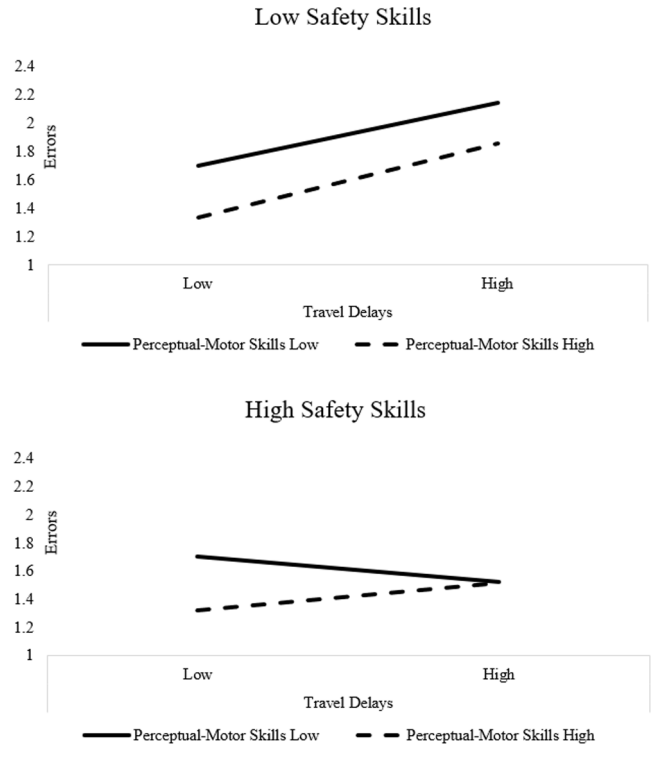

Fig. 3. Interaction between travel delays and perceptual-motor skills for low and high levels of safety skills in predicting errors.

First, the three-way interaction between *aggression from others* dimension of driving anger, perceptual-motor skills and safety skills in predicting errors was significant ($B = 0.12$, $F(1, 358) = 5.97$, $p = .015$). Safety skills moderated the moderation between the *aggression from others* dimension of driving anger and perceptual-motor skills, so that the two-way interaction between *aggression from others* and perceptual-motor skills was not significant for high levels of safety skills, while it was significant for low levels of safety skills ($B = -0.12$, $F(1, 358) = 5.03$, $p = .025$). Then, the simple slopes in this significant two-way interaction were examined and plotted (Fig. 2). For those with low levels of safety skills, the relationship between the *aggression from others* dimension of driving anger and errors was positive and significant ($B = 0.12$, $SE = 0.05$, $p = .016$) when perceptual-motor skills were low, while it was non-significant when perceptual-motor skills were high.

Second, the three-way interaction between the *travel delays* dimension of driving anger, perceptual-motor skills, and safety skills in predicting errors was marginally significant ($B = 0.13$, $F(1, 358) = 3.86$, $p = .050$). Thus, the two-way interaction between *travel delays* and perceptual-motor skills was significant when safety skills were high ($B = 0.18$, $F(1, 358) = 5.54$, $p = .019$), and was non-significant when safety skills were low (Fig. 3). For those reporting high levels of safety skills, the relationship between *travel delays* and errors was positive and significant ($B = 0.13$, $SE = 0.07$, $p = .048$) when perceptual-motor skills were high, and was non-significant when perceptual-motor skills were low.

Third, the three-way interaction between the *danger posed by others* dimension of driving anger, perceptual-motor skills and safety skills in predicting errors was significant ($B = 0.12$, $F(1, 358) = 8.01$, $p = .005$). Thus, the two-way interaction between *danger posed by others* and perceptual-motor skills was significant when safety skills were low ($B = -0.27$, $F(1, 358) = 19.65$, $p < .001$), but was non-significant when safety skills were high (Fig. 4). For those reporting low safety skills, *danger posed by others* yielded a significant positive association with errors ($B = 0.12$, $SE = 0.06$, $p = .048$) when perceptual-motor skills were low, and a significant negative association with errors ($B = -0.25$, $SE = 0.09$, $p = .004$) when perceptual-motor skills were high.

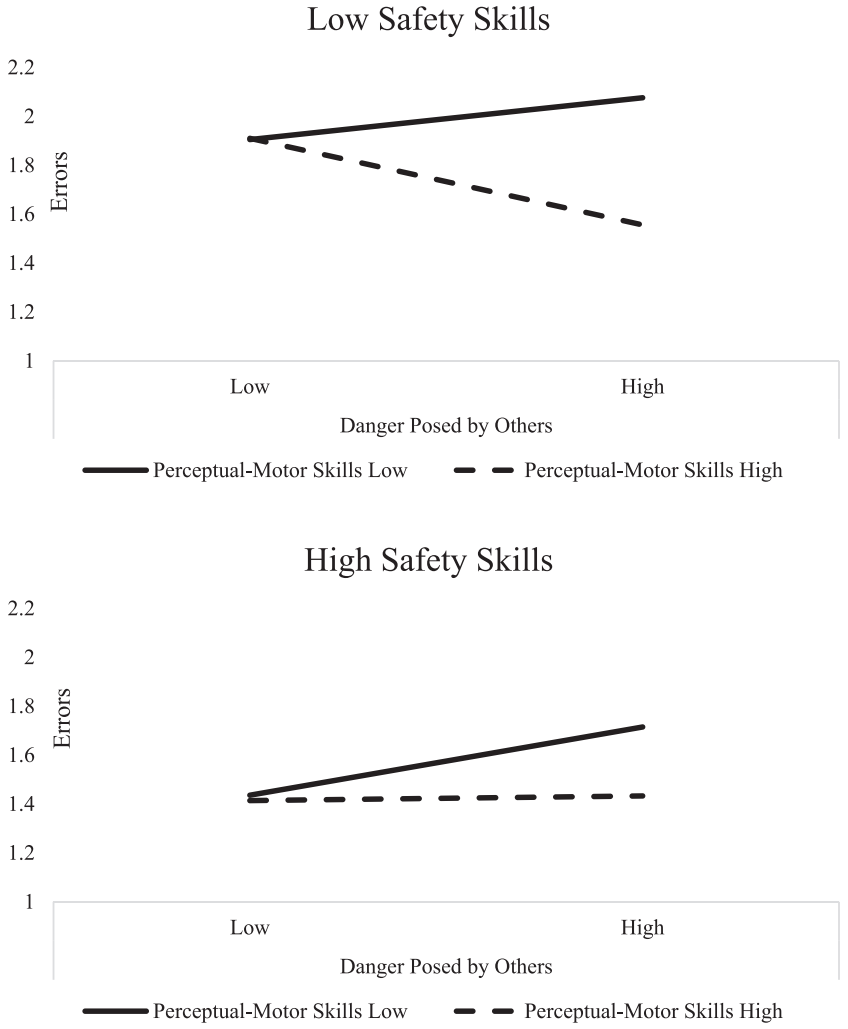

Fig. 4. Interaction between danger posed by others and perceptual-motor skills for low and high levels of safety skills in predicting errors.

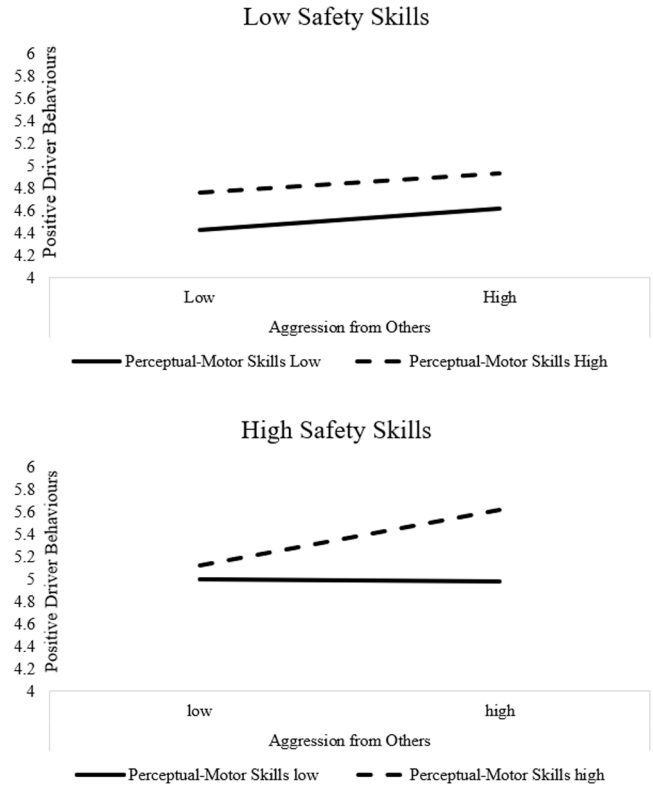

Fig. 5. Interaction between aggression from others and perceptual-motor skills for low and high levels of safety skills in predicting positive driver behaviours.

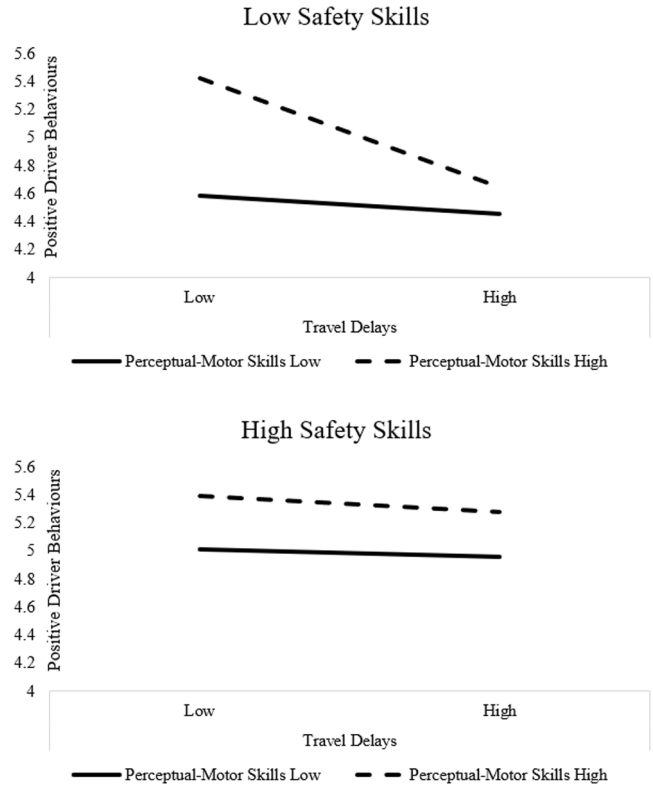

Fig. 6. Interaction between travel delays and perceptual-motor skills for low and high levels of safety skills in predicting positive driver behaviours.

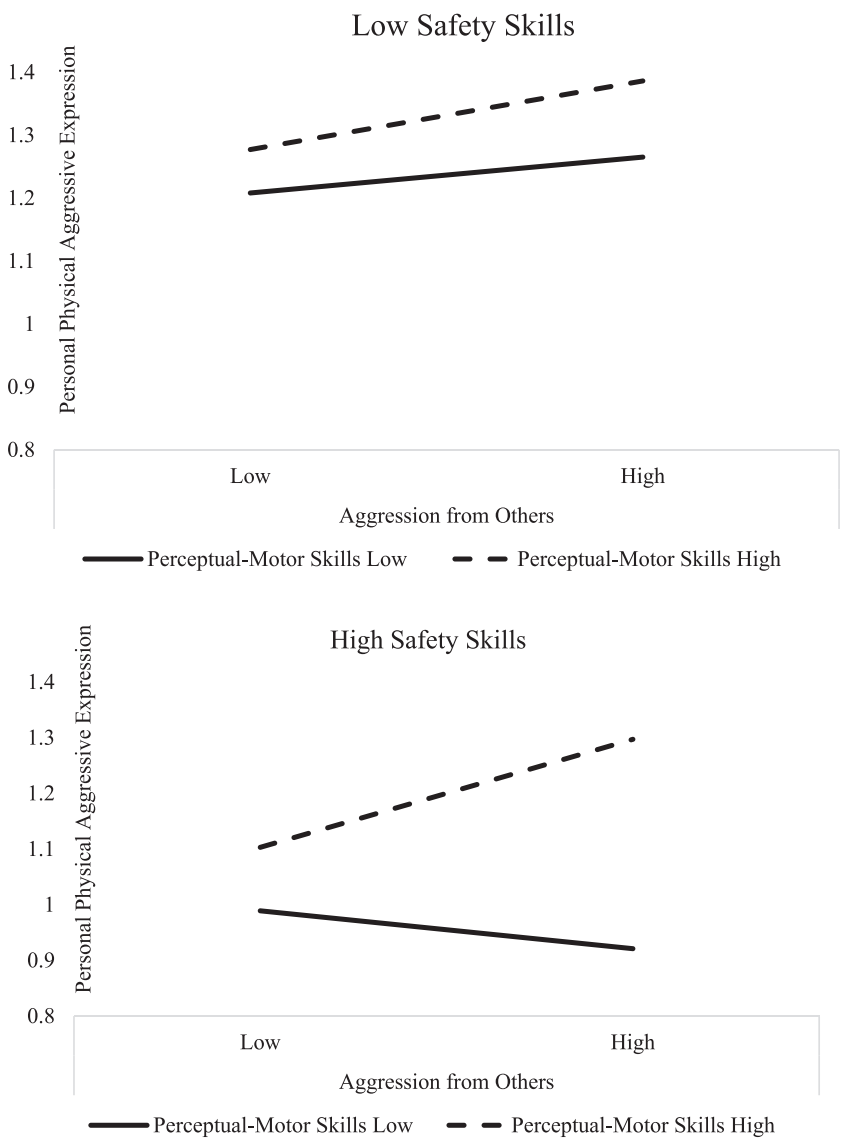

Fig. 7. Interaction between aggression from others and perceptual-motor skills for low and high levels of safety skills in predicting personal physical aggressive expression.

3.3.2. Driving anger and positive behaviours

Two significant three-way interaction effects were observed for the driving anger and positive behaviours relationship (the path indicated by the purple arrows numbered "3" at the end of each arrow in Fig. 1).

Fourth, safety skills moderated the moderation between the *aggression from others* dimension of driving anger and perceptual-motor skills in predicting positive behaviours ($B = 0.20$, $F(1, 358) = 4.99$, $p = .026$). Thus, the two-way interaction between *aggression from others* and perceptual-motor skills was marginally significant when safety skills were high ($B = 0.22$, $F(1, 358) = 3.37$, $p = .067$), and was non-significant when safety skills were low (Fig. 5). As depicted in the figure, for those reporting high levels of safety skills, the relationship between *aggression from others* and positive driver behaviours was positive and significant ($B = 0.30$, $SE = 0.11$, $p = .006$) when perceptual-motor skills were high, and was non-significant when perceptual-motor skills were low.

Fifth, safety skills moderated the moderation between the *travel delays* dimension of driving anger and perceptual-motor skills in predicting positive behaviours ($B = 0.26$, $F(1, 358) = 4.74$, $p = .044$). In detail, the two-way interaction between *travel delays* and perceptual-motor skills was not significant for high levels of safety skills, while it was significant for low levels of safety skills ($B = -0.32$, $F(1, 358) = 6.44$, $p = .012$). As depicted in Fig. 6, for those reporting low levels of safety skills, *travel delays* significantly and negatively predicted positive driver behaviours when perceptual-motor skills were high ($B = -0.53$, $SE = 0.19$, $p = .005$), and this association was non-significant when perceptual-motor skills were low.

3.3.3. Driving anger and personal physical aggressive expression

Two significant three-way interaction effects were observed for the driving anger and physical aggressive expression relationship (the path indicated by the green arrows numbered "4" at the end of each arrow in Fig. 1).

Sixth, safety skills moderated the moderation between the *aggression from others* dimension of driving anger and perceptual-motor skills in predicting the personal physical aggressive expression dimension of driving anger expression ($B = 0.08$, $F(1, 358) = 3.94$, $p = .048$). In detail, the two-way interaction between *aggression from others* and perceptual-motor skills was significant when safety skills were high ($B = 0.11$, $F(1, 358) = 4.49$, $p = .035$), and was non-significant when safety skills were low (Fig. 7). For those reporting high levels of safety skills, the relationship between *aggression from others* and personal physical aggressive expression was positive and significant ($B = 0.11$, $SE = 0.05$, $p = .014$) when perceptual-motor skills were high, and non-significant when perceptual-motor skills were low.

Finally, the three-way interaction between the *danger posed by others* dimension of driving anger, perceptual-motor skills and safety skills in predicting personal physical aggressive expression was significant ($B = 0.09$, $F(1, 358) = 5.76$, $p = .017$). The two-way interaction between *danger posed by others* and perceptual-motor skills was not significant when safety skills were either high or low. However, as observed in Fig. 8, for those reporting low levels of safety skills, the relationship between *danger posed by others* and personal physical aggressive expression was in the same direction and strength for high and low levels of perceptual-motor skills, while

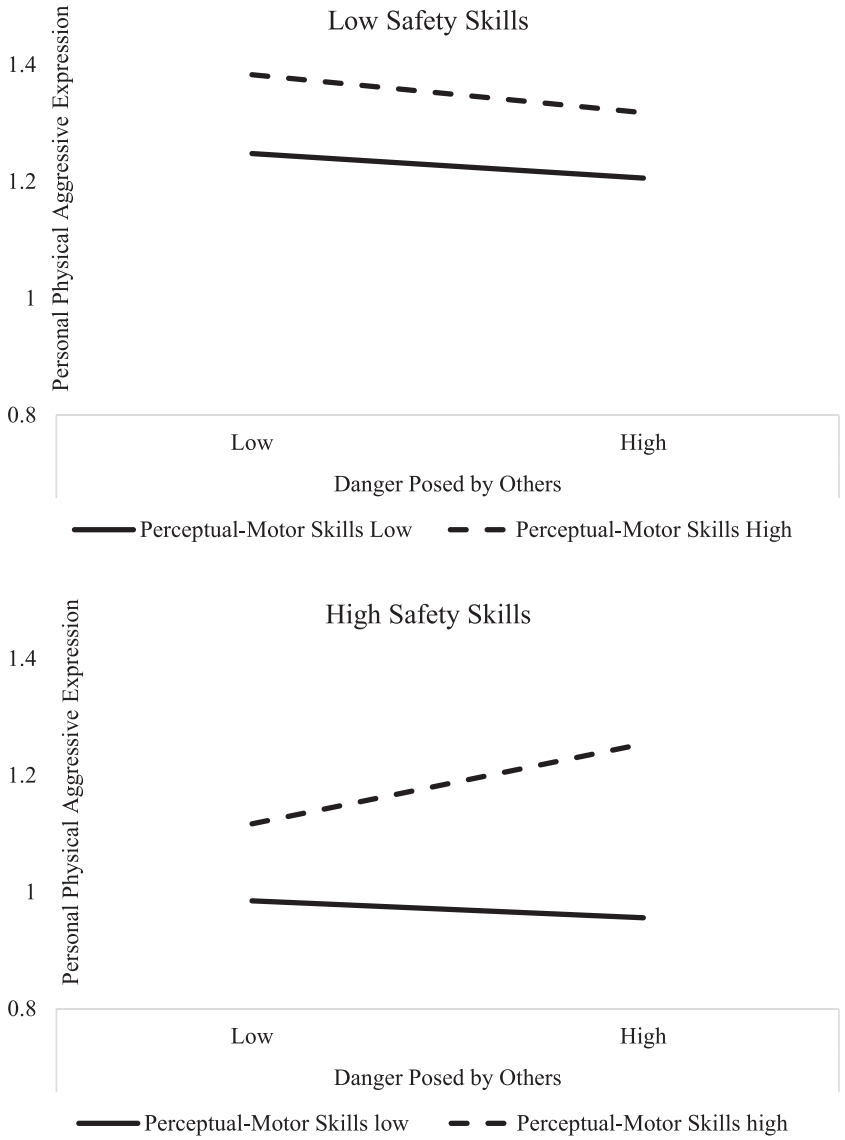

Fig. 8. Interaction between danger posed by others and perceptual-motor skills for low and high levels of safety skills in predicting personal physical aggressive expression.

this was not the case for those reporting high levels of safety skills. Thus, for those reporting high safety skills, the relationship between *danger posed by others* and personal physical aggressive expression was positive and significant ($B = 0.10$, $SE = 0.05$, $p = .038$) when perceptual-motor skills were high, and was negative and non-significant when perceptual-motor skills were low.

4. Discussion

In the current study, the relationships between self-reported anger (trait anger as a general/person-based reason and driving anger as a context/situation-based reason) and driver behaviours (driver behaviours as a general driving style and driving anger expression as a context/situation-based style for driving anger) through the moderating role of driver skills were studied. In addition to supporting the previous factorial structures of the MAD (Stephens et al., 2019) and DAX (Stephens & Sullman, 2014), the findings indicated different patterns of relationships, depending on the source of driving anger and the level of perceived driver skills over self-reported behaviours. More specifically, three-way interactions through driver skills were observed for aggression from others on errors, positive behaviours and personal physical aggressive expression, for travel delays on errors and positive behaviours, and for danger posed by others on errors and personal physical aggressive expression. When considered in this way, the model proposed in Fig. 1 shows that the 'trait anger as a general/person-based reason' part of the moderated moderation (three-way interaction effects) is not significant and the relationships show a driving-specific structure as in Fig. 9.

The adaptation of the General Aggression Model by Anderson and Bushman (2002) to aggressive driving by Sullman and Stephens (2021) revealed that aggressive behaviours differ as a function of two input factors: driver characteristics and situation. In support of this differentiation and interaction of individual factors and situational factors, the findings of the present study showed the interaction effects of individual factors (driving anger and driver skills) and implicit indirect effects of situational factors through the level of anger provoked by different situations.

More specifically, first of all, for drivers who perceived themselves to be low in perceptual-motor skills and safety skills (*less skilled drivers or drivers with low confidence in their own driving skills*), increased anger due to aggression from others and danger posed by others led to more errors while driving. Similar to the findings of Yang et al. (2022), which suggested more errors for less skilled drivers, this group of drivers in the current study who perceived themselves to be less skilled, observed that anger due to the behaviours of others resulted in more errors. The majority of the literature has focused on the aggressive behaviours of drivers from the eyes of the person who shows those behaviours. For example, in a qualitative study by Lennon and Watson (2011), it was reported that drivers showed aggressive behaviours as a way to "*teach them a lesson*" and motivate other drivers to self-correct when they encountered behaviours that were perceived to be occurring because of poor driving skills. It was also concluded that aggressive behaviours are more context-dependent (Lennon & Watson, 2011). This might be a good example of how others' behaviours affect driver behaviours in a way that leads to more errors, as a result of provoking certain emotions. Even though the motivations behind certain behaviours might be different (such as "*teaching them a lesson*" in the study of Lennon and Watson (2011)), less skilled drivers might make more errors due to increased time or emotional pressure, or due to trying to manage the demanding driving environment without the necessary driving skills.

As discussed by Özkan and Lajunen (2005), cognitive capacity and psychomotor skills were critical while interpreting errors. With the effects of context/situation-based anger on errors by less skilled drivers, increased errors could be observed due to the increased cognitive load from interactions with the external driving environment, leading to increased anger. Reason et al., (1990, p. 1315) defined errors as "*the failure of planned actions to achieve their intended consequences*". In this context, it can be claimed that drivers may not be successfully able to execute their planned behaviours due to high context/situation-based anger (*due to the behaviours of others*) together with a lack of certain skills needed to perform these behaviours (*in the case of less skilled drivers*). In other words, drivers might experience/show more errors due to limited driving skills and the cognitive capacity to endure situations requiring contact with other drivers. It was more interesting that skilled drivers (drivers with high perceptual-motor and safety skills) also reported more errors when they were angered by travel delays. Skilled drivers might experience more errors due to overestimating their own skills while trying to get out of situations that delay their travels, as they experience more anger. For example, in a simulator study, Roidl et al.

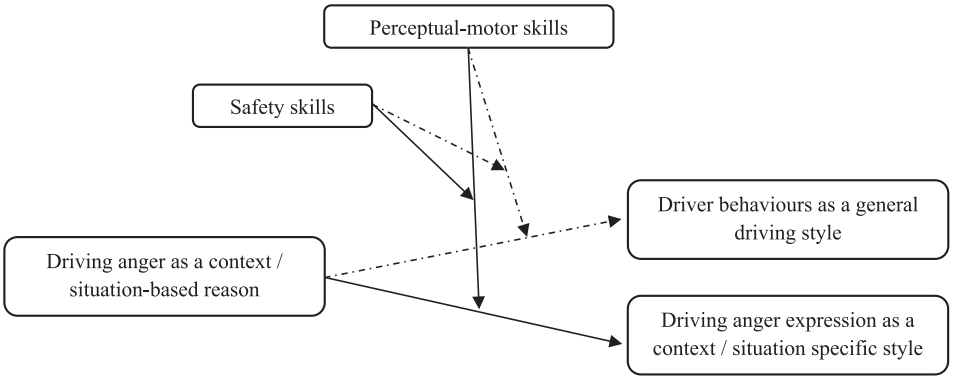

Fig. 9. The conceptual model - Updated based on the results.

(2014) found that higher levels of anger resulted in increased acceleration and speeding. These reckless behaviours, together with the overestimation of skills, might result in the driver failing to perform planned behaviours. Differences in contextual situations triggering anger (and possibly cognitive capacity) and driver skills showed the importance of context/situation-based driving specific anger on errors, by highlighting the importance of cognitive capacity and psychomotor skills (Özkan & Lajunen, 2005) together with the social and physical context (Özkan et al., 2006).

For *skilled* and *confident* drivers, increased anger due to aggression from others, or due to the danger posed by others, was positively associated with personal physical aggressive expression. Increased anger due to aggression from others was positively related to positive driver behaviours, and finally, increased anger due to travel delays was linked to increased errors. Previous studies focusing on interactions between perceptual-motor skills and safety skills (e.g., Sümer et al., 2006; Wu et al., 2018) have emphasised the buffering effect of safety skills on perceptual-motor skills, and undesired outcome relations, positive behaviours and personal physical aggressive expression might indicate the contextual effect of this relationship. In other words, the three-way interactions for highly skilled drivers may not always balance each other, and depending on the other motivations of drivers, certain behaviours, either positive or negative, might be expressed more frequently. In terms of aberrant driver behaviours, the current study results suggested that drivers who were confident of their driving skills respond to other drivers in physical ways as they experience aggression or aggressive behaviours from others. Considering the items of the *aggression from others* dimension of the MAD, it can be claimed that confident drivers were also more ready to express their anger physically against aggressive behaviours from others.

In terms of positive behaviours, the current study results support the findings of previous studies (Öztürk & Özkan, 2018; Xu et al., 2018) that have reported a positive association between being a skilled driver and exhibiting more positive behaviours. For skilled drivers, increased anger due to aggression from others was positively associated with positive driver behaviours. In line with the aforementioned definition of positive behaviours (Özkan & Lajunen, 2005), drivers may prefer to show positive behaviours, despite feeling angry due to the behaviours of others. It can be argued that drivers may engage in more positive behaviours in order to pay attention to the driving environment and even to calm down situations in which others' behaviours lead to elevated anger, and potentially dangerous situations.

For drivers with high perceptual-motor skills and low safety skills, anger due to travel delays was negatively associated with positive behaviours. Similarly, Wu et al. (2018) found that drivers with high perceptual-motor skills and low safety skills showed more aggressive warning behaviours, which may indicate a tendency to show aggressive behaviours. It is not surprising that increased anger due to travel delays had a negative effect on the likelihood of showing positive behaviours. As these positive behaviours were secondary behaviours that were not necessarily required for safe driving, particularly in a situation of feeling angry and delayed, drivers may prefer not to show positive behaviours because these behaviours may also lead to additional time spent in traffic and cause further delay. When compared with skilled drivers, a low level of safety skills and being angered by travel delays may indicate that the motivation for positive behaviours (derived from safety skills) and the time and context to show positive behaviours were lacking when feeling angrier due to travel delays.

As expected, the effects were stronger for anger as context/situation-based driving anger, than for a general/person-based trait anger in traffic. Strikingly, the opposite was seen when stronger effects were observed for general driver behaviours (especially as errors and positive driver behaviours) rather than contextual/situation-based anger expression-focused behaviours. In other words, even though the direct correlation coefficients between trait and driving anger and driving anger expression supported the previous literature (e.g., Stephens et al., 2019; Villieux & Delhomme, 2010), the interaction effects were mostly related to aberrant and positive driver behaviours rather than anger-specific behaviours. From these results, it can be concluded that the relationship between emotions and driver behaviours is more complex and skill-dependent when the focus is on a wide range of behaviours rather than emotion-specific behaviour. In other words, the lack of interactions between anger and anger expression was observed because the relationships between anger and anger expression were more direct and were not affected by the perceived level of driving skills. However, when the relationships between a specific emotion and different forms of behaviours were investigated, driving anger affected aberrant and positive behaviours differently, depending on the triggers of driving anger and the drivers' perceived level of driver skills. These findings can be an indicator of the context-specific impact of driving anger on driver behaviours, by considering driver skills.

A few limitations of the current study should be highlighted. First is that the results of the current study might have been affected by social desirability. While some studies (Sullman & Taylor, 2010; Wickens et al., 2008) have shown no effect, others (Smorti et al., 2018; Yılmaz et al., 2022) have highlighted the vulnerability of the self-reported measures of aberrant behaviours for socially desirable responses. Although the data were collected anonymously, in future studies, the use of social desirability measurements or forced-choice items (e.g., Kreitchmann et al., 2019; Nederhof, 1985) could be considered as other ways to overcome this limitation. A second limitation was that due to the nature of the data collection method (i.e., self-reports at a single point in time), the study was cross-sectional in design with limited power to draw cause-effect conclusions or may be subjected to common method variance. It would be useful for future studies to use experimental methods, including driving simulators (e.g., Abdu et al., 2012) or naturalistic driving data (e.g., Precht et al., 2017) to collect objective data to be able to draw more straightforward conclusions and observe and manipulate the source of anger more directly, thereby overcoming methodological limitations.

The results of the current study also suggest some ideas for future studies and anger management training interventions. The differences in behavioural outcomes due to changes in driver skills and the source of anger may also be useful for practitioners who focus on reducing anger and aggressive driving on the road by implementing different programmes (e.g., Stephens et al., 2022). For example, Stephens et al. (2022) highlighted the significance of aggressive driving programmes for safer road systems by demonstrating the effectiveness of the implemented programmes. Together with the findings of the current study, training programmes focusing on driving anger, anger management, and driver skills could contribute to a positive traffic safety culture by decreasing aberrant driver behaviours and increasing positive driver behaviours. Finally, the interaction relationships within the tested model, and the results

obtained, require further investigation in future studies. In line with the general conclusion of Lajunen and Parker (2001) suggesting context dependency of aggressive behaviours and the importance of driver characteristics and situations, highlighted in the General Aggression Model (Anderson and Bushman, 2002), the current study findings suggested that the source of driving anger and level of driver skills are important for a better understanding of these complex behaviours.

5. Conclusion

The results of the current study demonstrated the dynamic context-dependent relationships of driving anger and driver skills on driver behaviours, whilst also demonstrating that trait anger is not related to behavioural outcomes through driving skills. In addition to the literature presenting undeniable direct relationships, the conceptual model tested in the present study revealed the significance of driving anger as a context/situation-based reason over driver behaviours through driver skills. Overall, these findings provide new insights into road user behaviour research by providing evidence for the relationships between emotions and behaviours, through three-way interactions with driver skills.

CRediT authorship contribution statement

İbrahim Öztürk: Conceptualization, Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Conceptualization. **Pınar Bıçaksız:** Conceptualization, Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Yeşim Üzümcüoğlu:** Conceptualization, Writing – review & editing, Writing – original draft, Conceptualization. **Türker Özkan:** Conceptualization, Writing – review & editing, Supervision, 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.

Data availability

Data will be made available on request.

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