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Anger, aggression, and risky behavior: a comparison of high and low anger drivers☆

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Abstract

This research tested hypotheses from state-trait anger theory applied to anger while driving. High and low anger drivers drove equally often and as many miles, but high anger drivers reported more frequent and intense anger and more aggression and risky behavior in daily driving, greater anger in frequently occurring situations, more frequent close calls and moving violations, and greater use of hostile/aggressive and less adaptive/constructive ways of expressing anger. In low impedance simulations, groups did not differ on state anger or aggression; however, high anger drivers reported greater state anger and verbal and physical aggression in high impedance simulations. High anger drivers drove at higher speeds in low impedance simulations and had shorter times and distances to collision and were twice as likely to crash in high impedance simulations. Additionally, high anger drivers were more generally angry. Hypotheses were generally supported, and few gender differences were noted for anger and aggression.

Keywords: Anger; Anger expression; Angry drivers; Aggressive drivers; Risky drivers; State-trait theory

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1. Introduction

Anger and aggression on our highways have received considerable media attention in the past decade. For example, 'road rage,' the most violent cases involving assault or attempted assault, appeared to increase approximately 7% a year from 1990 through 1995 in the US, resulting in an estimated 200 deaths and another 12 000 injuries (American Automobile Association, 1997). Drivers who have altercations with other drivers also experience greater numbers of traffic violations and accidents (Hemenway & Solnick, 1993). However, for every physical assault or anger-related injury, there are thousands if not tens of thousands of angry drivers. Their experience is marked by intense emotional and physiological arousal. Some angry drivers behave aggressively (e.g. hostile gestures, loud epithets and denigrating comments, cutting a person off or tailgating in anger), whereas others are angry, but do not aggress (e.g. only mumble to self or think hostile thoughts).

Social and environmental factors such type of situations encountered, anonymity, and presence of hostile messages and bumper stickers influence anger and aggression while driving (Doob & Gross, 1968; Ellison-Potter, Bell, & Deffenbacher, 2001; Kenrick & MacFarlane, 1986; Lajunen & Parker, 2001; Shinar, 1998). Personality and emotional disposition also appear to contribute. For example, drivers who engage in risky and illegal driving and/or who have the highest crash rates are high in general anger, aggressiveness, risk taking, impulsiveness, social irresponsibility, and sensation seeking (Arnett, Offer, & Fine, 1997; Donovan, Queisser, Salzberg, & Umlauf, 1985; Mayer & Treat, 1987; McMillen, Pan, Wells-Parker, & Anderson, 1992; Underwood, Chapman, Wright, & Crundall, 1999). Traits like these are associated with risky driving, but transitory states also appear important. For example, in field studies, state anger correlated strongly with increased levels of aggression and risky behavior (Deffenbacher, Lynch, Oetting, & Yingling, 2001b). Anger was the only mood state associated with speeding in adolescents (Arnett et al., 1997), and reckless driving was associated with elevated state anger in college students (Morris, Deffenbacher, Lynch, & Oetting, 1996). Findings such as these suggest that the state-trait model of anger (Spielberger, 1988, 1999) might be adapted to anger while driving (Arnett et al., 1997; Deffenbacher, Oetting, & Lynch, 1994). Applied to anger when driving, trait driving anger refers to a person's general propensity to become angered frequently and intensely when driving (i.e. trait driving anger reflects a context-specific tendency to become angry when driving). State driving anger describes angry emotional and physiological arousal stemming from a specific driving event.

Deffenbacher et al. (1994) developed a measure of trait driving anger, and initial studies showed that state anger increased with driving-related frustration and provocation, and that trait driving anger correlated positively with risky driving-related attitudes and behaviors, the frequency and intensity of state driving anger, frequency of risky and aggressive behavior on the road, and some crash-related events such as close calls, (Deffenbacher et al., 2001a,b). In studies of British drivers, elements of trait driving anger correlated positively with traffic violations generally (Underwood et al., 1999) and with violations involving both aggression and non-aggression incidents (Lajunen, Parker, & Stradling, 1998). Two recent studies (Deffenbacher, Huff, Lynch, Oetting, & Salvatore, 2000a; Deffenbacher, Lynch, Filetti, Dahlen, & Oetting, 2002a) compared a group of angry drivers who identified driving anger as a personal problem for which they sought counseling to a group of low anger drivers who indicated they did not have personal problem with anger when driving. Groups did not differ on the frequency of driving, but high anger drivers reported more intense

and frequent anger in day-to-day driving and engaged in more frequent aggressive and risky behavior behind the wheel. Although they did not differ in terms of lifetime injury or major accidents, high anger drivers experienced more close calls, losses of vehicular control, traffic citations for moving offenses, and anger-related injury to themselves and damage to their vehicles. Although clinically interesting, sampling in these two studies confounds the person's propensity to become angry behind the wheel with self-identifying a problem with driving anger and an interest in counseling for driving anger reduction. That is, a significant portion of the findings may be due to identifying driving anger as problematic, rather than anger proneness per se.

The present study, therefore, sought to remedy this problem by identifying high and low anger drivers independent of their seeing driving anger as a problem and testing an application of state-trait theory to driving anger. Three predictions were derived from the state-trait model. Specifically, if trait driving anger reflects a person's disposition to anger while driving, then high anger drivers, compared to low anger drivers:

1. should experience anger more frequently when driving (frequency hypothesis)
2. should experience more intense anger when driving (intensity hypothesis); and
3. since anger may motivate and prompt aggression, should engage in more aggressive behavior on the road (aggression hypothesis).

Two collateral hypotheses were developed even though they did not derive completely from the state-trait model as not all of the phenomena included are necessarily mediated by anger. Specifically, since anger and aggression can interfere with attention, perception, information processing, and behaviors needed for safe handling of a vehicle, and since trait driving anger may be correlated with characteristics (e.g. impulsiveness) that may interfere with driving, it was predicted that, compared to low anger drivers, high anger drivers would:

1. engage in more risky behavior on the road (risky behavior hypothesis); and
2. experience more crashes and crash-related outcomes (negative outcomes hypothesis).

Hypotheses were tested by three different methodologies: self-report surveys, driving diaries, and performance on and emotional reactions to situations presented via a driving simulator. Gender was explored as a possible moderator of relationships, and trait anger was included to continue to map the characteristics of high anger drivers and to assess whether high anger drivers were also elevated on general anger and aggression as suggested by Lajunen and Parker (2001).

2. Method

2.1. Participants

Participants in the simulation portion of the study were 121 (54 male, 67 female) introductory psychology students (*Mdn* age = 19) who scored in the upper (DAS $>$ 52) or lower (DAS $<$ 42) quartiles of the 14-item Driving Anger Scale (DAS; Deffenbacher et al., 1994). There were 28 low anger male, 33 low anger female, 26 high anger male, and 34 high anger female drivers.

Students received one of three research credits for participation. At the completion of the simulation phase, students were offered an additional 1-credit experiment involving the completion of questionnaires and Driving Logs. Twenty-four declined stating they had completed research requirements, leaving 97 participants (24 low anger male, 27 low anger female, 19 high anger male, and 27 high anger female drivers). Four students did not have access to cars, leaving 93 completing Driving Logs.

2.2. Instruments

Alpha reliabilities are from this study unless otherwise noted

2.2.1. Driving Anger Scale (DAS)

On the 14-item DAS (Deffenbacher et al., 1994) participants rated items on a five-point scale (1 = not at all; 5 = very much) the amount of anger experienced if each driving situation occurred (α values = 0.80-0.92 and 10-week test-retest reliability of 0.84 based on previous research) (Deffenbacher, 2000; Deffenbacher et al., 1994). The DAS correlates positively with measures of the intensity and frequency of anger and frequency of aggression and risky behavior in general and clinical samples (Deffenbacher et al., 2000a, 2001b, 2002a).

2.2.2. Driving scenarios

The three driving scenarios (Ordinary Traffic, Stuck in Rush Hour Traffic, and Being Yelled at by Another Driver) involve reports of anger on seven, five-point semantic differentials in each situation (e.g. hotheaded-coolheaded) (Deffenbacher et al., 2000a). Clinical and non-clinical samples of high anger drivers reported greater anger on these measures than low anger drivers (Deffenbacher et al., 2000a, 2001b; Deffenbacher, Lynch, Oetting, & Swaim, 2002b).

2.2.3. Driving Anger Expression Inventory (DAX)

The DAX is a 49-item scale on which individuals rate items on a four-point scale (1 = almost never, 4 = almost always) according to how often the person expresses his/her anger in the manner described (Deffenbacher et al., 2002b). The DAX yields four measures of expressing anger while driving:

1. 12-item Verbal Aggressive Expression (α = 90) (e.g. swearing or yelling at another driver);
2. 11-item Personal Physical Aggressive Expression (α = 0.80) (e.g. giving another driver the finger or trying to have a physical fight with another driver);
3. 11-item Use of the Vehicle to Express Anger (α = 0.88) (e.g. speeding up to frustrate another driver or flashing lights at another driver); and
4. 15-item Adaptive/Constructive Expression (α = 0.90) (e.g. relaxing or thinking about things to distract one's self from frustration).

Verbal and Personal Physical Aggressive Expression and Use of the Vehicle to Express Anger correlate positively with each other (rs = 0.39 to 0.48) and negatively with Adaptive/Constructive Expression (rs = −0.10 to −0.22). Adaptive/Constructive Expression forms small negative correlations with measures of anger while driving, whereas aggressive forms of expression form larger

positive correlations with such measures. The three aggressive forms of anger expression correlate positively with aggressive and risky behavior on the road, whereas adaptive/constructive expression tends to be negatively correlated with aggression and risky behavior (Deffenbacher et al., 2001a, 2002b).

2.2.4. Driving Survey

The Driving Survey (Deffenbacher et al., 2000a) contains six items that assess Crash-related Outcomes over the last 3 months ($\alpha = 0.41$) on which participants reported the number of times (0-5+) they experienced the condition (e.g. close calls, a moving violation, or a minor accident). It also includes a 13-item report of Aggression ($\alpha = 0.88$) and 15-item report of Risky Driving Behavior ($\alpha = 0.86$) on which participants indicated number of times (0-5+) they engaged in specific behaviors in the last 3 months. Aggressive and Risky Behavior scores are the sum of the frequencies across the 13 and 15 behaviors, respectively. Clinical and non-clinical samples of high anger drivers report more aggressive and risky behavior and some crash-related outcomes (Deffenbacher et al., 2000a, 2001a, 2002a).

2.2.5. Driving Logs

For 3 days, participants completed Driving Logs (Deffenbacher et al., 2000a, 2001a) on which they reported the number of times and miles driven, frequency of anger while driving that day, a rating (0-100) of most intense anger experienced while driving that day, and frequencies of 6 aggressive and 14 risky behaviors. Compared to low anger drivers, clinical and non-clinical samples of high anger drivers report increased frequency and intensity of anger and frequency of aggression and risky behavior (Deffenbacher et al., 2000a, 2002a; Deffenbacher, Richards, Filetti, & Lynch, 2002c).

2.2.6. State Anger Scale (SAS)

The SAS is a 15-item scale (Spielberger, 1999) asking participants to rate on a 1-4 scale (1 = not at all, 4 = very much so) the degree of the item they feel at the moment. The SAS yields three 5-item subscales:

1. Anger (αs = 0.89-0.93) (e.g. feel annoyed or angry);
2. Verbal Aggression (αs = 0.90-0.94) (e.g. feel like swearing or yelling at someone); and
3. Physical Aggression (αs = 0.85-0.91) (e.g. feel like breaking things or pounding somebody).

State anger and aggression measures increase in response to frustration and provocation (Speilberger, 1999) generally and to driving provocations specifically (Deffenbacher et al., 2002c).

2.2.7. Trait Anger Scale (TAS)

The TAS (αs = 0.81-0.91 based on previous research) is a 10-item measure of general feelings of anger (Spielberger, 1988, 1999). Items are rated on a four-point (1 = almost never, 4 = almost always) scale according to how a person typically feels or reacts. Two-week test-retest reliabilities range from 0.70 to 0.77 (Jacobs, Latham, & Brown, 1988), and two-month retest reliability was 0.75 (Morris et al., 1996). The TAS correlates positively with measures of anger, aggression, and hostility (Deffenbacher, 1992; Deffenbacher et al., 1996b; Spielberger, 1988, 1999) and anger

consequences (Deffenbacher, Oetting, Lynch, & Morris, 1996a; Morris, Deffenbacher, Lynch, & Oetting, 1996) and forms larger correlations with anger variables than with other cognitive, emotional, behavioral, and personality measures (Deffenbacher, 1992; Deffenbacher et al., 1996a,b).

2.3. Procedure

Undergraduates in seven introductory psychology classes completed the DAS and indicated interest in participating in a study on driving by providing their name and phone number. A graduate research assistant called students meeting inclusion criteria and described the study as involving emotional reactions while driving on a driving simulator. Interested students were scheduled for an individual time in the laboratory.

One of four (one male, three female) undergraduate assistants, who were experimentally blind to participant driving anger, led participants into an L-shaped room, each portion of which was 12 ft long and 6 ft wide. They sat participants at a table in front of a STISM Version 8 Driving Simulator (Systems Technology Incorporated, Hawthorne, California), briefly described the study, answered questions, and gave participants two informed consent forms, one of which students signed and returned and the other of which students kept.

Assistants told participants they would complete a short questionnaire after driving on the simulator. Participants received a packet of four SAS and completed the first one (Trial 1). Participants then adjusted the chair to a comfortable position in front of the simulator so they could easily access the steering wheel, brake, and accelerator. The experimenter explained they would complete a simulation to familiarize them with the equipment. Participants then activated the familiarization simulation by pushing a button on the console. The 4-min familiarization simulation included, in order, driving on an open road, entering a town at reduced speed with buildings on the side of the road and several intersections, slowing for a yellow light, stopping at a stoplight, and then exiting the town for the open road. After the familiarization simulation, participants completed the second SAS regarding their feelings while completing the familiarization simulation (Trial 2). Then, the experimenter instructed the participant to activate the second simulation by pushing the button. The 10-min open road simulation involved driving on a gently curving, two-lane road with no traffic ahead of the person, occasional oncoming traffic, and a posted speed limit of 55 mph. When they finished the open road simulation, participants completed the SAS regarding their reactions in the open road simulation (Trial 3). Following the open road simulation, randomly half within each gender/anger group completed one of the two 10-minute, high impedance simulations. One impedance simulation involved the driver being stuck in three lanes of heavy traffic traveling approximately 20 mph below the posted limit of 60 mph and through which the person could not proceed. The other simulation emulated being stuck behind a slow driver on a road with few places to pass and where a long line of vehicles back up because the front driver goes slowly and does not pull over to let others by. The participant drove behind another driver who was traveling 15 mph below the posted limit of 55 mph, and the road had sufficient curves and oncoming traffic such that the participant could not pass safely. Immediately after concluding either impedance simulation, participants again completed the SAS (Trial 4).

The experimenter debriefed participants and gave them the opportunity to participate in another study on driving. The majority signed up, but 24 had fulfilled research requirements and declined.

In the second phase of the study, participants completed questionnaires in groups of five to ten in a small classroom. Upon arriving, students received two informed consent forms and a brief description of the study. Students signed and returned one consent form and retained the other. They then completed, in order, the Driving Scenarios, DAX, Driving Survey, and TAS. This order was chosen because it reduced confusion as it moved from asking about anger while driving to the expression of driving anger to general driving behaviors to trait anger. When participants finished questionnaires, assistants distributed three Driving Logs with instructions to complete them on three days they drove during the coming week. Participants who had not turn in Logs in 10 days were called and reminded.

3. Results

The primary analytic format was a 2 (Gender) × 2 (Anger) MANOVA on groups of logically related measures (e.g. measures assessed by a common methodology). Univariate ANOVAS followed significant MANOVAs, with significant interactions explored with Tukey tests. Effect sizes were expressed in terms of η^2, and qualitative evaluation of effect sizes employed Cohen's (1988) criteria where η^2 of 0.01-0.04 is considered a small effect, 0.05-0.14 a moderate effect, and >0.14 a large effect. In some cases, the proportions of groups engaging in a behavior or experiencing an outcome were compared by tests of differences between independent proportions (Bruning & Kintz, 1997).

3.1. Anger in response to specific situations

Diving Scenarios (Table 1) revealed a significant multivariate effect for anger, $F(3, 91) = 23.42$, $\eta^2 = 0.44$, $p < 0.001$, but not for gender or the interaction. High drivers reported significantly more anger in ordinary traffic, when stuck in rush hour traffic, and when yelled at by another driver (*M*s = 14.54, 25.65, and 26.13) than low anger drivers (*M*s = 10.39, 16.90, and 19.37). Anger effects sizes were large.

3.2. State anger, aggression, and performance during simulations

State anger and verbal and physical aggressive tendencies were assessed four times during the simulation portion of the study:

1. upon arriving (Trial 1);
2. after the familiarization simulation (Trial 2);
3. after the open country road simulation (Trial 3); and
4. after one of the two high impedance simulations (Trial 4).

A 2 (Anger) × 2 (Gender) × 2 (Simulation) MANOVA on state measures at Trial 4 was run to see if state measures required separate analyses by impedance simulation or if they could be collapsed. Since no main effect or interactions involving the simulation were found, state measures were collapsed across impedance simulations and analyzed by a 2 (Anger) × 2 (Gender) × 4

Table 1
Anger in response to common provocations, anger expression, and trait anger as a function of gender and anger

Measure	Gender	Group				Univariate Anger $F(1, 93)$	Anger effect size (η^2)
		Low anger		High anger			
		M	SD	*M*	SD		
Ordinary traffic	M	10.38	3.17	12.89	4.24	23.21*	0.200
	F	10.41	3.43	15.70	4.77		
Rush hour traffic	M	16.04	5.96	24.84	4.59	62.41*	0.402
	F	17.67	5.53	26.22	5.09		
Yelled at by another driver	M	19.21	7.81	26.89	5.53	33.75*	0.266
	F	19.52	5.42	25.59	3.83		
Verbal aggressive	M	23.63	7.23	31.95	6.65	50.93*	0.354
	F	21.00	6.90	32.85	6.72		
Physical aggressive	M	12.21	1.93	14.74	4.24	17.45*	0.158
	F	11.56	1.15	13.96	3.55		
Use of vehicle to express anger	M	16.58	3.92	24.21	6.24	44.26*	0.322
	F	15.15	3.48	20.78	5.63		
Adaptive/constructive	M	34.71	5.86	28.89	8.94	15.08*	0.140
	F	38.59	9.09	31.81	7.41		
Trait anger	M	16.21	3.40	22.47	3.40	36.85*	0.284
	F	17.52	4.12	23.15	5.65		

Note. M = male, F = female.
* $p<0.001$.

(Trials) repeated measures MANOVA. This analysis yielded no significant multivariate effects for gender or any interaction involving gender, but revealed significant multivariate effects for anger, $F(3, 119) = 11.40$, $\eta^2 = 0.22$, $p< 0.001$, and for trials and the anger x trials interaction, Fs(9, 113) = 34.80 and 4.47, η^2s = 0.74 and 0.26, ps< 0.001. Overall, high anger drivers reported greater state anger and verbal and physical aggression, and anger and aggression did not change for the first three trials, but increased following impedance (Trial 4). Significant anger × trials interactions (Table 2), however, qualify interpretation of these anger and trials main effects. State anger and verbal aggression revealed large anger x trials effects (Table 2). High and low anger drivers did not differ over the first three trials, within or between groups. State anger and the urge to aggress verbally increased significantly for both groups in the high impedance simulation, but high anger drivers reported significantly greater state anger and verbal aggressive tendencies as a function of impedance than did low anger drivers. State physical aggressive tendencies followed a slightly different pattern. Low anger drivers reported minimal, unchanged urges to physical aggression across all four trials. High anger drivers reported little state physical aggression over the first three trials and did not change across those trials or differ from low anger drivers. In the impedance simulation, state physical aggressive tendencies of high anger drivers increased significantly and were higher than those of low anger drivers. The interaction effect size was moderate for physical aggression.

Table 2
State anger and aggression during simulations

Measure	Trial	Group				Anger × trials F	Anger × trials (η^2)
		Low Anger		High Anger			
		M	SD	M	SD		
State anger	T1	5.59	1.09	5.69	1.69		
	T2	5.37	0.66	6.03	1.62		
	T3	5.68	0.91	6.58	1.94	29.31*	0.195
	T4	8.10	2.43	11.95	4.03		
Verbal aggression	T1	5.08	0.52	5.35	1.03		
	T2	5.00	0.00	5.40	1.03		
	T3	5.02	0.13	5.50	1.52	22.42*	0.156
	T4	6.29	2.42	9.65	4.45		
Physical aggression	T1	5.00	0.00	5.05	0.28		
	T2	5.00	0.00	5.11	0.58		
	T3	5.00	0.00	5.21	0.93	10.31*	0.078
	T4	5.16	0.72	6.42	2.81		

Note. T1 = Initial baseline assessment; T2 = Assessment after familiarization simulation; T3 = Assessment after unimpeded country road simulation; and T4 = Assessment after impedance simulation.

* $p<0.001$.

For the familiarization simulation, two measures of risky driving and one of crash-related outcomes were developed:

1. *M* speed in miles per hour;
2. root mean square error of speed as a measure of changes in speed or more erratic driving; and
3. proportion of participants experiencing a crash (i.e., either a collision with another vehicle or an off road crash).

Average speed and change of speed (Table 3) revealed multivariate effects for anger and gender, $F(2,116) = 3.61$ and 3.23, η^2s = 0.06 and 0.05, ps< 0.05, but not for the interaction. Average

Table 3
Performance in driving simulations as a function of gender and anger

Measure	Gender	Group				Univariate Anger $F(1, 117)$	Anger effect size (η^2)
		Low anger		High anger			
		M	SD	*M*	SD		
Simulation-familiarization							
Average speed (mph)	M	43.15	6.40	45.84	5.37	7.08**	0.057
	F	40.43	4.87	43.58	7.00		
RMSE of speed (mph)	M	14.05	2.74	14.95	3.70	3.91**	0.032
	F	13.54	2.84	14.94	3.37		
Simulation-open country road							
Average speed (mph)	M	59.72	5.31	66.29	9.02	15.18***	0.116
	F	57.27	4.81	60.90	8.62		
RMSE of speed (mph)	M	7.70	2.69	9.35	3.15	8.94**	0.072
	F	7.17	2.11	8.49	2.88		
Simulation-stuck behind a slow driver and unable to pass safely							
Minimum distance to collision (ft)	M	24.30	22.97	21.78	26.43		
	F	42.35	26.97	21.67	19.39		
Minimum time to collision (s)	M	2.04	1.89	1.21	1.59		
	F	3.19	1.62	2.08	1.79		
RMSE of speed (mph)	M	4.59	0.92	6.18	1.69		
	F	4.89	1.04	4.54	0.98		
Simulation-stuck in slow, bumper to bumper traffic							
Minimum distance to collision (ft)	M	28.52	18.15	11.63	8.63		
	F	52.81	37.33	20.80	21.02		
Minimum time to collision (s)	M	4.00	3.34	2.30	2.56		
	F	6.75	4.57	3.87	3.59		

Note. M = male, F = female, and RMS = root mean square error.
** $p<0.01$.
*** $p<0.001$.

speed showed a small univariate gender effect, $F(1,117) = 5.14$, $\eta^2 = 0.04$, $p<0.05$, due to men ($M = 44.44$) maintaining a higher speed than women ($M = 42.03$). Average speed and change in speed demonstrated moderate and small anger effects respectively; high anger drivers maintained a higher average speed and displayed greater changes in speed (Ms = 44.56 and 14.95) than low anger drivers (Ms = 41.68 and 13.78). The proportion of high (18%) and low (10%) anger drivers who crashed during the familiarization simulation did not differ, $z = 1.81$.

Average speed and change in speed in the simulation involving traveling on a gently curving road with little oncoming traffic (Table 3) showed significant multivariate effects for anger and gender, Fs(2, 115) = 7.30 and 4.53, η^2s = 0.12 and 0.07, ps<0.001 and 0.05, but not for the interaction. Average speed showed a moderate gender effect, Fs(1, 116) = 8.97, $\eta^2 = 0.07$, $p<0.01$, due to men ($M = 62.83$) traveling at high speeds than women ($M = 59.11$). Average speed and variability of speed revealed moderate anger effects, because high anger drivers drove faster and with greater changes in speed (Ms = 63.28 and 8.87) than low anger drivers (Ms = 58.43 and 7.42). Because of the lack of impedance and gently curving course of the road, participants could easily drive beyond the posted speed limit of 55 mph. The degree of speeding was explored by looking at the number of people who exceeded the speed limit by varying amounts. A significantly greater proportion of high than low anger drivers drove more than 5 mph (56% versus 39%), $z = 2.67$, $p<0.01$, and 10 mph (40% versus 10%), $z = 5.73$, $p<0.001$, over the posted limit. Significantly more high (12%) than low (0%) anger drivers averaged >20 mph over the limit, $z = 4.04$, $p<0.001$; in fact all seven traveling at these speeds were high anger drivers. In spite of these differences, high (2%) and low (3%) anger drivers did not differ in the proportions who crashed, $z = 0.45$.

Half of participants completed the simulation in which they followed a driver traveling significantly below the speed limit on twisting road with sufficient oncoming traffic such that the participant could not pass safely. The other half experienced a simulation in which they were stuck in three lanes of heavy, bumper to bumper traffic, moving well below the speed limit. Given the high degree of impedance in both simulations, dependent measures were minimum distance to collision in feet, minimum time to collision in seconds, and proportion of participants who crashed. A 2(Anger) x 2(Gender) x 2(Simulation) MANOVA on distance and time measures (Table 3) revealed no significant multivariate interactions, but revealed significant multivariate main effects for anger, gender, and simulation, Fs(2, 115) = 8.06, 4.99, and 15.36, η^2s = 0.12, 0.08, and 0.21, ps<0.001, 0.01, and 0.001, respectively. Distance and time to collision yielded moderate gender effects, Fs(1, 116) = 8.23 and 9.06, η^2s = 0.07 and 0.07, ps<0.01, as males had shorter distances and times to collision (Ms = 22.16 and 2.37) than females (Ms = 34.35 and 4.05). Only time to collision demonstrated a simulation effect, $F(1, 116) = 15.90$, $\eta^2 = 0.12$, $p<0.001$, due to the simulation involving being stuck behind a single slow driver leading to shorter times to collision than the simulation involving being stuck in heavy, slow traffic (Ms = 2.15 versus 4.46). This simulation effect may seem counterintuitive in that it is reasonable to expect that time and distance to collision should be highly correlated. The nature of the simulation, however, may account for the differences. When participants were stuck in heavy slow traffic, they traveled at fairly steady speeds. When stuck behind a slow driver and unable to pass safely, many participants dropped back and accelerated rapidly trying to pass, only to cut back in quickly behind the slow driver. Thus, in the latter simulation, they did not come any closer to another driver in terms of closest distance to impact, but did so at higher speeds, hence shorter time to

impact. Time and distance to impact (Table 3) demonstrated moderate anger effects, *F*s(1, 116) = 16.19 and 9.60, η^2s = 0.12 and 0.08, *p*s<0.001 and 0.01. High anger drivers had both shorter distances and times to collision (*M*s = 19.62 and 2.46) than low anger drivers (*M*s = 37.97 and 4.11). To see if high anger drivers engaged in more erratic driving in trying to pass the single slow driver, a 2(Anger) x 2(Gender) ANOVA was performed on the root mean square error of speed (Table 3). Main effects for anger and gender were not significant, but the anger x gender interaction was significant, $F(1, 50) = 12.59$, $\eta^2 = 0.13$, $p<0.01$. High anger males demonstrated significantly greater changes in speed ($M = 6.18$) than high anger females, low anger males, and low anger females (*M*s = 4.54, 4.59, and 4.89), who did not differ significantly from one another, suggesting that high anger male drivers drove more erratically in trying to pass the slow driver. A significantly higher proportion of high (55%) than low (23%) anger drivers crashed in the simulation involving being unable to pass a slow driver safely, $z = 3.86$, $p<0.001$, and significantly more high anger drivers (37%) than low anger drivers (16%) crashed when stuck in heavy, slow traffic, $z = 2.73$, $p<0.01$.

3.3. Driving diaries

Driving Logs were averaged across three days (Table 4) and revealed a significant multivariate effect for anger, $F(6, 84) = 6.27$, $\eta^2 = 0.31$, $p<0.001$, but not for gender or the interaction. High and low anger drivers did not differ on the frequency of driving or miles driven, but high anger drivers reported significantly more frequent ($M = 2.12$) and intense ($M = 50.97$) anger and engaged in more aggressive ($M = 1.59$) and risky ($M = 3.52$) behavior than low anger drivers (*M*s = 0.88,

Table 4
Day-to-day driving (driving logs) as a function of gender and anger

Measure	Gender	Group				Univariate Anger *2F*(1,92)	Anger effect size (η^2)
		Low anger		High anger			
		M	SD	*M*	SD		
Number of times driven	M	3.23	2.25	2.68	1.89	0.05	0.001
	F	2.42	1.33	3.13	1.73		
Number of miles driven	M	45.74	37.57	39.70	46.38	0.33	0.004
	F	40.68	50.84	36.60	32.65		
Frequency of anger	M	1.07	1.29	2.38	2.22	12.27*	0.121
	F	0.72	0.63	1.96	2.09		
Intensity of anger	M	32.28	27.32	51.57	24.24	22.46*	0.201
	F	21.23	21.61	50.59	24.45		
Aggressive behavior	M	0.81	1.01	1.73	1.40	17.98*	0.168
	F	0.52	0.72	1.51	1.07		
Risky behavior	M	1.96	1.37	4.47	2.32	27.45*	0.236
	F	1.70	0.92	2.91	1.79		

Note. M = male, and F = female.
* $p<0.001$.

26.18, 0.65, and 1.82, respectively). Significant anger effects were large, except for the moderate effect on frequency of anger.

3.4. Driving anger expression

Driving anger expression (Table 1) revealed a significant multivariate effect for anger, $F(4, 90) = 15.03$, $\eta^2 = 0.40$, $p<0.001$, but not for gender or the interaction. High anger drivers reported expressing their anger more through verbal aggression, personal physical aggression, and using the vehicle to intimidate and frustrate others (*M*s = 32.48, 14.28, and 22.20) than low anger drivers (*M*s = 22.24, 11.86, and 15.82). High anger drivers also reported less expression of anger through adaptive/constructive means than low anger drivers (*M*s = 30.61 versus 36.76). Effect sizes were large for anger expression variables.

3.5. Aggression, risky behavior, and crash-related events

Three-month reports of aggression and risky behaviors (Table 5) revealed significant multivariate effects for anger and gender, Fs(2, 92) = 26.80 and 3.93, η^2s = 0.37 and 0.08, ps<0.001 and 0.01, but not for the interaction. Gender effects resulted from men reporting more risky driving

Table 5
Three-month rates of aggression, risky behavior, and accident-related outcomes as a function of three-month rates of aggression, risky behavior, and accident-related outcomes as a function of gender and anger

Measure	Gender	Group				Univariate Anger $F(1,93)$	Anger effect size (η^2)
		Low anger		High anger			
		M	SD	*M*	SD		
Aggressive behavior	M	4.13	5.65	17.47	12.33	51.20**	0.355
	F	4.33	4.51	13.89	7.99		
Risky behavior	M	20.33	11.99	34.32	16.50	32.70**	0.260
	F	12.15	9.33	28.22	13.57		
Lost concentration	M	2.21	1.67	3.05	1.61	5.56*	0.053
	F	1.96	1.72	2.67	1.57		
Minor loss of control	M	0.88	1.33	1.32	1.60	2.23	0.023
	F	0.81	1.08	1.19	1.33		
Close calls	M	0.63	0.77	1.21	1.32	6.57*	0.066
	F	0.96	1.06	1.48	1.05		
Moving violations	M	0.08	0.28	0.37	0.68	6.71*	0.067
	F	0.00	0.00	0.11	0.32		
Minor accidents	M	0.13	0.34	0.00	0.00	0.19	0.002
	F	0.07	0.27	0.09	0.28		
Major accidents	M	0.00	0.00	0.00	0.00	0.79	0.008
	F	0.04	0.19	0.00	0.00		

* $p<0.05$.
** $p<0.001$.

than women (*M*s = 26.51 versus 20.19), $F(1, 93) = 7.38$, $\eta^2 = 0.07$, $p<0.01$. Aggression and risky behavior demonstrated large univariate anger effects (Table 5), due to high anger drivers reporting more aggressive and risky behaviors (*M*s = 15.37 and 30.74) than low anger drivers (*M*s = 4.24 and 16.00). Because crash-related outcomes did not form a reliable index, the six items (Table 5) were analyzed in a MANOVA, which yielded a significant multivariate effect for anger, $F(6, 88) = 3.16$, $\eta^2 = 0.18$, $p<0.01$, but not for gender or the interaction. Moderate anger effects were found on three variables. In the last three months, high anger drivers experienced more losses of concentration while driving, close calls, and moving violations (*M*s = 2.83, 1.37, and 0.22) than low anger drivers (*M*s = 2.08, 0.80, and 0.04).

3.6. Trait anger

A 2(Gender)x2(Anger) ANOVA on the Trait Anger Scale (Table 1) yielded a large, significant effect for anger, $F(1, 93) = 36.85$, $\eta^2 = 0.28$, $p<0.001$, but not for gender or the interaction. High anger drivers reported more trait anger ($M = 22.87$) than low anger drivers ($M = 16.90$).

4. Discussion

A simple explanation for several findings is differential exposure. If high anger drivers drove more than low anger drivers, then, assuming a random base rate of provocative events on the road, high anger drivers would experience more provocation and could report more frequent and intense anger and more aggression because of differential exposure, rather than as a result of their personal propensity to become angry while driving. This, however, was not the case. Driving diaries showed high and low anger drivers drove equally often and as many miles. Thus, findings do not appear to result from different amounts of driving, but rather from something about the person's characteristics in interaction with the driving environment (Deffenbacher et al., 2000a).

Hypotheses were generally supported. Confidence in these conclusions is strengthened by the fact that support was found across three different methodologies (i.e. self-report surveys, field study diaries, and driving simulations).

Findings supported the frequency hypothesis. High anger drivers became angry more often in day-to-day driving, replicating earlier findings (Deffenbacher et al., 2000a, 2001b). High anger drivers experienced anger 2.4 times more often than low anger drivers.

The intensity hypothesis also received support. High anger drivers reported greater anger in three commonly occurring situations (i.e., normal and rush hour traffic and another driver yelling at the person about his/her driving), during day-to-day driving, and when impeded during the simulations. The intensity hypothesis was, however, qualified by a person×situation interaction. High anger drivers were not uniformly angry behind the wheel. State anger levels of high and low anger drivers were low and not significantly different at baseline and during the familiarization and open road simulations. Anger level rose for both groups following impedance, but increased significantly more for high anger drivers. These findings are similar to those of Deffenbacher et al. (2000a) and Deffenbacher et al. (2001b) where high and low anger drivers reported minimal anger when driving unimpeded on a country road, whereas anger increased for both groups in normal and rush hour traffic or when yelled at by another driver, but increased significantly more

for high anger divers. Thus, it appears that the person's disposition to anger interacts with sources of provocation on the road, rather than high anger drivers being ubiquitously angry behind the wheel.

The aggression hypothesis also received support as found in clinical samples (Deffenbacher et al., 2000a, 2002a). For example, high anger drivers reported greater state verbal and physical aggressive tendencies following high impedance simulations. High anger drivers reported they were significantly more likely to express their anger through verbal aggression, physical aggression where the person is the primary instrument of aggression, and physical aggression wherein the vehicle is the instrument of aggression. They also reported that they were less likely to handle their anger in adaptive/constructive ways. High anger drivers reported engaging in more aggression as measured by driving diaries or reports of aggression over the past 3 months. For example, based on data from their driving diaries and three-month reports, high anger drivers committed 2.4-3.6 times more aggressive acts than low anger drivers. However, aggression was influenced by contextual variables. Verbal and physical aggressive tendencies were low and not different for high and low anger drivers across the baseline, familiarization, and open road simulations. However, when driving was impeded, tendencies toward verbal aggression went up for both groups, but more so for high anger drivers, whereas the tendency for physical aggression went up a small, significant amount for high anger drivers and did not increase for low anger drivers. Thus, aggression, like state anger, covaried with both the person's disposition toward anger and the situations in which they were driving.

Findings tended to support other hypotheses as well. The risky behavior hypothesis received support across methodologies. In the familiarization and open road simulations, high anger drivers drove faster and more erratically than low anger drivers. In the high impedance simulations, high anger drivers had shorter times and distances to collisions. Whether monitoring their behavior on a daily basis (Driving Logs) or via three-month reports (Surveys), high anger drivers engaged in 1.9 times more risky behavior than low anger drivers, corroborating findings in clinical samples (Deffenbacher et al., 2000a, 2002a). It should be noted, however, that some risky behavior was only correlated with rather than mediated by anger. For example, speeding and variation in speed in the familiarization and open road simulations were not mediated by anger, because state anger was uniformly low for all participants. That is, high anger drivers appear to have a tendency to engage in more risky behavior, even when they are not angry.

The hypothesis that high anger drivers would experience more crash-related outcomes (negative outcomes hypothesis) received partial support. For example, significantly larger proportions of high anger drivers drove over the speed limit in the open road simulation. In fact, four times as many high anger drivers averaged 10 mph over the limit, and everyone driving over 20 mph over the limit was a high anger driver. That is, larger numbers of high anger drivers drove at speeds that could eventuate in traffic fines and loss of points towards retention of their licenses, consistent with greater tickets for moving violations found in this and other studies (Deffenbacher et al., 2002a). On the other hand, there were no differences in the crash rates in the familiarization and open road simulations, perhaps because were neither simulation very demanding nor frustrating. However, significantly greater proportions of high anger drivers crashed in simulations of slow, bumper-to-bumper traffic and being stuck behind a slower driver and unable to pass safely. In both cases, proportions of high anger drivers crashing were sizable and roughly double those of low anger drivers. Clearly the external validity of findings in the simulations is qualified by the

lack of actual risk involved in simulations. Perhaps, high anger drivers do not take these risks in real life environments. Nonetheless, they engaged in more crash-risk in the low consequence environment of the simulation, which is consistent with greater risky behavior reported on the driving diaries and 3-month reports. Although there were no differences in rates of minor loss of vehicular control or major or minor accidents, high anger drivers reported greater losses of concentration, close calls, and moving violations, supportive of the negative outcomes hypothesis, as found for a clinical sample of high anger drivers (Deffenbacher et al., 2000a, 2002a) and in a correlational study (Deffenbacher et al., 2001b).

High anger drivers reported elevated general anger as found in other research (Deffenbacher et al., 2000a, 2002a; Lajunen & Parker, 2001). This suggests that angry drivers tend to be generally angry as well and perhaps that driving is another arena in which anger is played out. While there is a degree of correlation between anger behind the wheel and general or trait anger (*r*s on the order of 0.25-0.40) (Deffenbacher, 2000), this degree of relationship is not so great as to suggest that anger behind the wheel should be subsumed within general or trait anger. Elevated general anger does, however, suggest that high anger drivers are more likely to get into the car in an angry state and react with greater anger to provocative events on the road, as general anger is likely to show transfer effects to anger behind the wheel (Zillman, 1971). For example, an employee with elevated trait anger is more likely to be angered at work and have this carryover into anger behind the wheel on the commute home from work. That is, general anger is likely to carryover to driving, an environment to which the high anger driver is already vulnerable.

While anger effects were strong, gender effects for anger and aggression were minimal. Specifically, there were no gender effects on any anger measure. Men and women did not differ on frequency of anger or intensity of anger in day-to-day driving, intensity in the scenarios, state anger in the simulations, or trait anger. There were also no gender differences in measures of aggression (i.e., state verbal or physical aggression in response to simulations, reports of aggression in driving diaries or 3-month surveys, or aggressive forms of expression on the DAX). Thus, there was very little evidence of gender differences in the frequency and intensity of anger or aggression, and this absence of gender differences replicated across measures in this study. There were some gender effects on other indices. For example, men engaged in more speeding in two simulations, had shorter times and distances to impact in the impedance simulations, and reported more risky behavior on the Survey, suggesting men engaged in more risky behavior. However, the latter findings did not replicate on all measures, as men and women did not differ on risky behavior from the driving diaries and differences on 3-month reports were not found in another study (Deffenbacher et al., 2002c). In summary, some indices suggested that males engage in more risky behavior, but effects, when found, were small to moderate (4-9% of variance), tended not to replicate, and were not found at all on measures of anger and aggression while driving.

In summary, there were fairly consistent, often large anger effects across measures, but gender effects were minimal for many constructs with some evidence of gender effects for risky behavior. Moreover, there was but a single significant gender x anger interaction, suggesting no meaningful interactions. Together, findings suggest that the disposition toward anger behind the wheel has utility in understanding and predicting anger, aggression, risky and unsafe behaviors, and negative driving outcomes, whereas gender has less utility, cautioning against gender stereotypes, because young adult, college student male and female drivers looked much more alike than different, especially in terms of their anger and aggressive tendencies.

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