



A meta-analysis of the association between anger and aggressive driving

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ABSTRACT

The aim of this paper was to evaluate the relationship between anger (trait and driving anger) and aggressive driving. In order to test these relationships, we conducted a systematic review of the literature on anger and aggressive driving. We identified 51 eligible studies that we included in this meta-analysis. Based on previous literature, we hypothesised that: (1) there is a positive relationship between anger and aggressive driving; (2) the relationship between anger and aggressive driving behaviour differs based on whether anger is trait-based or traffic context-specific; (3) this relationship also varies depending on the type of aggressive driving; and (4) the relationship between specific anger type and aggressive driving vary according to gender, age, region where the studies were conducted and driving experience. The quantitative analysis was conducted using meta-analytic techniques. Results confirmed the fact that there is a positive relationship between anger and aggressive driving behaviour, the relationship being stronger for trait anger. Moreover, the relationship between anger and aggressive driving depends on different forms of aggressive driving, gender, age, driving experience, and the region where studies were conducted. The theoretical and practical implications of these results are discussed.

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1. Introduction

Aggressive driving consists of any type of behaviour directed to hurt another person, both other drivers and pedestrians, at a physical or emotional level, without taking into consideration those persons' rights or safety (Dula & Geller, 2003). The aggressive behaviours in traffic vary from the less aggressive forms such as flashing lights, running stops or red lights, honking, verbal threats, making non-verbal gestures, tailgating, blocking other drivers, to the most extreme aggressive forms such as unsafe lane changing, speeding, car ramming or physical attacks (Özkan, Lajunen, Parker, Sümer, & Summala, 2010). Aggressive driving is one of the risk factors of crash related conditions (e.g. loss of concentration, loss of control) and of serious crashes (Stephens & Sullman, 2014; Sullman, 2015). Moreover, aggressive behaviour can incite other traffic participants to act aggressively on the road, which may amplify the risks of accidents (Clapp et al., 2011). For these reasons, a recurrent question concerns the factors that predispose a driver to behave aggressively behind the wheel. Probably the most thoroughly studied cause of aggressive driving behaviour is anger, a significant and dangerous phenomenon that commonly occurs (Stephens & Ohtsuka, 2014; Sullman, 2015; Sullman, Stephens, & Kuzu, 2013).

As well as aggressive driving behaviour, anger represents a well-recognised and studied cause of crash involvement and crash-related conditions (Stephens & Groeger, 2011; Sullman & Stephens, 2013; Sullman et al., 2013). This study has focused on two forms of anger, trait anger and trait driving anger, and their relationship to aggressive driving. Regarding the strength

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of the relationship between anger and aggressive driving, empirical studies have yielded mixed findings. Some studies report weak relationships between aggressive driving and both trait anger (Deffenbacher, Alcazar-Olan, Kocur, & Richards, 2014) as well as driving anger (Sullman et al., 2013), while other studies suggest that there is a medium (Herrero-Fernández, 2013; Suhr & Nesbit, 2013) or a strong relationship between aggressive driving and both types of anger (Edwards, Warren, Tubré, Zypthur, & Hoffner-Prillaman, 2013; Nesbit, Blankenship, & Murray, 2012). However, the strength of the above presented relationships varies according to the specific form of measured aggressive driving and the participants' characteristics. Given this fact, the aim of this meta-analysis is to explore these relationships and some moderators that may explain these mixed results regarding the relationship between anger and different forms of aggressive driving behaviour. Due to the frequency of aggressive driving and its serious consequences, it is important to understand its predictors more clearly in order to advance solutions in this area.

2. Anger and aggressive driving

The last decade has been a very prolific period for the empirical research on the relationship between anger and aggressive driving. According to the frustration-aggression model (Berkowitz, 1993), aggression only appears when the frustrating element elicits an intense emotion, such as anger. However, even though the frustrating element elicits anger, aggression will not always occur. Another theoretical framework, the general aggression model (GAM; Anderson & Bushman, 2002), also suggests that specific dispositional and situational factors can produce arousal and an angry mood, which can further produce specific conscious appraisals and aggressive behaviours. These statements have been sustained by studies in traffic psychology (e.g. Kováčsová, Rošková, & Lajunen, 2014; Sullman, 2015).

2.1. Trait anger

Trait anger can be defined as a multidimensional construct, which can be expressed at a cognitive, emotional, psychological or behavioural level (Eckhardt, Norlander, & Deffenbacher, 2004). Many studies showed that individuals who have a propensity towards trait-anger will most likely behave aggressively not only in day to day contexts, but also in traffic situations (Haje & Symbaluk, 2014; Kováčsová et al., 2014; Sullman, 2015). Deffenbacher, Deffenbacher, Lynch, and Richards (2003) reached the conclusion that high trait anger drivers drove faster and in a much more dangerous way than drivers with low trait anger. Other studies suggest that the effect of trait anger on aggressive driving is mediated by trait driving anger (Deffenbacher, Lynch, Filetti, Dahlen, & Oetting, 2003; Kováčsová et al., 2014). Specifically, drivers who have higher levels of trait anger are more likely to become angry in traffic and to express their anger in dysfunctional ways (Deffenbacher, Lynch et al., 2003).

2.2. Trait driving anger

Trait driving anger represents the extrapolation of the general concept of anger into specific driving contexts, being conceptualised as a frequent and intense tendency to become angry when driving (Deffenbacher, Lynch et al., 2003). In this manuscript, we will use *driving anger* to refer to trait driving anger. The positive relationship between driving anger and aggressive driving behaviour has been confirmed in previous cross-sectional studies (Li, Yao, Jiang, & Li, 2014; Stephens & Ohtsuka, 2014; Sullman, 2015; Sullman & Stephens, 2013) and in a previous meta-analytic review (Nesbit, Conger, & Conger, 2007). Experiencing anger while driving can interfere with information processing, which may further lead to an increased tendency to manifest aggressive behaviours (Blankenship & Nesbit, 2013; Parrott, Zeichner, & Evces, 2005).

Moreover, previous studies analysing the relationship between the state of anger and aggressive behaviour showed that one's state of anger can increase the accessibility and activation of aggression-related cues and can facilitate a negative interpretation of information (Berkowitz, 1990). A study that tested these assumptions in a driving context showed that the participants with a high level of trait driving anger reported a greater tendency to overestimate the significance of the situation and a reduced number of anger control statements, compared to the participants with a low level of trait driving anger (Nesbit & Conger, 2011). Blankenship and Nesbit (2013) also found that participants high in trait driving anger responded more quickly to aggressive stimuli (words) when paired with driving than neutral stimuli. Other studies showed that this negative interpretation of a situation and related cognitions can further lead to a greater propensity to report aggressive driving behaviour (Deffenbacher, Petrilli, Lynch, Oetting, & Swaim, 2003).

A widely used instrument to measure trait driving anger is the Driving Anger Scale (DAS; Deffenbacher, Oetting, & Lynch, 1994). The items of this instrument describe situations often encountered while driving, like hostile gestures, police presence, illegal driving, slow driving, discourtesy and traffic obstructions. Respondents rate each item by the degree to which the situation would anger them.

2.3. Other determinants of aggressive driving

Regarding the expression of driving anger, the majority of self-report studies have used the Driving Anger Expression Inventory (DAX; Deffenbacher, Lynch, Oetting, & Swaim, 2002) that placed drivers' aggressive reactions into four categories: verbal aggressive expression (people's tendency to express their anger through verbally aggressive means), personal physical aggressive expression (the ways in which the person uses themselves to express anger by getting out of the car and picking a

fight, for example), use of vehicle to express anger (e.g. flashing the lights), adaptive/constructive expression (adaptive behaviours the driver can adopt in potentially anger inducing situations). Because DAX is the most widely used self-report measure of aggressive driving behaviour and many studies analysed the relationship between anger and DAX dimensions, we have also assessed the relationship between anger and different dimensions of aggressive behaviour. Studying different dimensions of this complex behaviour may offer a clearer picture about aggressive behaviour behind the wheel, given the fact that a driver may not manifest all types of aggressive driving behaviours to the same degree.

Previous studies suggested that certain demographic variables can account for the relationship between anger and aggressive driving. For example, males and younger people exhibit more aggressive tendencies while driving, compared to female and people of a higher age (Haje & Symbaluk, 2014; Sullman, Stephens, & Yong, 2014; Sullman et al., 2013; Wickens, Mann, Stoduto, Lalomiteanu, & Smart, 2011). Moreover, previous studies identified a relationship between the mileage and different dimensions of aggressive driving, like verbal aggressive expression (Deffenbacher et al., 2002; Sullman, 2015) or the use of the vehicle to express anger (Sullman, 2015; Villieux & Delhomme, 2010). However, there is some inconsistency regarding the driver characteristics that relate to aggressive driving. For example, some studies found no sex or age differences in the propensity to become aggressive while driving (Deffenbacher, Kemper, & Richards, 2007; Moore & Dahlen, 2008; Villieux & Delhomme, 2010) or found a small effect size of these differences (Sârbescu, Stanojević, & Jovanović, 2014). Moreover, there are studies that underline the idea that gender differences appear only for certain types of aggression. For example, some studies showed that female drivers report significantly more anger in traffic than males (Sullman et al., 2014) and display more aggressive driving on some dimensions, like verbal aggressive expression (Dahlen & Ragan, 2004), but they still express driving anger in a more adaptive/constructive manner than men (Deffenbacher, White, & Lynch, 2004). On the other hand, men have a higher tendency to use the vehicle to express anger (Sullman, 2015). Contrary to Dahlen and Ragan (2004), Sullman (2015) found that verbal aggressive expression did not differ significantly between male and female drivers. To conclude, we can assume that the gender differences regarding anger and its expressions are dependent on the type of anger expression.

A final particularity of the studies about the relationship between anger and aggressive driving that we want to mention here is that most of the research has been conducted in the United States of America (USA) (e.g. Deffenbacher et al., 2007; Moore & Dahlen, 2008) and Western Europe (Herrero-Fernández, 2011; Jovanović, Lipovac, Stanojević, & Stanojević, 2011; Sullman et al., 2013; Villieux & Delhomme, 2010). A previous review of the comparative database from across behavioural sciences suggests that the samples drawn from Western and developed societies are different compared with the rest of the world (Henrich, Heine, & Norenzayan, 2010). Although the expression and perception of anger is universal and biologically-based, anger also interacts with culture in determining a variety of behavioural expressions. There are many ways in which cultures endorse the universal angry expressions (Matsumoto, Yoo, & Chung, 2010). Therefore, cultural differences between different regions may partially explain the relationship between anger and aggressive driving. Developed and Western countries are characterised by individualism, while the less developed and Eastern European countries are characterised by collectivism (Hofstede, 2001). A greater endorsement of angry expressions towards ingroups compared to outgroups was documented in individualistic cultures. Collectivistic cultures foster a greater degree of conformity within their ingroups, therefore these cultures were associated with a greater endorsement of angry expressions towards outgroups rather than ingroups (Matsumoto et al., 2010). People who score high on individualism usually worry more about themselves and their immediate relatives, while collectivists care about everyone around them. Collectivistic cultures encourage regulating angry expressions by neutralizing or concealing the anger (Matsumoto et al., 2010). These dimensions have been linked to aggressive behaviour, the relationship being positive for individualism and aggression, and this relationship can be also reflected in traffic situations (Hofstede, 2005).

Other cultural dimensions may also account for the relationship between anger and its expression. For example, a study showed that the cultures that valued greater power distance, embeddedness, hierarchy, and long-term orientation endorsed more neutralization and masking of anger, while the cultures high on individualism, affective autonomy, and egalitarianism endorsed a greater expression of anger (Matsumoto et al., 2010). Another cultural dimension that can be linked to aggressive driving is “masculinity”. The Germanic countries (Germany, Switzerland, and Austria) and the USA scored higher than Latin and Asian countries (such as France, Spain, and Thailand). This aspect can be translated into traffic events, as high masculinity and macho personality is related to aggressive driving (Krahé & Fenske, 2002). Moreover, in some cultures, like the Asian culture, the people are educated to not express extreme emotions, this fact being disapproved (Chen, Cheung, Bond, & Leung, 2005; Maxwell, Sukhodolsky, & Sit, 2009). Therefore, the drivers from this region may have a lower tendency to report anger and aggressive driving behaviour.

As previous research has shown, the differences between countries regarding driving anger and its expression (e.g. Sullman, 2006; Sullman, Gras, Cunill, Planes, & Font-Mayolas, 2007) must be taken into consideration when discussing the relationship between anger and aggressive driving.

3. The present study

The first aim of this meta-analytic review is to explore the strength of the relationship between anger (both trait and driving anger) and aggressive driving. Secondly, we want to explore if the relationship between anger and aggressive driving depends on the type of anger (trait vs. traffic context-specific).

Nesbit et al. (2007) conducted the first meta-analysis in this area, investigating the relationship between different forms of anger and aggressive driving. It should be noted that trait anger and driving anger were found to be related to aggressive driving in Nesbit et al.'s (2007) meta-analysis. However the analysis was based on a sample of studies published up to that date. From 2007 to present, we have identified more than 30 studies published on the relationship between anger and aggressive driving. Therefore, we consider that an update is necessary. In addition, we have identified some differences between the average relationship between driving anger and aggressive driving outcomes in the previous meta-analytic study and the correlation between these variables identified in recent studies (e.g. Li et al., 2014). As the differences may be due to the different type of aggressive driving, the third aim of this study is to assess if this relationship varies depending on the type of aggressive driving (verbal aggression, physical aggression, use of vehicle to express anger, displaced anger).

Since not all angry drivers will become aggressive drivers (Vallières, Vallerand, Bergeron, & McDuff, 2014), the fourth aim of this study is to assess the demographic moderators of the relationship between anger and aggressive driving behaviour. Specifically, we have examined four moderators of the relationships between anger and aggressive driving: gender, age, region, and mileage.

Based on previous studies reported above, we hypothesise that: (a) there is a significant positive relationship between anger and aggressive driving (Hypothesis 1); (b) the relationship between anger and aggressive driving behaviour differs depending on whether anger is trait-based or traffic context-specific (Hypothesis 2); (c) this relationship also varies depending on the type of aggressive driving (Hypothesis 3); and (d) the relationship between specific anger type and aggressive driving vary according to gender, age, region where the studies were conducted and driving experience (Hypothesis 4).

4. Method

4.1. Study sample and selection of studies

We conducted a comprehensive search for empirical research regarding the relationships between anger and aggressive driver. In order to do so, three recommended procedures were used to retrieve both published and unpublished studies on this focus. First, we conducted a computerised literature search of all relevant empirical articles published in journals indexed in the Psycinfo and ProQuest Dissertations & Theses databases using keywords such as: “trait anger”, “driving anger”, “aggressive driving”, “driving”, “aggressive drivers”, and “anger”. The search was limited to English language articles. Secondly, for all dissertation abstracts that were identified through the first search method, we attempted to obtain copies of the complete unpublished document. Thirdly, to gain access to additional unpublished studies, we directly contacted approximately 20 relevant researchers through email. In addition, we reviewed the references of all relevant manuscripts and we searched the table of contents of key journals in the field of transportation research to ensure that we had not missed other studies on this topic. Using these search strategies, 125 original empirical studies were identified (including 2 unpublished dissertations). Each paper was then verified and kept or eliminated from the subsequent analyses.

Criteria for including studies in this meta-analysis were the following: (a) both anger and aggressive driving were measured; (b) the concept of *aggressive behaviour* was explicitly used by authors in their description of the instrument used to assess this variable; (c) the study reported the association between anger and aggressive behaviour; and (d) the reported results were sufficient to calculate an estimate of effect size. A study was excluded from the present sample in the following situation (the number of excluded studies are presented in parentheses): (a) a copy of the research article could not be obtained (16 studies); (b) too little information was provided to calculate an effect size (40 articles); (c) anger was measured by the presence of aggressive thoughts (2 studies) or was defined as state anger (1 study); and (d) no measure of the relationship between anger and aggression was provided (15). Overall, the final sample included 51 studies with a total of 15,381 participants (see Table 1 for a summary of the articles included in this meta-analysis). The average sample size per study was 301.58 ($SD = 193.70$).

4.2. Study feature coding

Each study that met inclusion criteria was coded on several methodological dimensions. In addition, we coded relevant demographic data (gender, age, region, and driving experience), sample type (college or non-college students), sample size, anger measures, and aggressive driving measures.

4.3. Preparatory analyses

All studies were separately evaluated by two researchers. The correlations were transformed through Fisher's r to Z transformation (Hedges & Olkin, 2014). The analysis, namely weighted mean effect sizes, heterogeneity, and subsequent moderator analyses, were conducted using Comprehensive Meta-Analysis version 3.0 (Borenstein, Hedges, Higgins, & Rothstein, 2009). Because the samples reporting multiple correlations violates the independence assumption (Johnson & Eagly, 2000), we calculated an averaged r to obtain one estimate per sample. These averages were used in the subsequent analysis.

Table 1
Summary of studies included in the meta-analysis.

Authors	Participants	Anger measures	Aggressive driving measures
Beck, Daughters, and Ali (2013)	769 students	Driving Anger Scale (DAS; Deffenbacher et al., 1994)	Items that were designed to measure aggressive driving
Berdoulat, Vavassori, and Sastre (2013)	455 drivers	Driving Anger Scale (DAS; Deffenbacher et al., 1994)	Driving Behaviour Questionnaire Transgression Subscale (DBQT; Lawton, Parker, Manstead, & Stradling, 1997; French version, Delhomme & Villieux, 2005)
Česniënė and Kašinská (2011)	196 drivers	Driving Anger Scale (DAS; Deffenbacher et al., 1994)	Aggression Questionnaire (Buss & Perry, 1992)
Dahlen et al. (2012)	322 drivers	Driving Anger Scale (DAS; Deffenbacher et al., 1994)	Driving Anger Expression Inventory (DAX; Deffenbacher et al., 2002)
Dahlen and Martin (2006)	619 students	State-Trait Anger Expression Inventory 2 (Spielberger, 1999)	Aggression Questionnaire (Buss & Perry, 1992)
Dahlen et al. (2005)	224 students	Driving Anger Scale (DAS; Deffenbacher et al., 1994)	Driving Anger Expression Inventory (DAX; Deffenbacher et al., 2002)
Dahlen and White (2006)	312 students	Driving Anger Scale (DAS; Deffenbacher et al., 1994)	Driving Survey (Deffenbacher, Huff, Lynch, Oetting, & Salvatore, 2000)
Deffenbacher (2003)	160 students	Driving Anger Scale (DAS; Deffenbacher et al., 1994) & Trait Anger Scale (TAS; Spielberger, 1988)	Driving Anger Expression Inventory (DAX; Deffenbacher et al., 2002)
Deffenbacher (2009)	200 students	Driving Anger Scale (DAS; Deffenbacher et al., 1994)	Driving Anger Expression Inventory (DAX; Deffenbacher et al., 2002)
Deffenbacher et al. (2014)	160 students	Trait Anger Scale (TAS; Spielberger, 1988)	Driving Anger Expression Inventory (DAX; Deffenbacher et al., 2002)
Deffenbacher, Lynch, Deffenbacher, and Oetting (2001)	272 students	Driving Anger Scale (DAS; Deffenbacher et al., 1994) & Trait Anger Scale (TAS; Spielberger, 1988)	Driving Anger Expression Inventory (DAX; Deffenbacher et al., 2002)
Deffenbacher et al. (2002)	290 students	Driving Anger Scale (DAS; Deffenbacher et al., 1994) & Trait Anger Scale (TAS; Spielberger, 1988)	Driving Anger Expression Inventory (DAX; Deffenbacher et al., 2002)
Deffenbacher, Lynch, Oetting, and Yingling (2001)	274 students	Driving Anger Scale (DAS; Deffenbacher et al., 1994)	Items that were designed to measure aggressive driving
Deffenbacher, Richards, Filetti, and Lynch (2005)	160 students	Driving Anger Scale (DAS; Deffenbacher et al., 1994) & Trait Anger Scale (TAS; Spielberger, 1988)	Driving Anger Expression Inventory (DAX; Deffenbacher et al., 2002)
Deffenbacher et al. (2004)	436 students	Driving Anger Scale (DAS; Deffenbacher et al., 1994) & Trait Anger Scale (TAS; Spielberger, 1988)	Driving Anger Expression Inventory (DAX; Deffenbacher et al., 2002)
Deffenbacher et al. (2004)	218 students	Driving Anger Scale (DAS; Deffenbacher et al., 1994)	Driving Anger Expression Inventory (DAX; Deffenbacher et al., 2002)
Dula and Ballard (2003)	119 students	State-Trait Anger Expression Inventory (STAXI; Spielberger, 1996)	Dula Dangerous Driving Index (DDDI; Dula & Ballard, 2003)
Edwards et al. (2013)	362 students	Driving Anger Scale (DAS; Deffenbacher et al., 1994)	Driving Anger Expression Inventory (DAX; Deffenbacher et al., 2002)
Ge et al. (2014)	242 drivers	10 items measuring trait anger	Dula Dangerous Driving Index (DDDI; Dula & Ballard, 2003)
González-Iglesias, Gómez-Fraguela, and Luengo-Martín (2012)	541 drivers	A reduced version of Driving Anger Scale (DAS; González-Iglesias, 2008)	Driving Anger Expression Inventory (DAX; Deffenbacher et al., 2002)
Herrero-Fernández (2011)	432 students	Driving Anger Scale (DAS; Deffenbacher et al., 1994)	Driving Anger Expression Inventory (DAX; Deffenbacher et al., 2002)
Herrero-Fernández (2013)	198 drivers	Driving Anger Scale (DAS; Deffenbacher et al., 1994)	Driving Anger Expression Inventory (DAX; Deffenbacher et al., 2002)
Houston, Johnson, Skinner, and Clayton (2006)	170 students	Driving Anger Scale (DAS; Deffenbacher et al., 1994)	The Aggressive Driving Behaviour (ADBS; Houston et al., 2003); The Driving Aggression Scale (Glendon et al., 1993); The Driver's Stress Profile (DSP; Larson, 1996)
Jovanović et al. (2011)	260 drivers	UK driving anger scale (UKDAS) (Lajunen, Parker, & Stradling, 1998)	Driving Anger Expression Inventory (DAX; Deffenbacher et al., 2002)
Jovanović, Stanojević, and Stanojević (2011)	260 drivers	UK Driving Anger Scale (Lajunen et al., 1998)	Driving Anger Expression Inventory (DAX; Deffenbacher et al., 2002)
Knee, Neighbors, and Viator (2001)	107 students	Driving Anger Scale (DAS; Deffenbacher et al., 1994)	Measure of Aggressive Driving (MAD; Knee et al., 2001)
Kováčová et al. (2014)	618 drivers	Driving Anger Scale (DAS; Deffenbacher et al., 1994)	Driver Anger Indicators Scale (DAIS) Lajunen and D. Parker
Li et al. (2014)	411 drivers	Driving Anger Scale (DAS; Deffenbacher et al., 1994)	Following Neighbors, Viator, and Knee (2002) study, we measured aggressive driving in terms of subjective aggression (Cronbach's alpha = .59) and aggressive actions.
Lucidi et al. (2010)	1008 students	Driving Anger Scale (DAS; Deffenbacher et al., 1994)	Driving Behaviour Questionnaire (DBQ; Reason, Manstead, Stradling, Baxter, & Campbell, 1990)
Lustman, Wiesenthal, and Flett (2011)	210 drivers	Driving Vengeance Questionnaire (Wiesenthal et al., 2000)	Scenarios – Attribution Driver Aggression and Attribution Measure (DAAM)
Lustman (2011)	117 students	Driving Anger Scale (DAS; Deffenbacher et al., 1994)	Dula Dangerous Driving Index (DDDI; Dula & Ballard, 2003)
Malomo and Balogun (2012)	72 drivers	Driving Anger Scale (DAS; Deffenbacher et al., 1994)	Bank Driver Selection Scale (BDSS; Malomo & Balogun, 2012)

Table 1 (continued)

Authors	Participants	Anger measures	Aggressive driving measures
Maxwell, Grant, and Lipkin (2005)	245 students	Propensity for angry driving scale (PADS; DePasquale, Geller, Clarke, & Littleton, 2001)	Driving behaviour inventory (DBI; Gulian, Matthews, Glendon, & Davies, 1989)
Moore and Dahlen (2008)	316 students	Driving Anger Scale (DAS; Deffenbacher et al., 1994)	Driving Anger Expression Inventory (DAX; Deffenbacher et al., 2002)
Neighbors et al. (2002)	111 students	Driving anger record	Subjective aggression and aggressive actions
Nesbit et al. (2012)	111 students	Trait Anger Scale (Spielberger, 1999), Driver Anger Scale (DAS; Deffenbacher et al., 1994)	The Anger Expression Scale (AXEX; Spielberger, 1999)
Philippe, Vallerand, Richer, Vallières, and Bergeron (2009)	44 drivers	Anger was measured through 3 items	Driving Anger Expression Inventory (DAX; Deffenbacher et al., 2002)
Przepiorka et al. (2014)	334 drivers	Driving Anger Scale (DAS; Deffenbacher et al., 1994)	Driving Behaviour Survey (DBS; Clapp et al., 2011)
Schreer (2002)	99 students	Driving Anger Scale (DAS; Deffenbacher et al., 1994)	Aggressive driving (Knee et al., 2001)
Stephens and Groeger (2009)	48 students & drivers	Driving scenarios	Driving Behaviour Questionnaire (DBQ; Reason et al., 1990)
Stephens and Ohtsuka (2014)	220 drivers & students	Driving Anger Scale (DAS; Deffenbacher et al., 1994)	Scenarios from the hostile behaviour continuum of James and Nahl (2000)
Stephens and Sullman (2014)	551 drivers	Driving Anger Scale (DAS; Deffenbacher et al., 1994)	Driving Anger Expression Inventory (DAX; Deffenbacher et al., 2002)
Suhr and Nesbit (2013)	271 students	Driving Anger Scale (DAS; Deffenbacher et al., 1994) & TAS (Spielberger, 1999)	History of aggressive driving behaviour (adapted from Deffenbacher, Deffenbacher et al., 2003)
Sullman (2015)	677 drivers	Driving Anger Scale (DAS; Deffenbacher et al., 1994)	Driving Anger Expression Inventory (DAX; Deffenbacher et al., 2002)
Sullman et al. (2013)	282 drivers	Driving Anger Scale (DAS; Deffenbacher et al., 1994)	Driving Anger Expression Inventory (DAX; Deffenbacher et al., 2002)
Sullman et al. (2014)	339 drivers	Driving Anger Scale (DAS; Deffenbacher et al., 1994) & Trait Anger Scale (TAS; Spielberger, 1988)	8 questions assessed the aggressive driving behaviour
Vallièrès et al. (2014)	102 students	Scenarios	8 items assessed the aggressive driving reactions
Vallièrès et al. (2014)	458 drivers	Scenarios	8 items assessed the aggressive driving reactions
Van Rooy, Rotton, and Burns (2006)	322 students	Anger Questionnaire (Buss & Perry, 1992)	Driving Anger Scale (Deffenbacher et al., 1994), Driving Vengeance Questionnaire (Wiesenthal, Hennessy, & Gibson, 2002), Driving behaviour inventory (Gulian et al., 1989)
Villieux and Delhomme (2010)	314 students	Driving Anger Scale (Deffenbacher et al., 1994)	Driving Anger Expression Inventory (DAX; Deffenbacher et al., 2002)
Zhang, Houston, and Wu (2014) A	343 drivers	State-Trait Anger Expression Inventory (STAXI; Spielberger, 1983)	Aggressive Driving Scale (ADS; Krahé & Fenske, 2002) & Aggression Questionnaire (Buss & Perry, 1992)

4.4. Publication bias

Publication bias was assessed using Orwin's Fail Safe N (FSN) procedure (Orwin, 1983), in order to identify the number of unpublished studies of non-significant effect size for the relationship between anger and aggressive behaviour, which was necessary to reduce the mean effect size observed in this study. Adopting a criterion mean effect size of missing studies of $r = .10$ gives a FSN value of 452, indicating the number of studies reporting negligible effect sizes correlations between anger and aggressive behaviour required to reduce the observed effect size to zero magnitude. Adopting a highly conservative criterion mean effect size of missing studies of $r = .60$, we obtained a FSN value of 81 studies.

5. Results

5.1. Study characteristics

The demographic characteristics of the included samples were heterogeneous. The samples were taken from the United States (50.00%), West Europe (15.38%), East Europe (7.69%), North America (5.77%), Asia (5.77%), Central Europe (5.77%), Australia, and Africa with 1.92% each. We also found studies where the region was not mentioned (5.77%).

The age of the participants from studies included in this meta-analysis ranged between 18 (Deffenbacher, 2003) to 63 years (Przepiorka, Blachnio, & Wiesenthal, 2014). The participants from the majority of the studies (29) were college students (56.86%); only 2 (3.92%) studies had a sample that contained both college students and non-college participants and 39.21% of the studies (20) had a sample which included only non-college participants.

For measuring driving anger, out of the 51 total studies, 38 (74.50%) used "Driving Anger Scale", 3 studies (5.88%) used scenarios, and 6 studies used other measures (11.76%). When referring to measuring "trait anger", out of the 51 studies included in the meta-analysis, 9 studies (17.64%) used "Trait Anger Scale" and 3 studies (5.88%) used "State-Trait Anger Expression Inventory". There were 8 studies (15.68%) that measured both driving anger and trait anger (with both "Trait Anger Scale" and "State-Trait Anger Expression Inventory"). The majority of the studies administered questionnaires to measure aggressive driving behaviour. Few of them used scenarios (3) or driving logs (3) to assess driving behaviour. From the total studies, 21 (40.38%) measured all the aggressive driving dimensions from the *Driving Anger Expression Inventory* (Deffenbacher et al., 2002): verbal aggression, physical aggression, use of vehicle to express anger, in relationship with trait and driving anger.

5.2. Anger type and aggressive driving

A fixed effect model meta-analysis was computed. In our analysis, the raw correlations between trait and driving anger, on the one hand, and aggressive driving, on the other hand, ranged from .09 (Li et al., 2014) to .68 (Vallières et al., 2014).

To test if there was a relationship between anger and aggressive driving (Hypothesis 1), we computed the Fisher's Z effect size for the relationship between self-reported measures of anger and aggressive behaviour, along with a 95% confidence interval (CI). Based on Cohen's (2013) criteria for magnitude of effect sizes, we considered 0.2, 0.5, and 0.8 as small, medium, and large, respectively. The results showed that the effect size for the relationship between anger and aggressive driving behaviour was .39, therefore the relationship between the two variables was medium. For both trait anger and driving anger, the relationship was medium, but we could observe a higher coefficient for trait anger (.46) than for driving anger (.38). These results are presented in Table 2. The confidence intervals (CIs) did not contain zero values, therefore we rejected the null hypothesis according to which the correlation coefficient was zero. Based on these results, we concluded that the higher the level of anger, the stronger the tendency to behave aggressively in traffic situations.

To test if the relationship between anger and aggressive driving behaviour differs systematically depending on whether anger was trait-based or traffic context-specific (Hypothesis 2), the between-classes effect, QB, was computed. It represents a test of the homogeneity between classes. The results showed that this coefficient was significant ($QB = 49.64, p < .001$), sug-

Table 2
Summary of study-level anger type effect sizes for aggressive driving.

Criterion	Any anger	Trait anger	Driving anger
<i>Weighted averages analysis</i>			
<i>k</i>	152	33	119
<i>Z</i>	.39	.46	.38
95% CI	.38–.40	.44–.49	.36–.39
QW	899.16***	197.40***	651.10***
QB		49.64***	
<i>I</i> ²		83.34	

Note. *k* – Number of included studies; *Z* – Fisher's Z effect size; QW – within heterogeneity coefficient; QB – between heterogeneity coefficient.

*** $p < .001$.

Table 3

Summary of study-level anger type effect sizes for different type of aggressive driving.

Criterion	Any anger	Trait anger	Driving anger
<i>Verbal aggression</i>			
<i>k</i>	29	7	22
<i>Z</i>	.46	.47	.44
95% CI	.43–.48	.42–.51	.42–.47
QW	114.95**	9.93	95.83**
<i>Physical aggression</i>			
<i>k</i>	26	7	19
<i>Z</i>	.35	.33	.32
95% CI	.32–.37	.28–.39	.30–.36
QW	97.19***	8.35	44.18**
<i>Use of vehicle to express anger</i>			
<i>k</i>	24	6	18
<i>Z</i>	.38	.37	.35
95% CI	.35–.40	.33–.41	.33–.38
QW	159.65***	13.92*	100.33***
<i>Displaced aggression</i>			
<i>k</i>	2		2
<i>Z</i>	.22		.22
95% CI	.16–.29		.16–.29
QW	0.85		0.85
QB	120.52***	34.43***	103.20***

Note. *k* – Number of included studies; *Z* – Fisher's *Z* effect size; QW – within heterogeneity coefficient; QB – between heterogeneity coefficient.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

gesting that the mean sizes effect was different across anger types. Analysis of the CIs associated with the mean effect size estimates indicated that the relationship between trait anger and aggressive driving (.46) was significantly stronger than the relationship between driving anger and aggressive driving (.38) (Table 2). Therefore, we computed the next analysis separately for trait anger and driving anger.

For each type of anger included in our analysis, within-group heterogeneity estimates (QW) were computed, in order to assess whether the studies within groups are homogenous or heterogeneous. Since each QW was significant, we can conclude that there was heterogeneity of the effect sizes observed for both types of anger. Further we analysed the results for different dimensions used to assess aggressive driving within both types of anger (Hypothesis 3). The results showed that there were significant differences across different aggressive driving dimensions used in analysis, for both trait anger (QB = 34.43, $p < .001$) and driving anger (QB = 103.20, $p < .001$). When we evaluated the CIs for averaged effect sizes for the relationship between trait anger and aggressive behaviour, the results showed that the relationship between trait anger and verbal aggressive driving (mean effect size = .47) was significantly different from the relationship between trait anger and physical aggression (mean effect size = .33) or between trait anger and the use of vehicle to express anger (mean effect size = .37). When analysing driving anger and aggressive behaviour, the results also showed that the relationship between driving anger and verbal aggressive driving (mean effect size = .44) was significantly different from the relationship between driving anger and physical aggression (mean effect size = .32) or between driving anger and the use of the vehicle to express anger (mean effect size = .35). The effects were medium to high (Cohen, 2013). When considering the different types of aggressive driving, the results showed that both trait anger and driving anger are strongly associated with verbal aggression. Therefore, we concluded that the higher the levels of trait anger or driving anger, the higher the tendency to display aggressive behaviour, the relationship being stronger for verbal aggression (see Table 3).

Because the relationship between anger and aggressive driving is heterogeneous, based on QW associated with a high value of I^2 , some variation between studies may be explained by the participants' characteristics. Therefore, we analysed if the relationship between specific anger type and aggressive driving varies according to gender, age, region where the studies were conducted, and driving experience (Hypothesis 4). The existence of a significant *Q* and a high I^2 value suggested that there was some variance that can be potentially explained by subgroup analysis or meta-regression (Borenstein et al., 2009).

When we analysed the relationship between anger and aggressive driving, separately for males and females participants, the results indicated the following (Table 4). For the female sample, the Fisher's *Z* effect size for the relationship between trait anger and aggressive driving outcomes was .42. For driving anger, the Fisher's *Z* effect size for the relationship between anger and aggressive driving outcomes was .39. For male sample, the Fisher's *Z* effect size for the relationship between trait anger and aggressive driving outcomes was .43. For driving anger, the Fisher's *Z* effect size for the relationship anger and

Table 4

Summary of study-level anger type effect sizes for aggressive driving, separately for female and male

Criterion	Any anger	Trait anger	Driving anger
<i>Male</i>			
<i>k</i>	10	11	6
<i>Z</i>	.44	.43	.32
95% CI	.41–.48	.39–.47	.28–.36
QW	132.57	44.68***	30.52***
<i>Female</i>			
<i>k</i>	10	10	4
<i>Z</i>	.44	.42	.39
95% CI	.40–.48	.39–.45	.31–.46
QW	37.33	37.67***	8.47*
QB	30.52***	0.38	9.35*

Note. *k* – Number of included studies; *Z* – Fisher's *Z* effect size; QW – within heterogeneity coefficient; QB – between heterogeneity coefficient.

***p* < .01.

**p* < .05.

****p* < .001.

aggressive driving outcomes was .32 for both male and female samples; the corresponding QW was significant, indicating the heterogeneity of the effect sizes for both types of samples. The QB coefficient indicated the homogeneity of this effect for trait anger and the heterogeneity of the effect sizes for driving anger. Therefore, the relationship between aggressive driving and driving anger was stronger for females (.39) than for males (.32). Concerning the relationship between trait anger and aggressive behaviour, the effect size for studies on male samples was not statistically different from the effect size for studies on female samples.

The relationships between anger and aggressive driving for different regions are presented in Table 5. The QB is significant, indicating heterogeneity in the relationship between anger and aggressive behaviour for different regions. When we computed the relationship between aggressive driving behaviour and the total score of anger, the largest effect size was presented for studies conducted in the United States of America and North America. The same pattern of results appeared for the relationship between aggressive driving behaviour and driving anger. We could not identify studies for trait anger from all the regions. As for the analyses regarding the region of the studies, the largest effect size was presented for studies conducted in the United States of America.

To obtain more information about the effect of driving experience (in years and number of kilometres) and age, we conducted a meta-regression using the mean age of the sample, the mean number of kilometres per year, and the mean numbers of years since obtaining the diving licence as independent variables (see Table 6). We computed the analysis separately for trait and driving anger and we included in analysis only studies that reported these information. The results showed that there was a significant moderation of aggressive driving due to experience in kilometres driven ($\beta = -.001$, $p < .001$), and average age ($\beta = -.004$, $p < .001$). This indicated the tendency to obtain higher correlation values between driving anger and aggression in the studies in which the experience in kilometres driven was lower and the mean age was lower. For trait anger, we could analyse only age as a moderator, because the other studies that measured trait anger did not report information about driving experience. The results showed that age was not a significant predictor of effect size ($\beta = -.001$, $p = .844$).

6. Discussion

The aim of this meta-analytic review was to assess the relationship between two forms of anger (trait anger vs. driving anger) and aggressive driving. We assessed if this relationship varies systematically according to different aggressive driving dimensions and also if gender, age or region where studies were conducted, and driving experience moderate the relationship between anger and aggressive driving. Empirical studies from the past fifteen years were included in the analysis.

First, we hypothesised that there is a significant positive relationship between anger, both trait and driving anger, and aggressive driving. The results of the present meta-analysis for overall anger and aggressive driving variables indicated a moderate and positive association between anger and aggressive driving. The mean effect size reported in our study is highly comparable with that reported in the study of Nesbit et al. (2007). Therefore, our study confirmed that a high level of anger is moderately associated with a high level of aggressive driving.

The second hypothesis that the relationship between anger and aggressive driving systematically differs based on whether anger is a general trait or is specific to driving situations was also confirmed by our data. Specifically, contrary to our expectations, the relationship between trait anger and aggressive driving was stronger than the relationship between driving anger and aggressive driving. Since driving anger is a situation-specific form of trait anger (Deffenbacher et al., 1994),

Table 5

Summary of study-level anger type effect sizes for aggressive driving, separately for different regions.

Criterion	Any anger	Trait anger	Driving anger
<i>USA</i>			
<i>k</i>	85	21	64
<i>Z</i>	.44	.44	.43
95% CI	.43–.46	.41–.47	.41–.44
QW	484.59***	96.75***	326.37***
<i>North America</i>			
<i>k</i>	6	0	6
<i>Z</i>	.44		.44
95% CI	.36–.52		.36–.52
QW	7.13		7.13
<i>Central Europe</i>			
<i>k</i>	3	0	3
<i>Z</i>	.24		.24
95% CI	.19–.29		.19–.29
QW	1.56		1.56
<i>Eastern Europe</i>			
<i>k</i>	11	0	11
<i>Z</i>	.31		.31
95% CI	.28–.35		.28–.35
QW	15.68		15.68
<i>West Europe</i>			
<i>k</i>	24	3	21
<i>Z</i>	.36	.40	.36
95% CI	.34–.38	.31–.48	.34–.38
QW	139.67***	1.65	137.09***
<i>Asia</i>			
<i>k</i>	12	5	7
<i>Z</i>	.33	.44	.27
95% CI	.30–.36	.39–.48	.23–.30
QW	87.64***	32.88***	26.67***
<i>Australia</i>			
<i>k</i>	4	2	2
<i>Z (point estimate)</i>	.41	.41	.41
95% CI	.37–.45	.36–.46	.36–.46
QW	31.79***	6.78***	25.01***
QB	133.98***	141.784***	115.431***

Note. *k* – Number of included studies; *Z* – Fisher's *Z* effect size; QW – within heterogeneity coefficient; QB – between heterogeneity coefficient.***p* < .01.**p* < .05.*** *p* < .001.**Table 6**

Summary of the meta-regression for driving anger and trait anger

Criterion	Point estimate	Standard error	Z	QT
<i>Driving anger</i>				
DE years, <i>k</i> = 39	.002	.001	1.78	195.28***
DE km, <i>k</i> = 27	–.001	.000	–3.71***	92.04***
Age, <i>k</i> = 109	–.004	.0006	–6.9***	599.90***
<i>Trait anger</i>				
Age, <i>k</i> = 26	–.0012	<.001	–.19	111.47***

Note. *k* – Number of included measures of effect size; DEyears – driving experience in years.

DEkm – driving experience in number of kilometres.

*** *p* < .001.

it was expected that driving anger would be most strongly associated with aggressive driving. As well as in Nesbit et al. (2007) meta-analysis, our results did not bring support for this assumption. The analysis of previous results regarding the relationship between anger and aggressive behaviour can help us explain our findings. Specifically, individuals high on trait anger reported a higher frequency and intensity of anger on a daily basis and across different provocative contexts, including

traffic (Deffenbacher, 1992). Moreover, drivers who obtained higher scores in trait anger experienced more intense driving anger and this association leads further to aggressive behaviour (Deffenbacher, Lynch et al., 2003). These results may suggest that trait anger may be associated with aggressive behaviour directly or indirectly, through driving anger. Moreover, driving anger may be only a result of a high level of trait anger, which is not present in persons with a low level of trait anger. Therefore, our results may be explained by the fact that trait anger can exist without being associated with driving anger, while driving anger may be a result of trait anger. Based on these results, we can conclude that a combination of both driving and non-driving variables can influence the driving behaviour. Previous studies documented the interaction between driving and non-driving variables in determining the behaviour behind the wheel (Matthews, 2002). However, more studies are needed in order to better explain the interaction between anger and other personal non-driving variables in determining aggressive behaviour. Another explanation for these results could rely on the fact that the ways to measure driving anger are not efficient. Most of the studies used in our analysis employed DAS, which may need some updates since this scale was developed more than 20 years ago (1994). Moreover, the situations that evoke anger among drivers may not be similar across different cultures and numerous studies did not provide information on the validity (e.g. factorial structure) or the cultural adaptation of the scale. Finally, as other researchers suggest (e.g. Dahlen, Edwards, Tubré, Zyphur, & Warren, 2012), measures such as the *Driving Anger Scale* or the *Driving Anger Expression Inventory* have a high face validity that increases the susceptibility to response distortion and impression management. Moreover, the situation that needs to be evaluated in order to assess if they trigger anger may not be relevant for newer drivers.

Regarding the relationship between anger and different types of aggressive driving, the results showed that verbal aggression was the dimension of aggressive driving that had the strongest correlation with both types of anger. Moreover, the differences between different types of aggressive driving included in the analysis were significant. Verbal aggression is probably the most common and easiest way to express anger in traffic, compared to the other forms. Previous research has shown that swearwords, as a form of verbal aggression, have become rather popularised in certain contexts (Rassin & Muris, 2005). Future studies should assess if this is also true for traffic context. For a driver, it is more difficult and almost impossible in some situations to express anger by getting out of the car and picking a fight, for example, or through other forms of physical aggression (Deffenbacher et al., 2002). Moreover, some physical hostile gestures may require a high level of attention and the use of hands that may be more difficult in some demanding situations in the case of driving. From this point of view, verbal aggression is a more accessible and less resource consuming form to express anger. The third form of expressing anger analysed in this study, through the use of vehicle, may involve more negative consequences for a driver, like the risk for being caught by the police, of receiving a fine or even of being involved in an accident. For these reasons, a driver may inhibit more frequently the tendency to express anger in this manner (e.g., drive a little faster, cut in front of the other drivers). Moreover, although all forms of aggressive behaviours involve a cathartic function, it is possible that verbal aggression is preferred in order to express negative emotion, because it is easier to express. One study found that the least important reason for swearing was shocking others, while the strongest reason was to express negative emotions (Rassin & Muris, 2005). Swearing is a component part of many items that form the verbally aggressive dimensions of DAX, the most used scale for measuring aggressive behaviour in traffic. Finally, it is possible that other variables, such as risk perception, may mediate the relationship between anger and its expression on the road and they should be measured in future studies. In future studies, it would be interesting to assess the mechanisms that explain the relationship between anger and different forms of aggressive driving behaviour, since the direct relationship is well-documented and our results provide empirical support for the fact that anger is associated with aggressive driving.

Further, we hypothesised that the relationship between specific anger type and aggressive driving vary depending on gender, region, age, and driving experience. Concerning gender, the results showed that the overall correlation for trait anger was similar for both males and females. Regarding driving anger, the relationship was stronger for females than for males. Given the fact that women have a higher tendency to express their anger using verbal aggression (Dahlen & Ragan, 2004) and considering our results that showed that the relationship between anger and aggressive driving is stronger for the verbal dimension, it is reasonable to assume that the stronger association between anger and aggressive driving appears in the female sample. Concerning region, the results showed that the strongest relationship between anger and aggressive driving was for participants from the United States of America, whereas the weakest relationship appeared for participants from Central Europe.

In our study, it is possible for the participants' age to explain these relationships. We computed the mean age of the participants for each region, and the results showed that, with just one exception, the stronger the relationship between anger and aggressive driving, the lower the mean age. Specifically, for the USA the mean age is 20.81, while for Central Europe it is 33.06. Previous studies showed that the relationship between anger and aggressive driving was stronger for young people (Haje & Symbaluk, 2014; Sullman et al., 2013), therefore age may be a confounding variable for the region. Future studies should consider these differences identified in our study, in order to clarify if cultural issues may account for them. However, the only region that does not respect this pattern of results (i.e. the stronger the relationship between anger and aggressive driving is, the lower the mean is) is Australia. For Australia, we obtained a high correlation between anger and aggressive driving, although the mean age is the highest. Some cultural differences can also account for these results. Previous studies showed that in Australia swearing, even in front of parents, is not considered rude for a child (White, 2002), while in western societies, the children are punished for swearing at or in front of others (Jay & Janschewitz, 2006). Differences concerning the culture and the context where a person is born and live may account for the displaying of different behaviours at an older age. However, there is a scarcity of cross-cultural research examining the cultural differences that may account for the rela-

tionship between anger and aggressive driving behaviour. Therefore, our explanations are speculative and further studies are needed in order to provide an insight into the interplay between anger and cultural dimensions in causing aggressive behaviour in traffic.

Finally, our results showed higher correlation values between both trait and driving anger and aggressive driving in studies in which the mean age was lower and experience in kilometres driven was lower. Therefore, we can conclude that the most vulnerable group is represented by younger people. This result is supported by many studies which have concentrated their attention on young and novice drivers. Currently, it is very clear that all over the world inexperienced drivers represent a big problem when it comes to the number of tickets, accidents, and aggressive responses when confronted with experiencing anger (Sullman et al., 2007). Therefore, younger drivers should be the target group for intervention programs designed to reduce aggressive behaviour on the road.

Several scientific and practical implications of our results could be identified. The present study highlights the fact that trait anger and driving anger are different when it comes to aggressive behaviour. Moreover, the relationship between anger and aggressive behaviour depends on the type of aggression and on some demographic variables, like gender. These results should be taken into account when designing future studies, in order to better understand the relationship between anger and aggressive behaviour. Moreover, other variables should be included in order to discover the particular situations when this relationship occurs. The interaction between anger and personality variables should be of particular interest, giving the fact that human behaviour is often a result of the interaction between emotions and personality or between traits and situational characteristics (King & Endler, 1990). Therefore, despite demographic variables, other factors should be studied in relation to anger and aggressive driving. In addition, the variables that can mediate the direct relation between anger and aggressive driving, like thoughtful processing while driving or the level of arousal, should also be considered.

Because the effects of aggressive driving are prevalent in our society, the identification of factors associated with this phenomenon is very important because these factors could be used in the development of treatment programs for the reduction of anger and, consequently, aggressive driving. Furthermore, the results showed that the distinction between anger types is useful for aggressive behaviour and should be examined in future studies. Therefore, one should consider the different forms of anger, particularly trait anger, and the different types of aggression, particularly verbal aggression, for a better understanding of these relationships. The fact that the relationship between anger and aggressive driving is moderated by several variables, like age, region, and experience, can help other researchers or specialists to develop better prevention and intervention programs focused on the age (particularly for younger drivers) and the experience of the drivers, in order to reduce aggressive behaviours on the roads or to help the drivers cope with their anger (trait or driving anger). A study by the National Highway Traffic Safety Administration (National Highway Traffic Safety Administration, 1999) underlined the idea that aggressive drivers are more aware and interested in the public safety campaigns than non-aggressive drivers. Also, as Cialdini (1993) stated, the safety campaigns which targeted specific populations were more successful in changing attitudes and behaviours. Given the fact that aggressive driving is known to be a robust predictor of traffic accidents (e.g. Sullman, 2015) and having in view the present results concerning the relationship between anger and aggressive driving, an efficient way to improve safety is through the provision of relevant training on how to control anger and consequently aggressive driving. For example, not only the rules of the road should be included in driver education programs, but also coping strategies to handle the situations that trigger anger in traffic.

Finally, although our results do not represent an evidence for the fact that DAS is not a valid tool, we suggest that future studies should test the content validity and the factorial structure of the scale, in order to assess whether the initial items can still account for different types of anger provoking situations. Language and cultural differences should be fully considered when developing a questionnaire (International Test Commission (ITC), 2010). For example, the DAX has been translated into several languages and for several cultures (Esiyok, Yasak, & Korkusuz, 2007; Ge, Qu, Zhang, Zhao, & Zhang, 2015; Herrero-Fernández, 2011; Sullman et al., 2013; Sârbescu, 2012; Villieux & Delhomme, 2010), but the factors in each version differ. More studies exploring the cultural adaptation of DAS are needed.

This meta-analysis is not without limitation. Firstly, we must admit the fact that the magnitude of correlations may be influenced by different factors, like subject selection or the characteristics of the distribution (Carroll, 1961). Secondly, the majority of the studies included in this meta-analysis used self-reporting measures of driving anger, leading us to believe that it is not clear if these measurements reflect the probability of experiencing anger or if they underline the true meaning of the construct investigated. Although self-report measures are useful in driving research, they are sensitive to biases, like social desirability. If the participants are informed about the topic of the study (anger and aggressive driving behaviours), they may try to hide their real driving behaviours in order to provide socially desirable responses. Cultural differences in terms of norms and social pressure may also be responsible for the results. For example, in Asian culture, expression of extreme emotion in the forms of aggressive behaviours is disapproved, because extreme emotions are considered pathogenic (Chen et al., 2005; Maxwell et al., 2009). It is possible that the relationship between anger and aggressive driving is stronger than our study revealed, but to not be accurately measured through self-reports because social disapproval of anger may exert a strong influence on the honesty of the responses or on the attempts to manage anger (Maxwell et al., 2009). However, in most of the studies, the participants were assured about anonymity and confidentiality of their responses, which should decrease or eliminate impression management. Moreover, some previous studies showed that social desirability has little influence on self-reported aberrant or risky driving behaviours (Lajunen & Summala, 2003; Sullman & Taylor, 2010). Therefore, despite this limitation, we can assume that our result offers a reliable picture about the nature of the relationship between anger and aggressive driving, based on previous studies in this field, over the last years.

The third limitation refers to the low number of unpublished studies, dissertations and PhD thesis that we had accessed, in order to include in the meta-analysis. If the most common reason for not publishing a study is the fact that it reveals non-significant results (Dickersin, Min, & Meinert, 1992), then it is clear that not including these studies in a meta-analysis will bias this result so that relationships will appear stronger than they actually are (Berman & Parker, 2002). We tried to avoid this limitation, by contacting researchers through email, in order to gain access to additional unpublished studies. We received a few unpublished studies at that time, but until we finished our work, those studies were published. However, publication bias was assessed in our study, using Orwin's FSN procedure (Orwin, 1983), and the results showed that the risk of unpublished studies to influence the current results is minimum.

Fourth, not including the adaptive form of aggressive driving in our study represents another limitation. It would be interesting to look at the relationships trait anger and trait driving anger have with more positive forms of response to anger, but in this study we focused only on the other dimensions of aggressive driving. Our first aim was to update a previous meta-analysis (Nesbit et al., 2007), and we focused only on the relationship between anger and dysfunctional forms of expressing anger in traffic situations. Fifth, we should also mention that even if DAS is the most widely used measure for trait driving anger, it has different versions and the factor structure across different studies is not always consistent. Therefore, this measurement variability may explain the variability of the relationship between anger and aggressive driving. Finally, although we did not consider it a limitation of our study, for a clear and more complete understanding of the relationship between anger and aggressive driving, future studies should also consider the state of anger as a variable. It received limited research focus in previous studies regarding the relationship between anger and aggressive driving behaviour.

Despite the limitations mentioned above, our study has provided new information regarding the factors which may contribute to the development and maintenance of anger and aggressive behaviour on the road. To sum up, this meta-analytic study has managed to show that the relationship between anger and aggressive driving varies depending on the type of anger (trait or driving) and on the type of aggressive driving behaviour (verbally, physically, using the vehicle to express anger). The results also highlighted the factors that moderate the relationship between anger and aggressive driving, like age, gender and region. By knowing and understanding the factors which influence these two variables, professionals can help drivers to cope with them in order to reduce the number of accidents and victims of aggressive driving.

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