

# A quantitative review of the relationship between anger and aggressive driving

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## Abstract

The aim of this paper was to evaluate the relationship between anger and aggressive driving. It was hypothesized that: 1) there is a significant positive relationship between anger and aggressive driving; 2) this relationship systematically differs based on whether anger is trait-based, state/mood-based, or situation-specific; 3) this relationship also varies depending on the mode of measurement; and 4) the relationship between specific anger type and aggressive driving is heterogeneous. The three types of anger are described within the context of state-trait theory and a quantitative analysis was conducted using meta-analytic techniques. Results indicate that anger is generally associated with aggressive driving; however, subtypes of anger do not differentially predict negative driving outcomes. Findings are discussed from theoretical and psychometric perspectives.

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*Keywords:* Driving anger; Aggressive driving; State-trait anger theory

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## 1. Introduction

Driving anger is one type of anger that represents a significant and dangerous phenomenon that commonly occurs in our society. As opposed to other manifestations of anger, expression of driving anger (i.e., aggressive driving or “road rage” behavior) seems to be a frequent and more socially acceptable outlet of expressing negative emotion. According to a report from the [American Automobile Association Foundation for Traffic Safety \(1997\)](#), 218 deaths occurred due to disputes between drivers between 1990 and 1996. In a survey conducted on UK motorists, nearly 90% reported that they had been victims of what they perceived to be road rage. In addition, approximately 60% stated that they themselves had experienced anger while driving over the past year ([Joint, 1996](#)). Interestingly, drivers who identify themselves as having problems with anger drive the same amount (both distance and time) as low anger drivers. However, studies show that they are 2.5–3.0 times more likely to become angry while driving, 3.5–4.0 times more likely to be physically and/or verbally aggressive, and 1.5–2.0 times more likely to engage in risky behavior behind the wheel ([Deffenbacher, Deffenbacher, Lynch, & Richards, 2003](#); [Deffenbacher, Filetti, Richards, Lynch, & Oetting, 2003](#); [Deffenbacher, Huff, Lynch, Oetting, & Salvatore, 2000](#); [Deffenbacher, Lynch, Filetti, Dahlen, & Oetting, 2003](#)).

In their meta-analytic review of treatments for specific anger problems, [Del Vecchio and O’Leary \(2004\)](#) reported large effect sizes for cognitive, cognitive–behavioral, and relaxation therapies for driving anger problems. Although this is a hopeful indicator of treatment success, the overall effect size for each treatment modality was calculated on a very few number of studies. [Del Vecchio and O’Leary \(2004\)](#) specifically indicate the need for more research in this area to corroborate these findings. Due to the frequency of this phenomenon and its serious consequences, it is important to understand more clearly the nature, origins, and consequences of driving anger in order to advance treatment in this area.

Based on definitions provided by state-trait anger theory ([Spielberger, 1988](#)), and the extension of this theory to situation-specific driving anger ([Deffenbacher, Oetting, & Lynch, 1994](#)), it was expected that different types of anger would have varying relationships with aggressive driving outcomes. Given the disparate properties of the examined studies, the number of questionnaires utilized to measure each anger type, and the number of correlations averaged within each study, it was hypothesized that the magnitude of the individual anger–driver aggression correlation estimates would be significantly heterogeneous for the overall sample of studies. Finally, it was expected that the anger–aggression relationship would vary across different modes of measurement. This review will first delineate key variables and their place within the theoretical model of state-trait anger theory.

### 1.1. Aggressive driving and driving anger

Over the past 10 years, there has been a surge of research on the experience and expression of anger and aggression while driving. Nevertheless, researchers have not always been consistent in the terms they use to define these constructs. Sometimes driving anger and aggressive driving have been used interchangeably in the literature. At other times, researchers have distinguished between these two terms and used them as though they represented different

constructs. One of the major challenges of this research review was to distinguish clearly between these terms using previous research and proposed theoretical models.

For purposes of this review, aggressive driving was defined as a behavioral construct that includes behaviors such as tailgating, running a red light, cutting another driver off, etc. [Stradling and Parker \(1997\)](#) discussed different types of problematic driving behavior (lapses, errors, and violations), but found that driving violations are most closely linked to aggressive driving. Multiple studies have also demonstrated that violations are most closely associated with motor vehicle accidents (MVAs; see [Lajunen, Parker, & Stradling, 1998](#), for a review.)

Driving anger, as opposed to aggressive driving, was initially defined as a situation-specific emotional construct comprised of anger-related feelings and thoughts that occur while driving. [Deffenbacher et al. \(1994\)](#) first defined the concept of driving anger as the propensity to become angry behind the wheel. The Driving Anger Scale (DAS; [Deffenbacher et al., 1994](#)), developed as a measure of driving anger, has been found to be related to the frequency and intensity of angry thoughts and feelings as well as aggressive driving, traffic violations, close calls, and minor motor vehicle accidents ([Deffenbacher, Huff, Lynch, Oetting, & Salvatore, 2000](#); [Lajunen & Parker, 2001](#); [Lajunen et al., 1998](#); [Underwood, Chapman, Wright, & Crundall, 1999](#)).

Driving anger has been measured in a variety of ways and a number of driving anger questionnaires exist, such as the DAS, the Driving Behavior Inventory (DBI; [Glendon et al., 1993](#)), the Driving Vengeance Questionnaire (DVQ; [Wiesenthal, Hennessy, & Gibson, 2000](#)), and the Dula Dangerous Driving Index ([Dula & Ballard, 2003](#)). All of these measures tap into negative affect and aggressive driving behavior. Problematically, each of these scales measure the emotional experience of anger in a somewhat different way and most “driving anger” scales include items related to aggressive driving or risky behavior to varying degrees. Thus, these measures tend to be heterogeneous. For example, the DAS asks individuals to simply rate their emotional intensity (i.e., anger) for each item, which is comprised of different potentially anger-provoking driving situations ([Deffenbacher et al., 1994](#)). In contrast, the Dula Dangerous Driving Index ([Dula & Ballard, 2003](#)) is a composite measure of negative emotions and frequency of aggressive car-related actions and aggressive personal acts while driving. Moreover, both driving anger and global aggressive driving measures are able to predict specific aggressive driving outcomes ([Deffenbacher, Lynch, Deffenbacher, & Oetting, 2001](#)). Thus, the relationship between driving anger and aggressive driving outcomes can become blurred. In this paper, one set of analyses was conducted to assess the relationship between anger and aggressive driving (i.e., violations), while a second set of analyses was conducted to evaluate the overall correlation between anger, aggressive driving, and MVAs.

To understand the construct of driving anger more clearly, we must first examine its initial definition and application to state-trait personality theory.

## *1.2. State-trait anger theory*

Many researchers have hypothesized that individual differences in the tendency to become angry while driving can account for aggressive driving (e.g., [Arnett, Offer, & Fine, 1997](#); [Deffenbacher et al., 1994](#)). They suggest that state-trait personality theory can account for these differences, in that trait-level emotion (i.e., anger) can predict increased state emotional arousal and behavior.

First defined by [Cattell and Scheier \(1961\)](#), state-trait theory posits that emotional experience can be experienced in one of two ways: individuals are likely to experience an emotion either as a transient mood state (labeled ‘state’) or as a more chronic, stable personality dimension (a ‘trait’). Although this theory was developed to explain anxiety, this model of emotional experience has been frequently applied to conceptualize anger ([Spielberger, 1988](#); [Spielberger, Jacobs, Russell, & Crane, 1983](#); [Spielberger, Krasner, & Solomon, 1988](#); [Spielberger, Reheiser, & Sydeman, 1995](#)).

### *1.2.1. State anger*

One predictor of aggressive behaviors may be an individual’s mood or state. Although state anger is a more transient phenomenon, some researchers have posited that environmental triggers and mood state can be the strongest predictors of aggressive driving. Thus, [James and Nahl \(1998\)](#) suggest that road rage is a direct consequence of frustration on the roadways. Others point to environmental conditions, such as driver anonymity, driving congestion, and level of impedance as all being symptomatic of driver aggression ([Ellison-Potter, Govern, Petri, & Figler, 1995](#); [Novaco, Kliever, & Broquet, 1991](#); [Novaco, Stokols, Campbell, & Stokols, 1979](#); [Novaco, Stokols, & Milanese, 1990](#)). For example, a classic study done by [Doob and Gross \(1968\)](#) demonstrated that horn-honking behavior increased as drivers became more irritated due to immediate provocations in their surroundings. Further, [Arnett et al. \(1997\)](#) hypothesized

that various state factors, including situational characteristics and mood, would be predictive of aggressive driving. They found that participants drove faster when in an angry mood (as evidenced by a driving log); in fact, anger was the only mood state that predicted reckless driving. It is clear that an individual's anger state could prove to be an important predictor of angry behaviors while driving.

### 1.2.2. *Trait anger*

Trait anger is currently thought to be a multidimensional construct, made up of physiological, cognitive, behavioral, and emotional expression (Eckhardt & Deffenbacher, 1995; Eckhardt, Norlander, & Deffenbacher, 2004; Edmondson & Conger, 1996). Spielberger (1988) defined trait anger as a global or chronic tendency of experiencing anger (i.e., an anger “disposition”). Therefore, individuals high in trait anger are expected to interpret a wide variety of situations as being anger provoking, and to react to situations with an elevated level of anger (Spielberger, 1988). A related construct is that of hostility, also thought to be multidimensional in nature and composed of negative cognitions and emotions (Eckhardt et al., 2004).<sup>1</sup> It is possible that measures of hostility (e.g., the Buss–Durkee Hostility Scale; developed by Buss & Durkee, 1957) and trait anger (e.g., Trait Anger Scale, developed by Spielberger, 1988) may be better predictors of aggressive driving than measures of transient, or state, anger.

### 1.2.3. *Driving anger within state-trait theory*

Although research has shown that both emotional and personality factors influence driving behavior, Deffenbacher et al. (1994) suggested that driving anger is a situation-specific form of anger. Published driving anger research has supported the notion that driving anger, as defined by Deffenbacher et al. (1994), often follows a similar pattern to that of general trait anger. Individuals high in driving anger are likely to experience anger more frequently and intensely in situations where they are driving more than those low in driving anger. These individuals are more likely to become angry in driving-specific situations, compared to other anger-provoking situations. They are also more likely to engage in aggressive driving behavior, resulting in more traffic violations and automobile accidents, compared to low anger drivers (Deffenbacher et al., 2000; Deffenbacher, Lynch, Oetting, & Yingling, 2001).

Although driving anger appears to share some characteristics with trait anger, research has repeatedly shown only moderate correlations ( $.27 < r < .33$ ) between trait anger (as measured by the TAS) and measures of driving anger (Deffenbacher et al., 2000). Moreover, Deffenbacher, Lynch, Oetting et al. (2001) demonstrated a significant relationship between state anger (as evidenced by situational provocation measures) and the DAS ( $.35 < r < .50$ ). Because the relationship between driving anger and either trait anger or state anger range from low to moderate at best, this suggests that the DAS may measure a construct unique from that measured by trait or state measures. While all three types of anger are significantly related to aggressive driving behavior, it is not yet known if one type is more highly correlated than the others.

## 1.3. *Purpose/hypotheses*

The purpose of this review was to investigate the relationship between overall anger and aggressive driving (Hypothesis 1). It was assumed that anger would be positively related to aggressive driving, regardless of the type of anger being measured. However, the above conceptual discussion suggests that the type of anger measured may influence the anger–aggression association while driving. It was therefore hypothesized that the relationship between anger and aggressive driving would be moderated by anger type (i.e., trait anger, state anger or driving anger; Hypothesis 2). It was expected that driving anger would be the most strongly associated with aggressive driving, as compared to other types of anger. Further, it was hypothesized that the method of outcome assessment (e.g., self-report rating, driving simulator as measures of aggressive driving) would moderate the relationship between anger and aggressive driving (Hypothesis 3). Finally, it was hypothesized that individual correlation estimates would be heterogeneous both within and across studies, due to

<sup>1</sup> Hostility, as initially defined by Buss (1961), was believed to be a predominantly cognitive construct; historically, researchers have considered hostility and anger to be distinct concepts (Miller, Jenkins, Kaplan, & Salonen, 1995). However, Eckhardt et al. (2004) point out that there is little empirical evidence that the two constructs are truly distinct from one another. According to their review, both hostility and anger share the characteristic of being multifaceted in nature; in particular, both anger and hostility are thought to comprise negative cognitions and emotions toward a given target (Eckhardt et al., 2004). Further, both trait anger and hostility have been shown to influence mood level, sensitivity to stimuli, arousal level, and cognitive appraisal of events (Matthews, Dorn, & Glendon, 1991). Thus for the purposes of this review, the current study will code both hostility and anger questionnaires as “trait” measures of anger.

disparities in construct definitions (Hypothesis 4). Each of these four hypotheses was evaluated separately for aggressive driving and MVAs. Quantitative evidence for these hypotheses is examined using meta-analytic techniques.

## 2. Methods

### 2.1. Study sample

Literature was collected using various recommended search strategies, including a computerized bibliographic database search, the ancestry approach, and a hand search of important journals (Johnson & Eagly, 2000). A preliminary computerized search was conducted using PsycINFO. Searches were performed using the following keywords and Boolean connectors: “driving anger,” “road rage,” “driving” and “anger,” and “aggressive driving.” Searches were limited to English language articles and chapters using human participants and published since 1989. Reference pages of articles obtained from these searches (both relevant, eligible articles, and review articles) were further examined for relevance. In addition, a hand search of the table of contents of key journals from 1989 to the present was conducted. Each abstract and article was then examined and kept or eliminated based on the inclusion criteria and the nature of this paper. One hundred forty-nine articles were generated from these initial searches.

Criteria for including studies in this sample were that: a) the study was published in 1989 or later (within the past fifteen years); b) the study must have been conducted using an adequate sample (findings published based on case examples were excluded from this review); c) the study was published by a peer-reviewed journal or book<sup>2</sup>; d) the study contained a unique sample(s) (this was to ensure that samples were independent from one another); e) the study reported the association between the two variables of interest<sup>3</sup>; and f) the eligible study involved the measurement of anger and some measure of aggressive driving<sup>4</sup>. An anger measurement included any of the three forms of anger discussed in detail below (trait-based, situation-specific, or state-based). Measures of other emotional states while driving (such as driving anxiety) were not included in statistical analyses. Thirty-five studies were eliminated due to the lack of measurement of anger. However, measures of broadly defined emotional states (such as “driver stress” or “Type A Behavior”) that included a valid subscale measuring anger were included. In these cases, the relationship between aggressive driving behavior and the pertinent subscale was reported, and the questionnaire from which it was taken was recorded.<sup>5</sup>

Due to some confusion in the literature surrounding the measurement of “aggressive driving,” this variable was composed of either a global measure or a specific driving outcome. A measure of global aggressive driving included any questionnaire that measured a composite of aggressive driving behavior. In contrast, a specific driving outcome measure was a specific behavioral measure (aggressive car-related action and/or aggressive personal act). These outcome measures for aggressive driving included traffic violations (which comprised traffic citations, risky driving, driving while under the influence of alcohol or other substances, loss of concentration, and speeding); motor vehicle accidents (which included minor and major MVAs, as well as close calls and loss of control); and driver aggression (which included both physical and verbal aggressive acts conducted by the driver).

All anger observations and much of the aggressive driving observations included in this review were collected via self-report questionnaires. Campbell and Fiske (1959) suggested that people should be cautious of a method-halo effect, which can inflate the correlation among traits when they are measured by the same method. It is likely that the key variables included in this study share a great deal of method variance, which can mask the actual shared construct variance. Because of this issue, the method by which aggressive driving was measured (i.e., interview, public record, self-report questionnaire, driving simulator) was coded and later analyzed as a possible covariate.

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<sup>2</sup> Although there is potential for an upward bias due to including only published studies (as published studies generally have larger study effects and imply statistical significance), they tend to represent high quality research. Moreover, Kurtzweil, Scogin, and Rosen (1996) found unpublished studies on self-help programs to test the fail-safe *N*. Their findings suggest the number of null findings in unpublished reports does not significantly impact the effect size calculated by a meta-analysis (Kurtzweil et al., 1996). Because the articles were generated from a computer database of published journal articles, no articles were eliminated from the original set based on this criterion.

<sup>3</sup> This particular review did not examine group differences (high versus low anger) on aggressive driving; rather, the question of interest was to what degree each level of anger is associated with aggressive driving. Therefore, samples pre-selected on anger scores were not included in the analyses.

<sup>4</sup> Studies that included a measure of global driving and *no* measure of anger were allowed to be included in the MVA analyses.

<sup>5</sup> Hypothesis 4 was assessed to evaluate variability within each type of anger, in order to ensure homogeneity within anger constructs.

Table 1  
Summary of studies included in the meta-analysis

Author	Subjects <sup>a</sup>	Anger measures	Driving outcome measures <sup>b</sup>	Accident measures <sup>b</sup>	Included correlations
Blanchard Barton, and Malta (2000)	176 community drivers (US)	Larson's Driver Stress Profile (ST)		Number of accidents	.20
Blockey and Hartley (1995)	135 college students and community drivers (AUS)	Larson's Driver Stress Profile	Number of traffic citations		-.01
Deffenbacher, Lynch, Deffenbacher et al. (2001)	272 college students (US)	Trait Anger Scale (T)	Driving Anger Expression Inventory — 3 subscales	Number of accidents	.00, .00, .00
		Mood rating (S)	Driving Anger Expression Inventory — 3 subscales		.31, .40, .42
		Driving Anger Scale (ST)	Driving Anger Expression Inventory — 3 subscales		6 <i>r</i> s (.14 to .41)
			Driving Anger Expression Inventory — 3 subscales	Various accident outcomes	.29, .33, .34
Deffenbacher, Lynch, Oetting, and Swaim (2002)	290 college students (US)	Trait Anger Scale	Driving Anger Expression Inventory — 3 subscales		9 <i>r</i> s (-.07 to .15)
		Trait Anger Scale	Driver aggression		-.21, .36, .39
		Trait Anger Scale	Risky behavior	Various accident outcomes	.19, .22
		Trait Anger Scale			4 <i>r</i> s (.04 to .15)
		Mood rating	Driving Anger Expression Inventory — 3 subscales	Various accident outcomes	4 <i>r</i> s (-.12 to .03)
		Driving Anger Scale	Driving Anger Expression Inventory — 3 subscales		9 <i>r</i> s (.13 to .39)
		Driving Anger Scale	Driver aggression		.25, .41, .49
		Driving Anger Scale	Risky behavior		.32, .36
		Driving Anger Scale		Various accident outcomes	4 <i>r</i> s (.01 to .23)
		Driving Anger Scale	Driving Anger Expression Inventory — 3 subscales	Various accident outcomes	4 <i>r</i> s (-.13 to .04)
Deffenbacher, Lynch, Oetting et al. (2001)	274 college students (US)	Driving Anger Scale	Aggressive behavior	Various accident outcomes	12 <i>r</i> s (-.11 to .12)
		Driving Anger Scale	Risky behavior		.12, .28, .36
		Driving Anger Scale	Loss of concentration		.35
		Driving Anger Scale	Moving violations		.26
		Driving Anger Scale		Various accident outcomes	.11
					6 <i>r</i> s (-.03 to .16)
	179 college students (US)	Anger intensity (S)	Aggressive behavior		.62
		Anger intensity	Risky behavior		.33
		Driving Anger Scale	Aggressive behavior		.28
		Driving Anger Scale	Risky behavior		.23
Deffenbacher, Petrilli, Lynch, Oetting, and Swaim (2003)	272 college students (US)	Hostile Automatic Thoughts Questionnaire — 3 subscales (T)	Driving Anger Expression Inventory — 3 subscales		9 <i>r</i> s (.21 to .59)
		Hostile Automatic Thoughts	Driver aggression		.35, .48, .48

(continued on next page)

Table 1 (continued)

Author	Subjects <sup>a</sup>	Anger measures	Driving outcome measures <sup>b</sup>	Accident measures <sup>b</sup>	Included correlations
Deffenbacher et al. (2004)	218 male college students (US)	Questionnaire — 3 subscales			
		Hostile Automatic Thoughts	Risky behavior		.22, .25, .28
		Questionnaire — 3 subscales			
		Driving Angry Thoughts	Driving Anger Expression		12 <i>r</i> s (.18 to .80)
		Questionnaire — 4 subscales (ST)	Inventory — 3 subscales		
		Driving Angry Thoughts	Driver aggression		4 <i>r</i> s (.23– .63)
		Questionnaire — 4 subscales			
		Driving Angry Thoughts	Risky behavior		12 <i>r</i> s (–.01 to .36)
		Questionnaire — 4 subscales			
		Driving Angry Thoughts		Various accident	16 <i>r</i> s (–.07 to .12)
		Questionnaire — 4 subscales		outcomes	
		Trait Anger Scale	Driving Anger Expression		.50, .56, .64
	218 female college students (US)	Trait Anger Scale	Inventory — 3 subscales		
		Trait Anger Scale	Driver aggression		.61
		Trait Anger Scale	Risky behavior		.46
		Trait Anger Scale	Loss of concentration		.15
		Trait Anger Scale	Moving violations		.03
		Trait Anger Scale		Various accident	4 <i>r</i> s (.11 to .19)
				outcomes	
		Driving Anger Scale	Driving Anger Expression		.40, .47, .49
			Inventory — 3 subscales		
		Driving Anger Scale	Driver aggression		.45
		Driving Anger Scale	Risky behavior		.34
		Driving Anger Scale	Loss of concentration		.16
Driving Anger Scale	Moving violations		.09		
Driving Anger Scale		Various accident	4 <i>r</i> s (.08 to .24)		
		outcomes			
Driving Angry Thoughts	Driving Anger Expression		12 <i>r</i> s (.30 to .81)		
Questionnaire — 4 subscales	Inventory — 3 subscales				
Driving Angry Thoughts	Driver aggression		4 <i>r</i> s (.23 to .64)		
Questionnaire — 4 subscales					
Driving Angry Thoughts	Risky behavior		4 <i>r</i> s (.05 to .53)		
Questionnaire — 4 subscales					
Driving Angry Thoughts	Loss of concentration		4 <i>r</i> s (.12 to .21)		
Questionnaire — 4 subscales					
Driving Angry Thoughts	Moving violations		4 <i>r</i> s (–.10 to .02)		
Questionnaire — 4 subscales					
Driving Angry Thoughts		Various accident	16 <i>r</i> s (–.04 to .20)		
Questionnaire — 4 subscales		outcomes			
		Various accident	12 <i>r</i> s (.02 to .23)		
		outcomes			
	Trait Anger Scale	Driving Anger Expression		.49, .53, .57	
		Inventory — 3 subscales			
		Driving Anger Expression			
		Inventory — 3 subscales			

Deffenbacher et al. (2004)	218 female college students (US)	Trait Anger Scale	Driver aggression	.31	
		Trait Anger Scale	Risky behavior	.42	
		Trait Anger Scale	Loss of concentration	.15	
		Trait Anger Scale	Moving violations	.15	
		Trait Anger Scale	Various accident outcomes	4 rs (.08 to .23)	
		Driving Anger Scale	Driving Anger Expression Inventory — 3 subscales	.30, .35, .37	
		Driving Anger Scale	Driver aggression	.36	
		Driving Anger Scale	Risky behavior	.35	
		Driving Anger Scale	Loss of concentration	.18	
		Driving Anger Scale	Moving violations	.09	
		Driving Anger Scale	Various accident outcomes	4 rs (.01 to .18)	
		Driving Angry Thoughts Questionnaire — 4 subscales	Driving Anger Expression Inventory — 3 subscales	12 rs (.28 to .80)	
		Driving Angry Thoughts Questionnaire — 4 subscales	Driver aggression	4 rs (.36 to .63)	
		Driving Angry Thoughts Questionnaire — 4 subscales	Risky behavior	4 rs (.21 to .42)	
		Driving Angry Thoughts Questionnaire — 4 subscales	Loss of concentration	4 rs (.10 to .26)	
Driving Angry Thoughts Questionnaire — 4 subscales	Moving violations	4 rs (.04 to .12)			
Driving Angry Thoughts Questionnaire — 4 subscales	Various accident outcomes	16 rs (−.06 to .22)			
DePasquale, Geller, Clarke, and Littleton (2001)	96 college students (US)	Driving Anger Scale	Driving Anger Expression Inventory — 3 subscales	Various accident outcomes	12 rs (−.02 to .21)
		Buss–Durkee Hostility Scale (T)	Propensity for Angry Driving Scale	.40	
		Driving Behaviour Inventory (ST)	Propensity for Angry Driving Scale	.40	
Dorn and Matthews (1995)	166 community drivers (UK)	Interpersonal Behavior Survey — 6 subscales (T)	Risky behavior	6 rs (−.13 to .23)	
		Interpersonal Behavior Survey — 6 subscales	Dula Dangerous Driving Inventory	6 rs (−.40 to .44)	
Dula and Ballard (2003)	119 college students (US)	Trait Anger Scale	Propensity for Angry Driving Scale	6 rs (−.26 to .41)	
		Trait Anger Scale	Dula Dangerous Driving Inventory	.53	
		Trait Anger Scale	Propensity for Angry Driving Scale	.39	
Furnham and Saipe (1993)	73 college students and community drivers (UK)	Interpersonal Behavior Survey — 6 subscales	Dula Danger Driving Inventory	Various accident outcomes	−.29, .24
		Driving Behaviour Questionnaire	Driving Behaviour Questionnaire	Accident involvement	6 rs (−.13 to .06)
Hennessy and Wiesenthal (2001)	192 college students and community drivers (CAN)	Driving Behaviour Inventory	Self-reported driver violence and aggression	.27, .57	
		Cook–Medley Hostility Scale (T)	Aggressive Driving Behavior Scale	.36	
Houston, Harris, and Norman (2003)	200 college students (US)	Driving Behaviour Inventory	Aggressive Driving Behavior Scale	.54	
		Inventory—Driver Aggression Scale			

(continued on next page)



Table 1 (continued)

Author	Subjects <sup>a</sup>	Anger measures	Driving outcome measures <sup>b</sup>	Accident measures <sup>b</sup>	Included correlations
Jonah (1990)	9943 community drivers <sup>c</sup> (CAN)		Driver aggression	Accident involvement	.15
Knee, Neighbors, and Vietor (2001)	109 college students (US)	Driving Anger Scale	Measure of Aggressive Driving		.35
		Driving Anger Scale	Number of tickets		.07
Lajunen et al. (1998)	270 community drivers (UK)	Driving Anger Scale — 3 subscales	Measure of Aggressive Driving	Number of accidents	.09
			Aggressive violations	Number of accidents	.29
Matthews et al. (1997)	583 college students and community drivers (UK)	Driver Stress Inventory — 3 subscales (ST)	Traffic violations		-.1, .49, .61
		Driver Stress Inventory — 3 subscales	Speed		-.26, .38, .62
	219 college students (US)	Driver Stress Inventory — 3 subscales	Major and minor driving errors		6 <i>r</i> s (.02 to .28)
		Driver Stress Inventory — 3 subscales	Traffic violations		.24, .54, .59
Matthews, Dorn, Hoyes, Davies, Glendon and Taylor (1998)	298 community drivers (UK)	Driver Stress Inventory — 3 subscales	Speed		-.21, .48, .52
		Driver Stress Inventory — 3 subscales	Major and minor driving errors		6 <i>r</i> s (.00 to .32)
Neighbors, Vietor, and Knee (2002)	111 college students (US)	Driving Behaviour Inventory — 3 subscales	Various driving outcomes		14 <i>r</i> s (-.32 to .54)
Norris et al. (2000)	640 community drivers <sup>c</sup> (US)	Brief Symptom Inventory—Hostility subscale (T)	Driver aggression	History of accidents	.12
Schreer (2002)	91 college students (US)	Driving Anger Scale	Aggressive driving measure		.31
		Vengeful feelings (ST)	Aggressive driving measure		.56
Underwood, Chapman, Wright, and Crundall (1997)	161 community drivers (UK)	Attitudes toward Driving Violations (ST)	Driving Behaviour		.14, .15, .43
Underwood et al. (1999)	100 community drivers (UK)	Anger intensity (S)	Questionnaire — 3 subscales	Severity rating of near accidents	.50
		Driving Anger Scale		Severity rating of near accidents	-.03
			Driving Behaviour Questionnaire—3 subscales	Severity rating of near accidents	-.09, .07, .12
Ward, Waterman, and Joint (1998)	362 community drivers (UK)	Driving Anger Scale	Driving Violence Index		15 <i>r</i> s (.31 to .48)
		Driving Anger Scale	Thrill-seeking behavior		.18
		Driving Anger Scale	Driver Coping		.41
			Questionnaire—Confrontative subscale		
West, Elander, and French (1993)	108 community drivers <sup>c</sup> (UK)	Driver Stress Inventory — 2 subscales	Driving Violence Index		.15, .56
		Type A Behavior (T)	Driving deviance, speed		.07, .27
		Type A Behavior		Number of accidents	.00

Note. US = American sample; AUS = Australian sample; UK = British sample; CAN = Canadian sample; T = coded as a trait measure of anger; S = coded as a state measure of anger; ST = coded as a situation (driving)-specific measure of anger.

<sup>a</sup> Both male and female participants included in each study, unless otherwise noted.

<sup>b</sup> All driving outcome measures collected via self-report questionnaires unless otherwise noted.

<sup>c</sup> Study measures collected as part of a larger survey.

Each abstract was then read and a determination was made as to whether it met the inclusion criteria. Articles not meeting these criteria were eliminated, resulting in 25 included articles with  $s=28$  independent studies<sup>6</sup> (see Table 1 for a summary of the articles included in this meta-analysis). For the aggressive driving analyses, this sample of studies generated  $k=275$  correlation estimates and the total sample size was  $N=4984$ . The average sample size per study was 216.70 and the average sample size per correlation estimate was 18.12. For the MVA analyses, this sample of studies generated  $k=149$  correlation estimates and the total sample size was  $N=13,090$ . The average sample size per study was 818.13 and the average sample size per correlation estimate was 87.85.

## 2.2. Study feature coding

One of the strongest criticisms of this quantitative approach to research synthesis is the “apples and oranges” phenomenon: the issue that different studies employ different variables, measurement techniques, and samples (Lipsey & Wilson, 2001). In order to meaningfully combine and compare across studies, Lipsey and Wilson (2001) report that the findings must be both conceptually and statistically similar; however, this is not always feasible in various psychological domains. The authors state that one approach is to code for all methodological characteristics that might influence the study findings; the researcher can then statistically examine whether (and how) these characteristics are related to the key findings (Lipsey & Wilson, 2001). Therefore, in this meta-analysis, research studies that met inclusion criteria were coded on numerous methodological dimensions.

Each study was coded on the following participant characteristics: gender, national affiliation, and age. Participants were also coded according to their population characteristics, including high and/or low anger status, clinical diagnosis, college or non-college students, selection based on impedance condition (or exposure to a certain level of traffic congestion), selection based on some other measure, and whether this was some other specialized population.

Studies that meet inclusion criteria were categorized on key design dimensions, including: a) presence of key variables (anger and aggressive driving); b) type of driving measurement (to evaluate aggressive driving); c) dependent measures of aggressive driving; and d) specific methodological features.<sup>7</sup> Based on suggestions by Stock (1994) and Wortman (1994), the research quality of the study was assessed by examining reliability of anger questionnaires, reliability of driving questionnaires, whether the study measures multiple types of anger and/or multiple aspects of aggressive driving, and pre-selected sample characteristics that could potentially influence the relationship between anger and driving.

## 3. Analyses

### 3.1. Preparatory analyses

Two graduate researchers independently evaluated all studies, and intercoder reliability was calculated. Reliability coefficients ranged from .83 to 1.00. Once reliability was calculated, coders discussed each disagreement and came to a consensus resolution.

Correlations were corrected for measurement unreliability according to Hunter and Schmidt (1990).<sup>8</sup> After this correction, they were then transformed through Fisher's  $r$  to  $Z$  transformation (Hedges & Olkin, 1985).<sup>9</sup>

<sup>6</sup> Three articles contained two unique studies within them: Deffenbacher, Lynch, Oetting et al. (2001), Deffenbacher, White, and Lynch (2004) and Matthews, Desmond, Joyner, Carcary, and Gilliland (1997). Five studies only contained relationships between anger and MVA variables: Blockley and Hartley (1995), Furnham and Saïpe (1993), Jonah (1990), Norris, Matthews, and Riad (2000) and Underwood et al. (1999).

<sup>7</sup> A more comprehensive review of the included instruments, with additional information regarding reliability and validity, is available from the authors.

<sup>8</sup> The correlation coefficient  $r$  tends to underestimate the magnitude of the population correlation  $\rho$ , particularly for studies with small samples sizes. Because of this, several estimation procedures have been suggested. Hedges and Olkin (1985) provide a formula to transform  $r$  into an unbiased estimator of  $\rho$ , labeled  $G(r)$ . This transformation provides a more accurate approximation of  $r$  to within .01 if  $n > 8$ , and to within .001 if  $n > 18$ . This unbiased estimator has the same range (from  $-1$  to  $+1$ ) and asymptotic distribution as  $r$  (Hedges & Olkin, 1985). However, one of the limitations to this suggested correction of bias is that it tends to overestimate  $\rho$  in small populations. Moreover, studies included in this review are already weighted by their standard error, which is a function of sampling variance (where the variance is calculated as  $v=1/(N-3)$ ). Therefore, this calculation was not conducted.

<sup>9</sup> As  $\rho$  moves further from zero, the distribution of  $r$ 's becomes more skewed. The  $r$  to  $Z$  transformation allows the correlation variance (or standard error) to be independent of  $\rho$ , and also allows correlation coefficient estimates to be additive in nature (Hedges & Olkin, 1985; Rosenthal, 1991).

### 3.2. Computation of effect sizes

Many studies included within this meta-analysis reported more than one statistic for each anger type. In order to offset potential problems arising from the violation of the assumption of effect size independence, a two-stage meta-analysis was conducted (as suggested by Johnson & Eagly, 2000). In the “weighted averages” analysis, the unbiased estimates of  $r$  were averaged to obtain one estimate per sample; analyses were conducted using this average. After this set of analyses was run, all  $r$  estimates were included, allowing information from a particular sample to appear more than once. In this analysis, each  $r$  estimate from a particular study was weighted by the total number of estimates resulting from that study. Again, this second stage violates the independence assumption, and results can only be interpreted with caution (Johnson & Eagly, 2000). This set of analyses was labeled the “all correlations” analysis.

### 3.3. Analysis of computed effect sizes

For each set of analyses (whether it be the weighted averages analyses or the all correlations analyses), Johnson and Eagly (2000) suggest five general steps. First, effect sizes were combined across studies to determine an overall effect size that denotes the relationship between anger and aggressive driving (Hypothesis 1). If the CI for  $Z_+$  does not include zero, then it can be said that there is a positive relationship between anger and aggressive driving. The strength of effect sizes were evaluated based on Cohen’s (1988) criteria for magnitude of effect sizes, where 0.2, 0.5, and 0.8 are considered small, medium, and large, respectively. Moreover, a  $Q_T$  for this overall effect size was calculated.  $Q_T$  represents the total heterogeneity of the sample of effect sizes. A significant  $Q_T$  suggests that the effect sizes are heterogeneous (Johnson & Eagly, 2000; Lipsey & Wilson, 2001).

Second, type of anger was entered into the model to determine if the type of anger measured moderates the relationship between the two general variables (Hypothesis 2). For each type of anger, an average effect size was calculated along with a 95% CI. CIs across averaged effect sizes were examined, to see if the effect sizes were statistically different from one another. As with the calculation of overall  $Z_+$  (discussed above), heterogeneity statistics were calculated (to assess Hypothesis 4). The between-classes effect, labeled  $Q_B$ , is a test of the homogeneity between classes. A significant  $Q_B$  would indicate that the relationship between anger and aggressive driving varies by the type of the anger measured.

If heterogeneity was found, additional third and fourth steps in these analyses deal with evaluating outlying effect sizes.<sup>10</sup>

Finally, other moderator variables were added to the model, in an attempt to account for differences in effect sizes (Hypothesis 3).<sup>11</sup> These moderators were coded study characteristics such as publication year or type of aggressive driving outcome. The underlying idea behind this step is that there may be certain study characteristics that account for effect size differences, and these characteristics may influence the proposed relationship between anger and aggressive driving. This step parallels step 2, in that categorical models were conducted to examine a potential moderator influence on the relationship between anger and aggression.

## 4. Results

### 4.1. Characteristics of the studies

The demographic characteristics of the included samples were relatively homogenous. Most samples were taken either from the United States (54%) or from Great Britain or Canada (43%). Researchers with psychology department affiliations published most (23) studies. The age range of participants in most studies was between 18 and 34 years. The majority (50%) of participants were college students; three studies utilized a sample that contained both college students and non-college participants.

Based on inclusion criteria (see above), all studies contained at least one anger measure and one aggressive driving measure (see footnote 4). Eighteen studies (64%) measured a situation-specific (i.e., driving) form of anger, whereas

<sup>10</sup> Because heterogeneity was not found in any of the calculated mean effect sizes, steps 3–4 were not conducted.

<sup>11</sup> In some analyses, heterogeneity was not found. Typically, moderator variables are not assessed if weighted effect sizes are homogeneous. However, to evaluate Hypothesis 3, a categorical model was conducted using outcome measurement type as a potential moderating variable.

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

Criterion	Any anger	Trait anger	State anger	Driving anger
<i>Weighted averages analysis</i>				
<i>k</i>	32	9	3	20
Mean weighted $Z_+$	0.38	0.41	0.37	0.37
95% CI for $Z_+$	0.29/0.48	0.20/0.62	-0.26/1.00	0.25/0.49
$Q$	15.02	1.86	0.75	12.28
Mean unweighted $Z_+$	0.33	0.36	0.34	0.32
95% CI for $Z_+$	0.24/0.43	0.15/0.56	-0.29/0.97	0.20/0.45
$Q$	8.53	1.26	0.67	6.50
<i>All correlations analysis</i>				
<i>k</i>	275	60	17	198
Mean weighted $Z_+$	0.40	0.42	0.32	0.40
95% CI for $Z_+$	0.37/0.44	0.35/0.49	0.19/0.45	0.37/0.44
$Q$	394.31 *	60.19	5.38	326.46*
Mean unweighted $Z_+$	0.34	0.35	0.29	0.34
95% CI for $Z_+$	0.31/0.37	0.28/0.42	0.17/0.42	0.30/0.37
$Q$	257.00	37.70	4.48	214.05

\* Indicates significance of heterogeneity at the  $p < .05$  level.

eight studies measured trait anger and four studies measured state anger. Several studies measured more than one form of anger: two studies measured all three types of anger; three studies measured both trait and driving forms of anger; and two studies measured both state and driving forms of anger. When measuring aggressive driving outcomes, most studies (79%) administered questionnaires. However, three studies utilized a driving log and two studies measured outcomes via driving simulation programs. Eighteen (64%) studies used a global measure of aggressive driving. Four studies (20%) measured aggressive driving outcomes, which included verbal aggression, physical aggression, and general driver aggression. Nine studies (45%) measured traffic violations, which included cutting another driver off, speeding, traffic citations, traffic violations, risky behavior, and loss of concentration.

Sixteen studies (57%) measured MVAs, which included close calls, minor and major MVAs, involvement in an accident over the lifespan, and loss of control. When moderators were examined, both the general categories — aggressive driving and traffic violations — were examined, as well as more specific categories of aggressive driving.

#### 4.2. Anger types and aggressive driving

The raw correlations between anger and aggressive driving ranged from -0.40 (the relationship between the DDDI and the IBS-Denial subscale; Blanchard et al., 2000) to 0.81 (the correlation between the DATQ-Revenge and Retaliatory Thinking subscale and the DAX-Use of Vehicle subscale; Deffenbacher, Petrilli et al., 2003). The overall summary of the study-level effect sizes given in Table 2 allows one to determine whether, on the whole, anger is significantly related to aggressive driving.<sup>12</sup>

For the all correlations analyses, the mean attenuated effect size averaged across all studies was 0.34. When adjusted by the reported (or estimated) reliability for measures, the mean effect size increased to 0.40. For the weighted averages analysis, the attenuated mean effect size was .33; when adjusted by reliability, it increased to 0.38. The heterogeneity statistics,  $Q_T$ , for the weighted statistics was found to be significant, suggesting that the effect sizes used to create this particular set of averages are different from one another.

An evaluation of the relationships between various types of anger and aggressive driving resulted in comparable statistics. The average correlation (adjusted for unreliability of measurement) between trait anger and aggressive driving outcomes was 0.42 for the all correlations analysis and 0.41 for the weighted averages analysis.

Similarly, the average correlation (adjusted for unreliability of measurement) between state anger and aggressive driving outcomes was 0.32 for the all correlations analysis and 0.37 for the weighted averages analysis. This particular

<sup>12</sup> In all tables, a significant relationship is suggested by a mean effect size that differs significantly from zero. This is indicated by a CI that does not include zero.

set of analysis (for state anger) was derived from a smaller set of correlations ( $k=17$  in the all correlations analysis,  $k=3$  in the weighted averages analysis); it should therefore be interpreted with caution.

Further, the average correlation (adjusted for unreliability of measurement) between driving anger and aggressive driving outcomes was 0.40 for the all correlations analysis and 0.37 for the weighted averages analysis. Thus, all measures of anger appear to relate to aggressive driving in a similar manner.

For trait and state types of anger, the corresponding  $Q_W$  was not significant, indicating that the effect sizes that comprised each mean effect size were homogenous. Thus, state and trait measures of anger were related to driving outcomes in a similar way. However, the  $Q_W$  statistic for driving anger in the all correlations analysis was found to be significant, suggesting that there is significant heterogeneity of the effect sizes for this anger type. An analysis of the method used to examine aggressive driving within this anger type resulted in significant differences across method classes. This is discussed in more detail below (see Examination of possible method variance section). Driving anger was also analyzed by examining the type of aggressive driving measure used. A significant class difference was found ( $Q_B=119.55, p<.05$ ), and an evaluation of the CIs for each averaged effect size showed that the relationships between driving anger and aggressive driving using the DAX (mean effect size=.60) and driver aggression (mean effect size=.58) were significantly different from those using risky behavior (mean effect size=.29), traffic violations (mean effect size=.21), loss of concentration (mean effect size=.15), and overtaking/passing (mean effect size=.01).

As discussed above, the mean effect sizes for each type of anger were not statistically different from one another, indicating that the overall relationship between anger and aggressive driving is not moderated by anger type. Although heterogeneity was found in the all correlations analysis with disattenuated effect sizes, this was not corroborated by other analyses. In the absence of heterogeneity both within and between anger types for the remainder of the analyses, there was no need to further account for variability through the use of categorical moderator models or outlier analyses.

#### 4.3. Examination of possible method variance

Due to the concern that method variance might have masked the content variance, a categorical analysis of outcome measure type was conducted, collapsing across all anger classes (All method variance calculations were conducted using the all correlations dataset and are summarized in Table 3.). When measure type was added into the overall model, the heterogeneity statistic,  $Q_B$ , became significant ( $Q_B=13.32, p<.01$ ). This suggested that there was a difference in the mean effect size across methods. Analysis of the CIs associated with the weighted effect size estimates (to account for unreliability of measures) indicated that aggressive driving outcomes measured by a driving simulator (mean effect size=.14) were significantly smaller than those outcomes garnered by a self-report measure (mean effect size=.32).

To further explore this method variance issue, the type of aggressive driving measure was added to the individual anger class models as a potential moderator. For trait and state anger, measure type did not appear to significantly impact the mean calculated effect size. When measure type was added into the driving anger model, however, the heterogeneity statistic,  $Q_B$ , became significant ( $Q_B=9.73, p<.05$ ). As before, analysis of the CIs associated with the weighted effect size estimates indicated that aggressive driving outcomes measured by a driving simulator (with a mean effect size of .12) were significantly smaller than those outcomes garnered by a self-report questionnaire (mean effect size=.31). These outcome measure differences indicate a problem with the common methodology associated with this area, as true differences between the anger constructs appear to be masked by systematic methodological similarities.

Table 3  
Summary of study-level method type effect sizes for aggressive driving

Criterion	Any method	Self-report questionnaire	Driving log	Driving simulator
$k$	275	247	11	14
Mean weighted $Z_+$	0.40	0.42	0.33	0.16
95% CI for $Z_+$	0.36/0.44	0.39/0.45	0.16/0.50	0.02/0.30
$Q$	394.31 *	344.02*	4.37	26.16*
Mean unweighted $Z_+$	0.34	0.36	0.30	0.14
95% CI for $Z_+$	0.31/0.37	0.32/0.39	0.13/0.47	-0.003/0.28
$Q$	257.00	220.32	3.62	19.65

\* Indicates significance of heterogeneity at the  $p<.05$  level.

#### 4.4. Anger types and motor vehicle accidents

Several studies examined for inclusion in this quantitative review also contained measures of MVA involvement. Although this was not considered by the authors to be a measure of aggressive driving, it is assumed that there should be a relationship between anger, aggressive driving, and accident involvement. Therefore, a separate set of analyses was conducted to evaluate these relationships.

The raw correlations between anger and MVA involvement ranged from  $-0.29$  (the relationship between the DDDI and lifetime involvement in an accident; Blanchard et al., 2000) to  $0.50$  (the correlation between anger intensity (mood state) and occurrence of near accidents; Deffenbacher, Lynch, Oetting et al., 2001). Only one article (Deffenbacher, Lynch, Oetting et al., 2001) provided a correlation between state anger and MVAs; thus, the average relationship between this type of anger and MVAs could not be evaluated across studies. The overall summary of the individual- and study-level effect sizes is given in Table 4.

For the all correlations analysis, the mean attenuated and disattenuated effect sizes averaged across all studies were  $0.07$ . For the weighted averages analysis, the attenuated and disattenuated mean effect sizes were  $.09$ . The CIs for the all correlations analysis did not contain zero, indicating a significant relationship between anger (regardless of type) and MVAs. Surprisingly, however, the CIs for the weighted averages analysis did contain zero. This set of analyses suggested a very small relationship between anger and MVA involvement. All heterogeneity statistics were found to be non-significant, indicating that the effect sizes used to create this particular set of averages are not different from one another; therefore, further analyses were not conducted.

The average effect sizes for the relationship between aggressive driving and MVAs are also provided in Table 4. The mean disattenuated effect size averaged across all studies was  $.06$ ; the mean attenuated effect size in this set of analyses was  $.07$ . The mean attenuated and disattenuated effect sizes for the weighted averages analysis were somewhat higher ( $.11$ ). The CIs for these effect sizes overlapped with those calculated for trait anger and driving anger; therefore, it does not appear that driver aggression is more closely associated with incidence of MVAs than either anger construct.

## 5. Discussion

The main purpose of this study was to provide a meta-analytic review of the relationship between anger and aggressive driving. By integrating the results of published empirical studies over the past fifteen years, four principal questions were examined for aggressive driving and MVA involvement. These questions were answered using both primary and moderator analyses.

Table 4  
Summary of study-level anger type effect sizes for motor vehicle accidents

Criterion	Overall anger	Trait anger	Driving anger	Aggressive driving
<i>Weighted averages analysis</i>				
<i>k</i>	25	5	9	11
Mean weighted $Z_+$	0.09	0.08	0.07	0.11
95% CI for $Z_+$	$-0.01/0.19$	$-0.22/0.39$	$-0.14/0.28$	$-0.04/0.25$
<i>Q</i>	2.40	0.37	0.52	1.40
Mean unweighted $Z_+$	0.09	0.08	0.07	0.11
95% CI for $Z_+$	$-0.01/0.19$	$-0.22/0.39$	$-0.14/0.28$	$-0.04/0.26$
<i>Q</i>	2.51	0.38	0.56	1.44
<i>All correlations analysis</i>				
<i>k</i>	149	14	71	64
Mean weighted $Z_+$	0.07	0.08	0.07	0.06
95% CI for $Z_+$	$0.03/0.11$	$-0.06/0.23$	$0.01/0.13$	$0.00/0.13$
<i>Q</i>	15.69	1.63	5.69	8.29
Mean unweighted $Z_+$	0.07	0.08	0.07	0.07
95% CI for $Z_+$	$0.03/0.11$	$-0.06/0.23$	$0.01/0.13$	$0.01/0.13$
<i>Q</i>	17.49	1.71	6.37	9.38

\* Note: All heterogeneity statistics were non-significant.

The first hypothesis evaluated the overall relationship between anger and aggressive driving. The results of the overall meta-analysis for aggressive driving variables indicated an average correlation of .40. This is a significant association between anger and aggressive driving, in that the calculated CI for this value did not include zero. This suggests that anger, regardless of the type of measure, is moderately and positively associated with aggressive driving. This also lends credibility to the state-trait assumption that both trait and state emotional arousal predict behavior.

In contrast, results for MVA variables demonstrated a weighted average correlation of .07. This illustrates a surprisingly weak relationship between anger and MVA involvement. It was assumed that anger (regardless of type) would be associated both with aggressive driving and negative consequences associated with this behavior; however, these results suggest that angry drivers are *not* at a significantly elevated risk for accidents. One of the limitations in examining the relationship between anger and MVAs is that the decreased incidence of MVAs may contribute to the low correlation between the two constructs. It may be that the low base rate of MVAs and the lack of age diversity in the samples restricted the range of the correlation and thus may not be a good estimate of the true value.

The second purpose of this paper was to determine whether this overall relationship varied across types of anger. This hypothesis was not supported, as the overall heterogeneity value ( $Q_T$ ) was not significant and the CIs for driving anger, trait anger, and state anger overlapped with each other. This would seem to contradict predictions made by state-trait theory. Although both trait anger and state anger should be related to aggressive driving, it was expected that state anger would have a stronger relationship with situational behavior. Trait anger, in contrast, is expected to be more distal, yet more consistently associated with behavior. This unusual finding may be explained by the diversity of “state” measures included in the analyses. Because different studies by default measure different situations, overall state levels of anger may have more closely approximated trait anger. This is further elaborated upon in the discussion of the fourth hypothesis.

The lack of support for the second research question is somewhat puzzling. Researchers developed the concept of driving anger within the framework of state-trait theory. Deffenbacher et al. (1994) defined driving anger as a situation-specific form of trait anger. According to the existing theoretical framework, it was expected that driving anger, above all other types of anger, would be most strongly associated with aggressive driving outcomes. The current findings do not lend clear support to this claim.

Deffenbacher et al. (1994) initially conceptualized driving anger as a situation-specific form of trait anger. However, items on driving anger measures tend to focus on situation-specific factors contributing to an individual’s emotional experience; rather than personality characteristics per se. For example, the Driving Anger Scale asks individuals to rate their level of emotional intensity in situations such as “Someone is driving right up on your back bumper” and “Someone cuts in right in front of you on the freeway.” In contrast, the Trait Anger Scale (Spielberger, 1988) asks the person to rate their general predisposition to feel angry, such as “I am a hotheaded person” and “I have a fiery temper.” It may be that the combination of trait and situational factors contributes to the prediction of aggressive behavior. Enderl (1975), King and Enderl (1990), Magnusson and Enderl (1977) noted that one of the four principles of an interactionist perspective on human behavior is that behavior is the result of the interaction between individual (i.e., trait) and situational factors. Although this has been more systematically evaluated in the anxiety literature, this model has not been examined utilizing preexisting anger constructs such as trait anger and driving anger. The current findings suggest that neither trait nor situational measures of anger differ in their ability to predict aggressive driving behavior. Perhaps an interactionist approach to understanding anger would be worth pursuing in the future, as this more complex perspective might shed some light on the current results.

Validity of measurement becomes a concern with the evaluation of the third research question where the relationship between anger and aggressive driving was influenced by the measurement method. All measures of anger were collected via questionnaires, as were most outcome measures of aggressive driving. However, some studies measured aggressive driving using other methods, such as driving simulators and peer ratings. According to Campbell and Fiske (1959), if the relationship between driving anger and aggressive driving does not differ across modes of measurement, this would provide support for the validity of this trait across measurement modalities. If instead the relationship between anger and aggressive driving varies across modes of measurement, this would suggest the presence of method variance. An overall evaluation of the anger–aggression relationship suggested differences across modes of aggressive driving measurement; therefore, each type of anger was examined separately for the presence of method variance. Trait and state anger were homogeneous across measurement modalities,

providing support for their convergent validity. Driving anger, as in the general analysis, was impacted by measurement modality; an analysis of the CIs showed that aggressive driving outcomes measured by self-report were significantly higher than those measured by a driving simulator. This may indicate that the type of aggressive driving measure used influences the relationship between driving anger and aggressive driving, suggesting the presence of method variance.

This finding, taken in combination with the results of the second research question, suggests a larger problem, for two reasons. First, according to predictions made by state-trait theory, aggressive behavior (of any form) is thought to be the behavioral manifestation of the emotional experience of anger. Similarly, the definition of driving anger (as a situation-specific form of anger) leads to the assumption that it, above all other forms of anger, would be most closely associated with aggressive driving. The findings of this study tend to not support these claims. Second, the relationship between driving anger and aggressive driving should not significantly vary across measurement modalities. These findings suggest a reevaluation both of the theoretical model currently driving the anger literature and measurement properties of existing driving anger questionnaires.

The final purpose of this paper was to examine heterogeneity of the relationships between each type of anger and aggressive driving, done by examining the  $Q_w$  statistic for each type of anger. This hypothesis was partially supported, in that only driving anger was found to be heterogeneous (This finding is qualified, in that this heterogeneity was found to be significant in only one of four sets of analyses on this section of data.).

This is a particularly valuable finding for trait anger. In the current study, hostility and Type A instruments were coded as measures of trait anger. Miller et al. (1995) cautioned that these measures may be heterogeneous and should be considered separate from trait anger. However, the results from this study support the opposing claim made by Eckhardt et al. (2004) that trait anger and hostility are similar constructs.

State anger was also found to be homogeneous under this hypothesis. To some degree, this weakens the assertion made above regarding similarities between state anger and trait anger. One explanation for the lack of differences found between these two types of anger is the variability within the construct of state anger. Lack of heterogeneity suggests this is not the case. Therefore, it leads one to question the degree to which self-report measures of state anger and trait anger overlap with one another. As is the case with driving anger, measures of state anger and trait anger might share a common method variance that would mask true differences. This is a difficult problem to evaluate, as one would expect the content of the two domains to substantially overlap.

It is also important to note that driving anger was found to be (at least partially) a heterogeneous construct under this fourth hypothesis. However, this finding is tempered by other theoretical and psychometric concerns regarding measures of driving anger.

### *5.1. Practical implications*

The state-trait theory (Cattell & Scheier, 1961) has been embraced in the anger literature as a way to conceptualize the experience and expression of anger. Driving anger was initially defined within the structure of this theory (Deffenbacher et al., 1994). Results of the current analyses support a reevaluation of the definition of driving anger as it relates to this theory and/or of the current questionnaires used to measure this construct.

#### *5.1.1. General guidelines*

Two general findings appear particularly important for both researchers and clinicians. First is the understanding that, overall, anger was found to be positively and moderately related to aggressive driving outcomes. This is a useful finding, in that negative outcomes associated with aggressive driving are increasingly prevalent and costly to our society. There is a need to find factors associated with this behavioral phenomenon, as this may have implications for the development of treatment programs and overall reduction of aggression behind the wheel.

Second, this study raises questions regarding the relationship between anger and aggressive driving as being moderated by anger type. Although the distinction between anger types may be useful for behavioral outcomes in other types of anger-provoking situations, this may not be necessary for this domain. All measures of anger were moderately associated with aggressive driving, regardless of the type of anger these instruments were purported to measure. The theoretical structure guiding this research may need to be reexamined according to this evidence.



### 5.1.2. *Alternative models of anger*

Although driving anger was initially conceptualized under the rubric of state-trait theory (Deffenbacher et al., 1994), the relationship between anger and aggressive driving may be better explained by other models of emotion and personality, such as the interactionist model discussed above. Other alternative models suggest that there is not a direct relationship between emotional experience and behavioral expression; rather, there are mediating factors that influence this relationship. For example, the general aggression model (GAM; Anderson & Bushman, 2002) proposes that the level of cognitive appraisal (immediate appraisal versus effortful reappraisal) will influence the final action outcome (impulsive versus thoughtful). When individuals do not have the resources (time, cognitive capacity) available to cognitively evaluate the situation, they only make an immediate appraisal of the situation, which typically results in impulsive aggressive behaviors. In contrast, if a person has the resources available to engage in more effortful thought, their actions tend to be more thoughtful. It is important to note that these thoughtful actions can still be aggressive; the only difference is that they will likely be less impulsive (i.e., the individual will have more control over the behavior sequence). This model suggests that aggressive behavior may be less influenced by anger type (although there is a place in the model to account for personality differences); instead, behavior is influenced by level of thought processing (Anderson & Bushman, 2002). Under this theory, it can be hypothesized that individuals, regardless of anger type and driving anger levels, tend to engage in more thoughtful processing while driving. Because of this, they are better able to control their behavior. This translates into few negative outcomes (such as traffic citations and MVAs), which can explain this paper's findings.

Some of the current review's findings may be explained by the classic theory of arousal and performance developed by Yerkes and Dodson (1908). They predicted an inverted U-shaped relationship between arousal and performance, suggesting that a moderate level of arousal can motivate cognitive processing and enhance performance. However, too much arousal can result in hyperactivity of thought processing, which then can result in a reduction in performance. This theory also suggests that the optimal level of arousal is dependent upon the task at hand; more arousal is necessary for tasks that require endurance and perseverance (Yerkes & Dodson, 1908). The argument can be made that the act of driving requires a high level of endurance and perseverance. Thus, individuals need a certain degree of arousal in order to be cognizant of their surroundings and drive safely and effectively. Therefore, the experience of anger while driving may actually enhance the optimal level of cognitive processing and result in greater awareness while behind the wheel. Angry individuals may express aggression while driving, but they may also be more careful and attend to the danger presented by their actions. This theory helps explain the stronger relationships between anger and violations (i.e., driver aggression variables) and the weaker, non-significant, relationships between anger and errors (e.g., MVAs, traffic citations).

Rusting (1998) suggested a mediation model that contrasts with the traditional view that state and trait emotion each impact emotional processing and responding separately. Instead, she hypothesized that stable personality traits predispose individuals to experience various mood states, which then influence affective and behavioral responding. This model helps explain the lack of differences in anger type. Under this mediational model of emotional responding, people high in anger (regardless of whether they are trait angry or trait driving angry) are more likely to experience angry mood. Because of this relationship, these individuals are more likely to experience greater cognitive (and presumably behavioral) responding to a given situation.

Review of alternative models suggests that the relationship between anger and aggressive driving may be more complex than is currently conceptualized. It is likely that methodological and cognitive appraisal variables both directly and indirectly influence this relationship. Because of this, it is suggested that these variables be considered in future research, and the scope of the anger–aggression relationship be expanded to incorporate these concepts.

### 5.1.3. *Limitations*

Several limitations in this meta-analysis should be noted. First, only a small number of studies could be included in this analysis, due to inclusion criteria constraints. Although this was necessary to ensure the quality of this quantitative review, these results may not reflect the true relationships among variables. It is possible that null results reported here may become significant in an analysis with a larger sample of studies. However, even if more studies were added, it is suspected that the effect sizes would still remain small and homogenous (as evidenced by the lack of heterogeneity within classes in the current analyses).

Second, one set of analyses included in this study was conducted on statistically dependent effect sizes. Although the second set of analyses averaged within studies to reduce the impact of dependence, this does not eliminate the potential for multicollinearity. Therefore, these results must be interpreted with some degree of caution.

Third, all correlations included in these analyses were disattenuated by estimates of their reliability. However, many authors did not include psychometric properties for their included measures; instead, their properties had to be inferred from previous research. This may have skewed the results in a way that may not reflect the true relationship between variables. However, this disattenuation procedure was deemed necessary, as unreliability of measures can also affect these relationships.

Although correlations were corrected for unreliability and interdependency, other factors may influence the magnitude of correlations. In particular, subject selection may result in a restriction of range. The characteristics of the distribution, such as skewness and kurtosis, will also affect correlations (Carroll, 1961). For example, if MVAs are relatively rare with a positively skewed distribution, but driving anger is normally distributed, the correlation between them will necessarily be attenuated.

Finally, strong conclusions were made about theoretical foundations of anger types, particularly driving anger. However, most research was done using self-report measures. Due to the nature of self-report, it is unclear whether relationships across measures reflect the true construct versus simply the likelihood of admitting anger. And all arguments against self-report measures of anger can also be held against measures of aggressive driving. Like anger questionnaires, there is little consensus on how to define aggressive driving and little psychometric information to support current measures of this construct. Conclusions made in this paper must be weighed with some degree of caution until more research has been conducted using a variety of other measurement tools.

#### 5.1.4. *Suggestions for future research*

In light of these findings, several suggestions are made to improve the quality of research in this area. First, it is imperative that more research be conducted on the instruments used to assess driving anger. In the current study, six driving anger measures were included. Of these measures, only three were included in more than one study. Moreover, several studies did not report psychometric information on the scale for the relevant sample. One of the trends noticed in this literature was to report reliability coefficients from previous samples and studies. Until this construct is better defined, psychometric information should be assessed within every study.

The distinction between driving anger and global aggressive driving should be more clearly delineated in future research. Many studies measured aggressive driving via self-report questionnaires; it was often difficult to determine whether a questionnaire measured aggressive driving or driving anger. As discussed above, there is uncertainty regarding the role behavior plays in the experience of emotion. Spielberger (1988), a proponent of state-trait theory as applied to anger, suggested that the expression of general anger should be considered separately from the experience. This line seems to be less clear in the measurement of anger while driving, and at times the delineation between measures of driving anger and driver aggression was difficult to determine.

It also would be interesting to see if global measures of aggressive driving and driving anger are differentially related to specific driving outcomes. Several global aggressive driving instruments were used in this study; like driving anger, many were study-specific and only a few were psychometrically evaluated. A more critical evaluation of these measures would be useful, in that their validity might be increased and their relation to the theory would be expanded. It would make sense that these global aggression measures would better predict aggressive driving outcomes. However, this author suspects that these measures overlap significantly with driving anger, and therefore may not demonstrate a significant increase in relationship. In the current analyses, only correlations between anger and aggressive driving measures were included. An additional set of analyses examining erroneous (not just aggressive) driving acts and their relationship to anger would likely supplement the method variance concerns about driving anger. For example, do global aggressive driving and driving anger measures have differential relationships with the likelihood and frequency of motor vehicle accidents?

Another way to assess the content validity of the various measures used to assess anger (of any type) and aggressive driving would be to examine factorial validity. It is suggested that multiple, commonly used measures of driving anger, trait anger, state anger, and global aggressive driving be administered to a large sample, and then see if the measures load onto different, identifiable factors (e.g., driving anger items load onto a “driving anger” factor).

## 5.2. Conclusions

The current research examined the demonstrated relationship in the literature between types of anger and aggressive driving outcomes. Results from this meta-analysis indicated that there is a significant relationship between anger (in general) and aggressive driving; however, contrary to what was hypothesized, this relationship is *not* moderated by anger type (i.e., state or trait). This research is important to further understand the relationship between the emotional experience and behavioral expression of anger. It is also hoped that the results of this review will further research on the theoretical foundations underlying the anger types reviewed.

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