Psychological and Roadway Correlates of Aggressive Driving

Final Report

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16. Abstract (Limit: 200 words)

This study was conducted to better understand the psychological and roadway correlates of aggressive driving. The study had two phases: In Phase One, survey data was used to investigate the relationship between personality, emotional, and behavioral variables and self-reported driving behavior—710 people were surveyed. In Phase Two, 67 participants (35 classified as high hostile—those with the most extreme high hostility survey scores—and 32 classified as low hostile—those with the most extreme low hostility survey scores) drove for 19-miles on a simulated four-lane freeway. The data yielded a number of interesting findings; in particular, there were significant differences in driving behavior between drivers characterized as high hostile and those characterized as low hostile. For example, when drivers in the high hostility group were blocked by other vehicles, they responded by driving much closer to the blocking vehicles than drivers in the low hostility group. This risky driving behavior, found in a driving simulator, validates the self reports given by the high hostile drivers in the surveys. This finding is likely to be of value for public safety organizations whose mission is to educate the public about potentially dangerous and risky behavior. It is not likely that all those who are classified as high in hostility will engage in aggressive driving behavior. Further research may yield additional understanding on this point.

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Executive Summary

The goal of this two-phase study was to identify factors that might prompt aggressive driving behavior and examine how those behaviors might be expressed in a simulated driving environment. In the first phase, 710 people were surveyed—252 were male, 446 were female, and 12 participants did not indicate their gender. The participants ranged in age from 18 to 45 years old (the average age was 22.05 years old). The Phase 2 participants were selected after we examined the responses to the Phase 1 surveys. For Phase 2, we chose the participants with the most extreme high and most extreme low scores with regard to hostility. Sixty-seven participants were selected—35 (19 female and 16 male) had high hostility levels, and 32 (15 female and 17 male) had low hostility levels. All 67 participants were licensed drivers.

In Phase 1, the participants were asked to give information about their personality characteristics including hostility, anger expression, physical and verbal aggressiveness, competitiveness, and empathy; their emotional state including anger-provoking experiences, anger states, and negative thought patterns; and their behavioral tendencies with regard to driving.

We found that self-reported hostility was normally distributed among the survey participants. Based on a median split of this distribution, the hostility measure was used to assign the participants to a high or low hostility group. Compared to the low hostility participants, those in the high hostility group reported higher levels of experienced anger in response to rude gestures from other drivers; illegal driving by other drivers; the presence of the police; slow drivers; discourteous and rude driving by other drivers; and roadway obstacles. In addition, those in the high hostility group reported higher levels of physically aggressive behavior; verbally aggressive behavior; driving after drinking; speeding while driving; and risky driving behavior.

We also compared the responses obtained from the male participants with those of the female participants. Compared to the males, the female participants reported higher levels of experienced anger in response to rude gestures from other drivers; illegal driving by other drivers; and roadway obstacles. However compared to the females, the male participants reported higher levels of hostility. The male participants also reported higher levels of physically aggressive behavior; of verbally aggressive behavior, of driving after drinking; of speeding while driving: and of risky driving.

We used regression analyses to determine factors associated with driving-related anger—including anger due to (1) rude gestures from other drivers; (2) the presence of the police; (3) slow drivers; (4) discourteous and rude drivers; (5) roadway obstructions; and (6) illegal driving by others. We found factors, that apparently have little to do with driving, emerged from these analyses: For example, romantic problems were associated with the first five driving-related anger measures. This suggests that individuals bring their personal situations into their vehicles when they drive, and that the strains and stresses of personal life may contribute to anger states while people are driving.

We also conducted regression analyses to determine factors associated with self-reported driving behavior—including (1) driving after drinking; (2) speeding; and (3) risky driving. The analyses indicated that instrumental aggressiveness was associated with all three driving behaviors, and

that social competitiveness was associated with both speeding and risky driving behavior. These associations suggest that a driver's affective predispositions may influence his or her driving behavior.

The survey results suggest that a complex set of factors may contribute to deviant driving. These factors include the driver's emotional and personal baggage, his or her affective and personality predispositions, and the circumstances that he or she encounters on the roadway.

In Phase 2, participants classified as high hostile (those with the most extreme high hostile survey scores) or low hostile (those with the most extreme low hostile survey scores) drove for 19-miles on a simulated four-lane freeway. During the drive they encountered three events. In the first event, the participant was blocked by two vehicles, one in the right lane the other in the left. In the second event, the participant was passed by another vehicle which cut in and abruptly slowed down. In the third event, a vehicle tailgated the participant. We assessed the response to these events.

We found that for the first event in response to being blocked, there were no differences in the responses that could be attributed to gender. However, the following distance for participants in the high hostility group was considerably shorter than the following distance for the participants in the low hostility group. The following distances were on average 14.77 meters (48.47 feet) for the high hostility group and 22.87 meters (75.05 feet) for the low hostility group. The obstructing vehicles were programmed to drive at 5 mph below the speed of the participant. If the participants had been driving at the speed limit of 55 mph then the obstructing vehicles would have traveled at 50 mph, and the following distance (in time) would have been 0.66 seconds for the high hostility participants—far shorter than the typically recommended 2 second following distance.

For the second event in which the participant was passed by another vehicle which cut in and abruptly slowed down, there were no differences that could be attributed to gender. However, the participants in the high hostility group started breaking sooner than those in the low hostility group.

In response to the third event, in which a vehicle tailgated the participant, 20 participants reduced speed and 35 increased speed—but there were no differences in the responses that could be attributed either to hostility or gender.

Previous studies of aggressive driving have failed to comprehensively address the factors that precipitate aggressive driving. This study addressed that void. When drivers in the high hostility group were blocked by other vehicles, they responded by driving much closer to the blocking vehicles than drivers in the low hostility group. This risky driving behavior, found in a driving simulator, validates the self reports given by the high hostile drivers in the surveys. This finding is likely to be of value for public safety organizations whose mission is to educate the public about potentially dangerous and risky behavior. It is of interest that, although in the survey males self-reported higher levels of risky driving behavior than females, in the driving simulation study we did not find significant differences in the driving behavior of the male and female drivers.

It is not likely that all those who are classified as high in hostility will engage in aggressive driving behavior. Further research may yield additional understanding on this point. Issues that need to be addressed by future research include: (1) whether or not people with high hostility levels who drive aggressively are amenable to self-corrective measures; (2) whether or not those with high hostility levels recognize that aggressive driving behavior is counter-productive and that they need to change their driving behavior; and (3) whether or not they can be trained to self-correct their behavior.

Chapter 1
Introduction

1.1 Human Aggression and Driving Behavior

Human aggression is a pervasive and destructive social behavior. Not only is the violence and destruction spawned by human aggression considered a threat to public health (Acierno, Resnick, & Kilpatrick, 1997; Elliott, 1994; Kilpatrick, Resnick, & Acierno, 1997; Rodriguez, 1990; Straus & Gelles, 1980), but also, for specific segments of society, exposure to violence is a major health risk (Grisso, Wishner, Schwarz, Weene, Holmes, & Sutton, 1991; Hammond & Yung, 1993, Resnick, Acierno, & Kilpatrick, 1997). Couple this perspective with the fact that mass surveys reveal that large numbers of adults, especially within interpersonal relationships, engage in various forms of violence (Gelles & Straus, 1979; Vissing, Straus, Gelles, & Harrop, 1991), and one can surmise that the tendency to hurt others can be activated frequently during social interactions.

Because anger and aggression can be activated and enacted within a multitude of social contexts, examination of their influence is of interest for those who seek to understand, prevent, and control the behaviors associated with them (Caprara, Barbaranelli, Pastorelli, & Perugini, 1994; Hammock & Richardson, 1992; Hammond & Yung, 1993; Johnson & Johnson, 1996). The physical and psychological toll that aggression and violence exact on individuals, relationships, communities, and society underscores the importance of not only developing tools to predict aggressive tendencies (e.g., Caprara, 1986; Hammock & Richardson, 1992), but also understanding why and how aggressive behavior may surface within and across various social contexts.

Out of the multitude of social contexts within which individuals find themselves on a daily basis, driving is one in which anger and aggression can surface due to the inherent nature of driving in traffic. Often roadways are congested and drivers are rushed, which can result in drivers perceiving that their goals are being thwarted and their progress blocked. As a result, many drivers may become frustrated and angered while driving, both of which may activate hostility and aggressive tendencies (Berkowitz, 1993).

The fact that driving is essentially a social act requiring one to cooperate and communicate with fellow drivers to successfully navigate the roadway makes understanding the nature of aggressive behavior while driving an important theoretical and practical pursuit. However, it is an area of human behavior that has not received sufficient attention, even though citizens of most industrialized nations spend a great deal of time driving every day.

In part due to the nature of driving and the fact that many roadways are congested and littered with uncontrollable obstacles, driving can be stressful and frustrating, making some individuals susceptible to emotional outbursts and inappropriate behavior. As transportation in general consumes more of our time and resources, and as getting to one's destination becomes more difficult, people in general may become more and more frustrated while driving. Given this, people may come to believe that expressing hostility and aggressive intent while driving are

appropriate in certain situations, as a way for them to vent their emotions. However, how and the extent to which expressing hostility, anger, and aggressive intent promotes physical aggression and violence while driving is not well understood, nor is the link between frustration and anger states and the willingness to engage in risky driving behavior such as tailgating or flashing one's lights at another driver.

Because driving occurs within a social context, the extent to which this context influences aggressiveness is of great interest. However, little research has been devoted to understanding how the dynamics of social interaction processes contribute to aggressive behavior. This is due in part to the complexity of social interaction. Even within the relative isolation that encapsulates a driver in his or her vehicle a complex social dance plays itself out on our nation's roadways. Drivers cooperate with and communicate to each other through a series of established social driving rules in order to achieve their objectives. Even a simple lane change maneuver requires that a complicated set of procedures be enacted, transmitted to other drivers, and understood to be successful. One essential aspect of driving behavior is its social nature; the context within which drivers cooperate with and communicate to each other in order to achieve their goals and objectives needs to be understood. Given this, to understand aggressive driving more completely we must take into account the dynamics of the social context in which it occurs.

Given the frequency and social costs of violence, devoting greater attention to how the emotional and psychological states of drivers contribute to their aggressive and risky driving is important. The purpose of this research was to understand more fully how psychological, affective, and social factors may contribute to cognitive and affective processes that trigger aggressive and risky driving behavior.

1.2 Objectives of the Current Research

National and Federal agencies (e.g., The AAA Foundation for Traffic Safety, the National Traffic Safety Administration, the Federal Highway Administration) and the general public have expressed increasing concern about the frequency of aggressive driving on roadways. Several agencies have identified driver aggression as one of the major threats to safety in future roadway environments. Further, national and local media have fueled the perception that our roadways are congested battlegrounds where rude and unsafe driving is commonplace. The research reported here is an interdisciplinary effort to understand the extent to which pre-existing cognitions, emotions, roadway conditions, and attitudes toward driving contribute to aggressive driving. The general goal of the research reported here is to identify factors that might prompt aggressive driving behavior and to examine them in a simulated driving environment.

While previous research has addressed how individual components of driver perception (e.g., driver attitudes toward speeding) contribute to aggressive driving, we are unaware of previous work that systematically examines the problem of aggressive driving as comprehensively as that reported in this study. There is a rich body of research on human aggression suggesting that retaliation surfaces in very subtle ways. Among the most common ways that people retaliate against each other is the use of passive aggressive strategies or the development of hostile thoughts and negative feelings toward others. This study examines the extent to which these

strategies, thoughts, or feelings appear in the form of subtle aggressive driving behaviors in a driving simulator.

Although much research (e.g., Bandura, 1973; Baron, 1977; Berkowitz, 1993; Donnerstein & Berkowitz, 1981; Eron, 1987; Feshbach, 1984; Geen, 1978, 1990; Gelles, 1987; Huesman, 1986; Malamuth, 1986; Zillman, 1979; Zimbardo, 1969) has examined the nature of human aggression, its causes, and its consequences from many perspectives, relatively few studies have examined how anonymity and the use of weapons factor into the aggression equation. The use of an automobile as a type of weapon that can be used for retaliation has only become a social concern due to increased traffic congestion and the time that we are required to devote to commuting each day—both of these factors have the potential to increase our distress. No studies of which we are aware have linked personality attributes and roadway situations to distress and aggressive driving tendencies.

Understanding the factors that contribute to aggressive driving will foster the development of programs and policies to prevent and reduce it. The goal of this research was to identify psychological, emotional, and behavioral factors that contribute to aggressive driving behavior. There were two phases in this study. In Phase 1, we used survey data to explore the relationship between personality, emotional, and behavioral variables and self-reported driving behavior. In Phase 2, we used an advanced driving simulator to investigate the effects of three driving events on two groups of participants—a high hostility group, and a low hostility group—that were selected on the basis of their responses to the survey.

Chapter 2
Method

2.1 The Phase 1 Survey

During Phase 1, 710 people were surveyed. There were 252 male participants and 446 female participants. Twelve of the participants declined to indicate their gender. Participants ranged in age from 18-45 years old. The average age was 22.05 years (with a standard deviation of 3.45). In addition to demographic characteristics, the surveys yielded self-reported data for the following variables:

- Personality characteristics including hostility, anger expression, physical and verbal aggressiveness, competitiveness, and empathy.
- Emotional state including anger-provoking experiences, anger states, the ability to relinquish hostility, negative thought patterns, and hassles.
- Behavioral tendencies with regard to driving, such as speeding, driving under the influence, and risky driving.

2.2 The Phase 2 Driving Simulation Experiments

2.2.1 Participants

Survey participants with the most extreme high and low scores with regard to hostility were selected for participation in Phase 2. Sixty-seven survey participants (all licensed drivers) from Phase I were selected. Thirty-five (19 female and 16 male) participants were classified as having high hostility and 32 participants (15 female and 17 male) were classified as having low hostility.

2.2.2 Driving Simulator

Each of the 67 selected participants drove in an advanced driving simulator. The key components of this simulator were as follows:

2.2.2.1 Simulator Vehicle—The simulator vehicle was a full-body 2002 Saturn SC1 coupe.

2.2.2.2 Simulator Visuals—There was a 210-degree forward field-of-view—provided by five flat-panel screens each of which was 4.7-ft (1.43-meters) high by 6.5-ft (1.98 meters) wide. There was a central flat panel in front of the simulator vehicle. The center of this panel was aligned with the line of sight of the driver in the simulator vehicle. Two intermediate panels flanked the central panel, to the left and right. These two intermediate panels were set at 138-degrees to the central panel. Then there were two outer panels—one on the right, the other on the left—that were set at 138-degrees to the intermediate panels. The base of all five flat-panel screens was elevated 1.33 ft (0.06 meters) above the floor. Five projectors were used to project a coordinated, high-fidelity, virtual environment onto the five flat-panels comprising the 210-degree forward field-of-view. The simulator provided rear-view imagery in two ways. First, there was a 10-ft (3.05-meter) high by 7.5-ft (2.29-meter) wide screen—mounted behind the vehicle—that the driver could see through the vehicle's rear-view mirror. Second, two 5-inch

(12.7-cm) LCD panels were installed in place of the simulator vehicle's side-view mirrors. Coordinated imagery was presented through the five-forward and the three rear-view channels.

2.2.2.3 Simulator Vehicle Controls—The simulator vehicle's controls were equipped with sensors that relayed to the driving simulator computer the participant's inputs to the steering wheel, transmission, and accelerator and brake pedals. The simulator computer provided a real-time interface with the virtual environment. Force feedback was applied to the steering wheel, using a high-torque motor attached to the steering column. A vacuum assist pump was connected to the brake pedal in order to simulate realistic braking. The simulator vehicle was equipped with an automatic transmission interface, which was functional and which was controlled by the simulator computer.

2.2.2.4 Simulator Sound System—Road and traffic noise and the simulator vehicle's engine sounds were delivered through four speakers placed around the vehicle's exterior, near the base of the five panels that comprised the forward view. Each speaker received independent inputs from the simulator's 3D sound generation system. Low-frequency sounds were delivered using a ten-inch subwoofer located inside the simulator vehicle's engine compartment. If necessary, the experimenter could communicate with each participant via a dedicated intercom system that made use of four speakers installed in the simulator vehicle's factory speaker locations.

2.2.2.5 Simulator Vehicle Movement—A bass shaker mounted to the underside of the vehicle's frame provided additional low-frequency vibration.

2.2.2.6. Data Recording—The virtual position of the simulator vehicle, relative to the scenario that the participant was driving, was recorded at a rate of 20 Hz throughout each experiment drive. From this record, it was possible to determine the participant's steering performance and the speed at which he or she was driving the vehicle. In addition, three micro-video cameras positioned in the cab of the simulator vehicle were used to record (i) the participant's face, (ii) his or her foot position, and (iii) his or her steering wheel responses throughout the course of each experimental session. A video display at the experimenter's station enabled the experimenter to monitor the participant throughout each session.

2.2.3 Experimental Procedure

2.2.3.1 Consent Form—At the start of each experimental session each participant read and signed a consent form.

2.2.3.2 Practice Drive—To familiarize each participant with driving in the simulator, he or she was presented with a short training drive. The experimenter sat in the passenger seat of the simulator vehicle during this drive. The participant was instructed to drive at 55 mph while performing a series of lane-changing maneuvers. After performing some lane changes, the participant arrived at a stop sign, and was asked to stop. The participant was asked if he or she wanted more practice, and was allowed to continue if he or she so desired. At the end of the practice drive, the participant stopped the car, and was given additional information about the experimental session. The experimenter then exited the car and prepared the simulator for the first experimental drive.

2.2.3.3 Experimental Drives—The participant was informed that he or she would be driving on a two-lane undivided highway with a posted speed limit of 55 mph; the participant was asked to drive as he or she "normally would" on an actual highway. The experimenter then asked the participant if he or she had any questions.

2.2.3.4 Test Scenario—The simulated test scenario developed for this experiment consisted of a 19-mile four-lane freeway. The landscape around the freeway had the character of a rural agricultural area. Standard placement of speed limit signs and other standard signage was used. The speed limit was posted at 55 mph. The traffic density on the simulated freeway was 3.1 v/km/ln (5 v/mi/ln)—just below the middle of the range covered by Transportation Research Board Level of Service A (LOSA). Each of the 67 participants drove once on the test route.

2.2.3.5 Driving Scenario Trigger Events—As part of the driving simulation, participants encountered the following three driving events during the 19-mile drive

2.2.3.5.1 Event 1: Participant's Vehicle Blocked by 2 Vehicles—After driving for one mile on the simulated freeway, the participant's vehicle was blocked by two vehicles that were traveling 5 mph slower than the speed of his or her vehicle. One of these blocking vehicles was in the right lane and the other was in the left lane. As the participant drove behind these two vehicles, the lead position alternated between them, but the gap between them was never large enough for the participant to pass through—i.e., the gap was never more than one vehicle length, 14.5 ft (4.42 meters). The participant followed the pair of blocking vehicles for five miles. Then, at the 6 mile mark, the blocking vehicle in the right lane vehicle exited the freeway on an exit ramp, and the vehicle in the left lane moved into the right lane.

2.2.3.5.2 Event 2: Vehicle Cuts in Front of the Participant—At mile 7, a vehicle (a Jeep) traveling 10 mph faster than the participant passed him or her and "cut in" two vehicle lengths ahead. When the passing/cutting in vehicle moved into the right lane (just ahead of the participant), the passing vehicle abruptly reduced its speed to the same speed as the participant. The event was programmed so that if the experimental participant attempted to overtake the vehicle that cut-in, by moving into the left lane and them increasing speed, then at the point when the participant's vehicle drew even with the cut-in vehicle, the cut-in vehicle would increase its speed to match the speed of the participant's vehicle. If the participant continued to increase his or her speed, the cut-in vehicle would increase its speed until the participant was driving 15 mph faster than the speed limit. If the participant did this and passed the cut-in vehicle, then the cut-in vehicle reduced its speed to the speed limit and exited at next ramp. [It should be noted that no participant increased speed enough to overtake the cut-in vehicle in this experiment.] If the participant failed to overtake the cut-in vehicle and continued driving in the left lane, then after five miles, the cut-in vehicle reduced its speed to the speed limit and exited at the next ramp. If the participant gave up his or her attempt to overtake the vehicle, slowed down, and returned to the right lane, then the cut-in vehicle reduced its speed to the speed limit and exited at the next ramp. If, on the other hand, the participant made no attempt to overtake, then the cut-in vehicle continued driving at the reduced speed for another five miles and then exited the freeway at an exit ramp.

2.2.3.5.3 Event 3: Tailgating Vehicle—After driving for 13 miles on the test scenario, the participant approached a string of vehicles that were traveling close together in the right lane, at a speed which was approximately 5 mph less than the speed at which the participant was driving. If the participant remained in the right lane behind the string of slow moving vehicles, then the tailgating event was not triggered and the participant remained behind the traffic for the rest of the scenario. If, on the other hand, the participant moved into the left lane in order to overtake the long stream of traffic, a car appeared from behind traveling 15 mph faster than the participant. This car continued at that speed until it was one car length behind the participant, at which point the tailgating vehicle assumed the speed of the participant. The simulation was programmed such that if the participant increased his or her speed, then the tailgating car would also increase its speed by a similar amount. The tailgating car would continue to mimic the speed of the participant until it was traveling 15 mph above the speed limit, but would not drive faster than this. If the participant pulled into a gap in the slow moving traffic in the right lane, then the tailgating car increased its speed up to 15 mph above the speed limit and drove away. If the participant stayed in the left lane and maintained the same speed or reduced his or her speed, then the tailgating vehicle remained one car length behind and the slow moving traffic continued driving in the right lane until it reached mile 19.

2.2.3.6 Debriefing—After completing the experimental drive, the participant left the simulator vehicle. Then he or she completed a short questionnaire about the experience of driving in the simulator. The participant was then debriefed and paid.

Chapter 3
Results and Discussion

3.1 Phase 1: Survey

During Phase 1 of this research, 710 college students were surveyed. In the survey, we obtained demographic information, as well as information on the personality characteristics, the emotional state, and the driving behavior of the participants. The results of the survey are reported below

3.1.1 Demographic Information

The gender breakdown of the 710 participants was as follows: there were 252 male participants and 446 female participants (twelve participants did not indicate their gender). The age of the participants ranged from 18 to 45 years—the average age was 22.05 years (with a standard deviation of 3.45 years).

3.1.2 Hostility Differences

Self-reported hostility was normally distributed among the 710 participants and was negatively correlated with age ($r(362) = -0.16$, $p<0.002$), suggesting that younger individuals are more hostile than older individuals. Based on a median split, the hostility measure was used to assign the participants to high and low hostility categories. After this was done, the following differences between the participants in the high and low hostile categories emerged.

3.1.2.1 Psychological and Affective Predispositions—With regard to psychological and affective predispositions, when compared to those in the low hostile category, the participants in the high hostile category reported:

- Higher levels of experienced anger in response to rude gestures from other drivers ($t(701) = 4.44$, $p<0.001$).
- Higher levels of experienced anger in response to illegal driving by other drivers ($t(705) = 2.02$, $p<0.001$).
- Higher levels of experienced anger in response to the presence of the police ($t(705) = 6.61$, $p<0.001$).
- Higher levels of experienced anger in response to slow drivers ($t(705) = 8.21$, $p<0.001$).
- Higher levels of experienced anger in response to discourteous and rude driving by other drivers ($t(705) = 7.43$, $p<0.001$).
- Higher levels of experienced anger in response to roadway obstacles ($t(705) = 7.54$, $p<0.001$).

3.1.2.2 Behavior—With regard to behavior, when compared to those in the low hostile category, the participants in the high hostile category reported the following:

- Higher levels of physically aggressive behavior ($t(387) = 6.32$, $p<0.001$).
- Higher levels of verbally aggressive behavior ($t(387) = 7.01$, $p<0.001$).
- Higher levels of driving after drinking ($t(705) = 3.83$, $p<0.001$).
- Higher levels of speeding while driving ($t(705) = 4.51$, $p<0.001$).
- Higher levels of risky driving ($t(705) = 5.59$, $p<0.001$).

3.1.2.3. Summary of Hostility Differences—The participants in the high hostility category showed marked differences across the dispositional and reported behavior measure when compared with the participants in the low hostility category. Notably, the participants in the high hostility category experienced significantly higher levels of anger in the presence of the police and in response to slow drivers and to discourteous and rude driving by other drivers, as well as reporting that they engaged more often in driving after drinking, speeding, and risky driving behavior.

3.1.3 Gender Differences

As mentioned above, 252 male participants and 446 female participants took the survey (with twelve participants failing to indicate their gender). The survey responses of the male and female participants were compared.

3.1.3.1 Psychological and Affective Predispositions—With regard to psychological and affective predispositions, the following differences between male and female participants emerged:

- Female participants reported higher levels of experienced anger in response to rude gestures from other drivers ($t(691) = 5.57$, $p<0.001$) than male participants.
- Female participants reported higher levels of experienced anger in response to illegal driving by other drivers ($t(695) = 2.72$, $p<0.001$) than male participants.
- Female participants reported higher levels of experienced anger in response roadway obstacles ($t(695) = 2.16$, $p<0.001$) than male participants.
- Male participants reported higher levels of hostility ($t(696) = 4.36$, $p<0.001$) than female participants.

3.1.3.2 Behavior—With regard to behavior, the following differences between male and female participants emerged:

- Male participants reported higher levels of physically aggressive behavior ($t(380) = 8.84$, $p<0.001$) than female participants.
- Male participants reported higher levels of verbally aggressive behavior ($t(380) = 2.74$, $p<0.001$) than female participants.
- Male participants reported higher levels of driving after drinking ($t(695) = 4.66$, $p<0.001$) than female participants.
- Male participants reported higher levels of speeding while driving ($t(695) = 3.82$, $p<0.001$) than female participants.
- Male participants reported higher levels of risky driving ($t(695) = 3.77$, $p<0.001$) than female participants.

3.1.3.3. Summary of Gender Differences—The female participants experienced higher levels of anger in response to rude gestures from other drivers, illegal driving by other drivers, and roadway obstacles than the male participants. However, the male participants reported higher levels of hostility, higher levels of physically and verbally aggressive behavior and higher levels of driving after drinking, speeding, and risky driving behavior.

3.1.4 Factors that Predict Driving-Related Anger

We conducted two waves of regression analyses to examine the extent to which the set of personality, affective, and behavioral variables accounted for the anger that the participants

experience while they were driving. In the first wave of analyses, we used the entire set of variables from the personality and emotional state categories to determine the extent to which this larger set could account for variance in each dependent measure. In the second wave, we used only those variables that were significantly related to each dependent variable to determine the extent to which this refined set of variables accounted for variance in the dependent measures. [Please note, similar analyses examining self-reported driving behavior are described in section 3.1.5 below.]

3.1.4.1 Anger Due to Rude Gestures from Other Drivers—When the first regression analysis was conducted for this measure, using the full set of independent variables, the analysis accounted for a significant amount of variance in experiencing anger due to the rude gestures of other drivers ($R^2 = 0.26$, $F(39, 333) = 2.92$, $p<0.0001$). The following variables were the significant predictors:

- Verbal aggressiveness ($\beta = 0.26$, $t = 5.11$, $p<0.001$).
- Gender ($\beta = -0.21$, $t = 4.04$, $p<0.001$).
- Romantic problems ($\beta = 0.13$, $t = 2.63$, $p<0.009$).

Then, the second regression analysis was conducted, using only these three variables that showed a significant beta weight. This second analysis accounted for a significant amount of variance in the measure involving experiencing anger due to the rude gestures of other drivers ($R^2 = 0.11$, $F(3, 373) = 15.23$, $p< 0.0001$).

3.1.4.2 Anger Due to the Presence of the Police—The first regression analysis conducted using the full set of independent variables accounted for a significant amount of variance in experiencing anger due to the presence of the police ($R^2 = 0.25$, $F(39, 335) = 2.92$, $p<0.0001$). In this case, two variables were significant predictors:

- Hostility ($\beta = .24$, $t = 4.98$, $p<0.001$).
- Romantic problems ($\beta = .24$, $t = 4.96$, $p< 0.001$).

The second regression analysis, using only these two variables that showed a significant beta weight, accounted for a significant amount of variance in the measure involving experiencing anger due to the presence of police ($R^2 = 0.15$, $F(2, 385) = 33.24$, $p<0.0001$).

3.1.4.3 Anger Due to Slow Drivers—The regression analysis, in which we used the full set of independent variables, accounted for a significant amount of variance in experiencing anger due to slow drivers ($R^2 = 0.37$, $F(39, 335) = 5.10$, $p<0.0001$). The following three variables were significant predictors:

- Anger due to external situations ($\beta = .27$, $t = 5.91$, $p<0.001$).
- Romantic problems ($\beta = .20$, $t = 3.97$, $p< 0.001$).
- Friend problems ($\beta = .18$, $t = 3.58$, $p< 0.001$).

The second analysis, using only these three variables, accounted for a significant amount of variance in the measure involving experiencing anger due to slow drivers ($R^2 = 0.21$, $F(3, 384) = 33.09$, $p<0.0001$).

3.1.4.4 Anger Due to Discourteous and Rude Drivers—The first regression analysis using the full set of independent variables accounted for a significant amount of variance in experiencing anger due to discourteous and rude drivers ($R^2 = 0.36$, $F(39, 335) = 4.79$, $p<0.0001$). The following three variables were significant predictors:

- Anger due to external situations (β = .29, t = 6.01, p<0.001).
- Hostility (β = .18, t = 3.55, p<0.001).
- Romantic problems (β = .15, t = 3.16, p<0.002).

The second regression analysis using only these variables accounted for a significant amount of variance in the measure involving experiencing anger due to discourteous and rude drivers (R^2 = 0.20, F(3, 384) = 31.99, p<0.0001).

3.1.4.5. Anger Due to Roadway Obstructions—The first regression analysis using the full set of variables accounted for a significant amount of variance in experiencing anger due to roadway obstructions (R^2 = 0.31, F(39, 335) = 3.91, p<0.0001). There were three significant predictors:

- Anger due to external situations (β = .26, t = 5.60, p < 001).
- Romantic problems (β = .22, t = 4.86, p < .001).
- Verbal aggressiveness (β = .20, t = 4.31, p < .001).

When only these three variables were used in the second regression analysis, the analysis accounted for a significant amount of variance in the measure involving experiencing anger due to roadway obstructions (R^2 = 0.21, F(3, 383) = 34.31, p<0.0001).

3.1.4.6 Anger Due to Illegal Driving by Others—The first regression analysis using the full set of independent variables accounted for a significant amount of variance in the measure involving experiencing anger due to the illegal driving of others (R^2 = 0.15, F(39, 335) = 1.56, p<0.02). In this case there was only one significant predictor:

- Instrumental aggressiveness (β = -.19, t = 3.73, p < 001).

When only this variables was used in the second regression analysis, the analysis accounted for a significant amount of variance in the measure involving experiencing anger due to the illegal driving of others (R^2 = 0.04, F(1, 385) = 13.87, p<0.0001).

3.1.5 Factors that Predict Self-Reported Driving Behavior

As mentioned above, we also conducted two waves of regression analyses to examine the extent to which the set of personality, affective, and behavioral variables accounted for self-reported driving behavior—with the first wave of analyses utilizing the entire set of variables, and the second wave using only those variables that were significantly related to each dependent variable. The results of theses analyses are reported below.

3.1.5.1 Driving After Drinking—The first regression analysis with full set of independent variables accounted for a significant amount of variance in the measure involving driving after drinking (R^2 = 0.29, F(39, 335) = 3.58, p<0.0001). The following variables were significant predictors of this measure:

- Instrumental aggressiveness (β = .35, t = 6.33, p<0.001).
- Anger due to social situations (β = .20, t = 3.76, p<0.001).
- General anger experiences (β = .16, t = 3.40, p<0.001).
- Willingness to express anger (β = -.14, t = 2.58, p<0.01).
- Anger rumination (β = -.17, t = 3.15, p<0.002).

The second regression analysis, using only these five variables that showed a significant beta weight, accounted for a significant amount of variance in the driving after drinking measure (R^2 = 0.18, F(5, 378) = 16.39, p<0.0001).

3.1.5.2 Speeding—The first regression analysis, with the full set of independent variables accounted for a significant amount of variance in the speeding measure ($R^2 = 0.31$, $F(39, 335) = 3.81$, $p<0.0001$). Two variables were significant predictors:

- Instrumental aggressiveness ($\beta = .31$, $t = 6.11$, $p < 001$);
- Social competitiveness ($\beta = .18$, $t = 3.68$, $p < .001$).

The second regression analysis used only these two variables. This analysis accounted for a significant amount of variance in the speeding measure ($R^2 = 0.17$, $F(2, 384) = 38.74$, $p<0.0001$).

3.1.5.3 Risky Driving—The first regression analysis, using the full set of independent variables accounted for a significant amount of variance in the risky driving measure ($R^2 = 0.29$, $F(39, 335) = 3.42$, $p<0.0001$). The following two variables were significant predictors:

- Instrumental aggressiveness ($\beta = .31$, $t = 6.24$, $p<0.001$);
- Social competitiveness ($\beta = .18$, $t = 3.65$, $p<0.001$).

The second analysis using only these two variables accounted for a significant amount of variance in the risky driving measure ($R^2 = 0.17$, $F(2, 384) = 39.62$, $p<0.0001$).

3.2 Phase 2: Driving Simulation

The participants in Phase 2 of this research were selected on the basis of their responses to the survey conducted in Phase 1. Those with the most extreme high and low scores were selected. Sixty-seven of the 710 participants who took the Phase 1 survey were selected for Phase 2. All 67 were licensed drivers—35 (19 females and 16 males) were classified as having high hostility and 32 (15 females and 17 males) were classified as having low hostility. Each of these 67 participants drove for 19 miles on a four-lane freeway. During this drive they encountered three driving events. The results of these encounters are described below.

3.2.1 Event 1—Participant's Vehicle Blocked by Two Vehicles

The first event involved two vehicles that blocked the forward progress of the participant as he or she drove on the simulated freeway. The vehicles began blocking the participant after he or she had driven one mile on the simulated highway. One of the two vehicles dove in the left lane, while the other drove in the right lane. The two vehicles drove at a speed that was on average 5 mph slower than the speed at which the participant was driving. The two vehicles alternated lead position, but never left a gap large enough to allow the participant to overtake either vehicle—i.e., the gap between the two vehicles was never more than one-vehicle length, 14.5 ft (4.42 meters). The participant followed the pair of blocking vehicles for five miles. Then, at the 6-mile mark, the vehicle in the right lane vehicle exited the freeway on an exit ramp, and the vehicle in the left lane moved into the right lane.

To determine the effect of these blocking vehicles on the participant we examined the following driving measures.

- The number of times the participant changed lanes while following the obstructing vehicles.
- The mean following distance during the 5-miles at which the participant followed the obstructing vehicles.

We conducted an analysis of variance (ANOVA) to determine the effects of hostility level and gender on each of both of these measures. The results of these analyses are discussed in the next two subsections of this report.

3.2.1.1 Effect of Hostility Level and Gender on Number of Lane Changes—We examined the distribution of the number of times that the participants changed lanes in the 5-mile section of the freeway in which they were obstructed. This examination revealed that the distribution was highly positively-skewed—the skew value was 2.394 and the kurtosis was 6.017. Because it is not appropriate to use parametric statistics to analyze data with this much skew and kurtosis, we transformed the data using a logarithmic transformation, in which X, the original data values, were transformed to log (X+1). This transformation is recommended by Weiner, Brown, and Michels (1991, p 357) for data with the characteristics exhibited by the lane change data we obtained. The transformation normalized the data, reducing the skew and kurtosis values to 1.287 and 1.635, respectively. Then we conducted an ANOVA. Table 3.1 presents a summary of this ANOVA.

Table 3.1. Summary of the ANOVA examining the effects of hostility level and gender on the number of lane changes.

Source of variation	Degrees of freedom	Sum of Squares	Variance estimate	F-Value	*p*-value
Hostility Level	1	0.013	0.013	0.459	0.5005
Gender	1	0.058	0.058	2.064	0.1558
Interaction: Hostility Level x Gender	1	0.014	0.014	0.496	0.4838
Residual	63	1.761	0.028		

As Table 3.1 shows there were no statistically significant differences in the number of lanes changes lanes between the male and female participants or between the participants in the high and low hostility groups. However, it should be noted that there were three outliers—all from the high hostility group—who had a large numbers of lane changes in the 5-mile section of the freeway in which they were obstructed: Two of these outliers were high-hostility females who changed lanes seven times, and one was a high-hostility male who changed lanes six times.

3.2.1.2 Effect of Hostility Level and Gender on the Mean Following Distance—We also examined the distribution of the mean following distance of the participants while they were driving in the 5-mile section of the freeway in which they were obstructed. In this case, the skew and kurtosis values were low (they were 0.988 and 0.351, respectively). Consequently, it was not necessary to transform these data before conducting an ANOVA. A summary of the ANOVA conducted on the mean following distances is presented in Table 3.2.

Table 3.2. Summary of the ANOVA examining the effects of hostility level and gender on the mean following distance.

Source of variation	Degrees of freedom	Sum of Squares	Variance estimate	F-Value	*p*-value
Hostility Level	1	1,095.963	1,095.963	20.648	<0.0001
Gender	1	0.907	0.907	0.017	0.8964
Interaction: Hostility Level x Gender	1	0.349	0.349	0.007	0.9356
Residual	63	3,343.967	53.079		

Table 3.2 shows there was a statistically significant effect of hostility level on the mean following distance (at the $p<0.0001$ level). However, there was no gender effect and there was no interaction between hostility level and gender. The effect of hostility level is illustrated below in Figure 3.1.

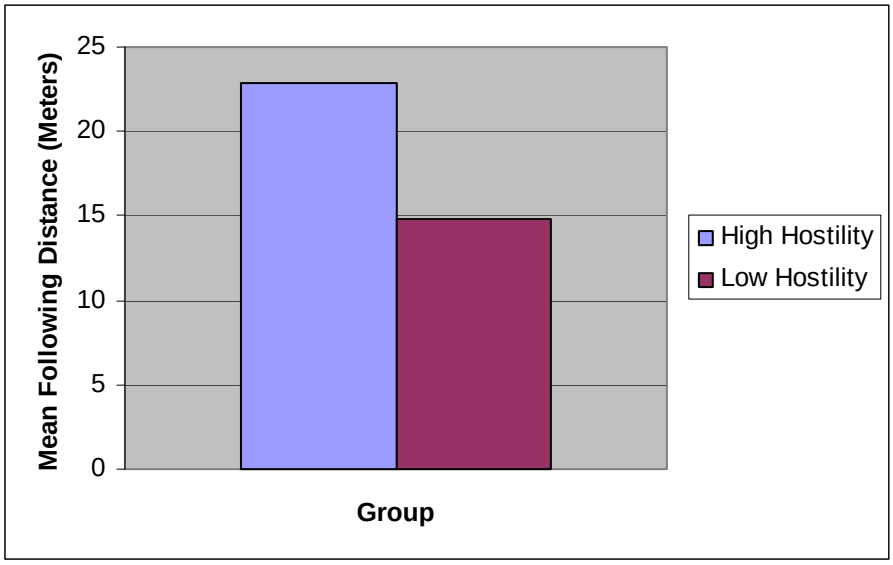

Figure 3.1. Mean following distance (meters) for the high hostility and low hostility groups.

As Figure 3.1 shows, the following distance between the participants and the two obstructing vehicles was considerably shorter for the high hostility group than it was for the low hostility group—the mean distances were 14.77 meters (48.47 feet), with a standard deviation of 6.39 meters (20.97 feet), for the high hostility group participants, and 22.87 meters (75.05 feet), with a standard deviation of 7.94 meters (26.05 feet), for the low hostility group participants.

If this result that was obtained in a driving simulator were to be replicated in real world driving, the following distance for the high hostility group would potentially be dangerous. The obstructing vehicles were programmed to drive at 5 mph below the speed at which the participant was driving. This means that, if the participant had been initially driving at the speed

limit of 55 mph, then the obstructing vehicles would have been traveling at 50 mph. At 50 mph, the following distance of 14.77 meters (48.47 feet) for the participants in the high hostility group is equivalent to a 0.66-seconds gap—this is far less than the typically recommended 2-second gap.

3.2.2 Event 2— Vehicle Cuts in Front of Participant

The second event involved a vehicle (a Jeep) that traveled 10 mph faster than the participant and passed him or her in the left lane. After overtaking the participant, the Jeep cut into the right lane two vehicle lengths ahead of the participant and abruptly slowed down to the same speed as the participant—so that the participant was likely to respond by braking to avoid a possible collision. The event occurred after the participant had driven seven miles on the simulated highway—i.e., one mile after the first event had ended.

Thirty participants did not experience the second event. This was for one of two reasons—either because they were driving in the left lane so that it was not possible for the Jeep to move from the left to the right lane and cut them off, or because they were traveling at an excessive speed so that the Jeep was unable to catch up with them before the scenario for Event 3 was programmed to begin.

The remaining 37 of the 67 participants did experience the cut-in event. Of these 37 participants, 17 were in the high hostility group and 20 in the low hostility group

The Jeep was programmed so that if the participant moved into the left lane and attempted to overtake it, at the moment that the participant's vehicle was level with the Jeep, it increased its speed to match the speed of the participant. Then, if the participant increased his or her speed in response, the Jeep also increased its speed. The Jeep was programmed to continue increasing speed until the participant was driving 15 mph above the speed limit. [It should be noted that none of the participants in this study continued to increase speed to this extent.]

On the other hand, if the participant did not overtake the Jeep but continued driving in the left lane, then after travelling for five miles, the Jeep reduced its speed to the speed limit and exited at the next ramp. If the participant gave up the attempt to overtake the Jeep, slowed down, and returned to the right lane, then the Jeep was programmed to reduce its speed to the speed limit and exited at the next ramp. With those participants who made no attempt to overtake the Jeep, but simply drove behind it, the Jeep was programmed to continue at the reduced speed for five miles and then leave the freeway on an exit ramp.

To determine the effect of the cut-in event on the driving behavior of the participants, we examined the following measures.

- The likelihood that the participant would apply the brakes.
- The likelihood that the participant would change lanes.
- The length of time from the moment that the Jeep cut into the right lane to the moment that the participant applied the brake.
- The length of time from the moment that the Jeep cut into the right lane to the moment that the participant began to move from the right to the left lane.

- The extent to which the participants who did slow down in response to being cut off by the Jeep reduced their speed.

Our analyses of the effect of hostility and gender on these measures of the cut-in maneuver are discussed below.

3.2.2.2. The Effect of Hostility Level and Gender on the Likelihood of Braking—The number of participants in the high hostility group and the low hostility group who did apply the brakes and did not apply the brakes in response to the cut-in maneuver is presented in Table 3.3.

Table 3.3. Number of participants in the high and low hostility groups who did and did not apply the brakes.

Group	Did Apply brakes	Did Not Apply Brakes	Total
High Hostility	12	5	17
Low Hostility	17	3	20
Total	29	8	37

We used the Fisher exact probability test to conduct a statistical comparison of the number of participants in the high and low hostility groups who did and did not apply the brakes. The test yielded a *p*-value of 0.4283, indicating that there was not a statistically significant difference in the number of participants in the high and low hostility groups who did and did not apply the brakes in response to the cut-in maneuver.

The number of participants who were male and female and did and did not apply the brakes is presented in Table 3.4.

Table 3.4. Number of male and female participants who did and did not apply the brakes.

Group	Did Apply Brakes	Did Not Apply Brakes	Total
Male	12	5	17
Female	17	3	20
Total	29	8	37

We also used the Fisher exact probability test to compare of the number of male and female participants who did and did not apply the brakes. The *p*-value obtained with the test was of 0.4283. There was no statistically significant difference in the number of male and female participants who did and did not apply the brakes in response to the cut-in maneuver.

3.2.2.2. The Effect of Hostility Level and Gender on the Likelihood of Changing Lanes—Similar analyses were performed to determine whether or not hostility level or gender had an effect on the likelihood that the participants would change lanes in response to the cut-in maneuver. The number of participants in the high hostility group and the low hostility group who changed lanes and did not change lanes is presented in Table 3.5.

Table 3.5. Number of participants in the high and low hostility groups who did and did not change lanes.

Group	Did Change Lanes	Did Not Change Lanes	Total
High Hostility	17	1	18
Low Hostility	13	6	19
Total	30	7	37

When we used the Fisher exact probability test to compare of the number of participants in the high hostility group with the number in the low hostility group who did and did not change lanes, we obtained a *p*-value of 0.0897. This indicates that there was not a statistically significant difference between the number of participants in the high hostility group and the number in the low hostility group who did and did not change lanes in response to the cut-in maneuver.

The number of participants who were male and female who changed lanes and did not change lanes is presented in Table 3.6.

Table 3.6. Number of male and female participants who did and did not change lanes.

Group	Did Change Lanes	Did Not Change Lanes	Total
Male	15	2	17
Female	15	5	20
Total	30	7	37

We used the Fisher exact probability test to compare of the number of male and female participants who did and did not change lanes in response to the cut-in maneuver. We obtained a *p*-value of 0.4165, which indicates that there was not a statistically significant difference in the number of male and female participants who changed lanes.

3.2.2.3. Effect of Hostility Level and Gender on the Response Time from the Cut-in to the Application of the Brake—We examined the distribution of the response times of the participants from the moment the Jeep cut in front of them to the moment that they began to apply the brakes. This examination revealed that the distribution was highly positively skewed, and that there were three extreme outliers, two females and one male, all three of whom were in the high hostility group—their braking response times were between 4 and 6 seconds. We transformed the data, using a logarithmic transform, in which *X*, the original data values, were transformed to log (*X*)—as recommended by Weiner, Brown, and Michels (1991, p 357). The transformation normalized the data, and resulted in skew and kurtosis values of 1.505 and 1.344, respectively. After the data were transformed the three pre-transformation outliers, mentioned above, were still extreme outliers. Therefore, the data from these participants were excluded—this reduced the skew and kurtosis values still further to 1.149 and 0.463, respectively. Then an ANOVA was conducted. A summary of this ANOVA is presented in Table 3.7.

Table 3.7. Summary of the ANOVA examining the effect on the response times to start braking of hostility level and gender.

Source of variation	Degrees of freedom	Sum of Squares	Variance estimate	F-Value	*p*-value
Hostility Level	1	0.064	0.064	5.123	0.0338
Gender	1	0.006	0.006	0.497	0.4880
Interaction: Hostility Level x Gender	1	0.005	0.005	0.427	0.5201
Residual	22	0.276	0.13		

As Table 3.7 indicates there was a statistically significant difference (at the p=.0338 level) in the braking response times of the two hostility groups. The gender of the participants did not have a significant effect.

The effect of hostility level is shown in Figure 3.2. Please note, in order to make the figure meaningful, it uses as the measure of central tendency the anti-logs of the means of the logarithmically transformed data used in the ANOVA.

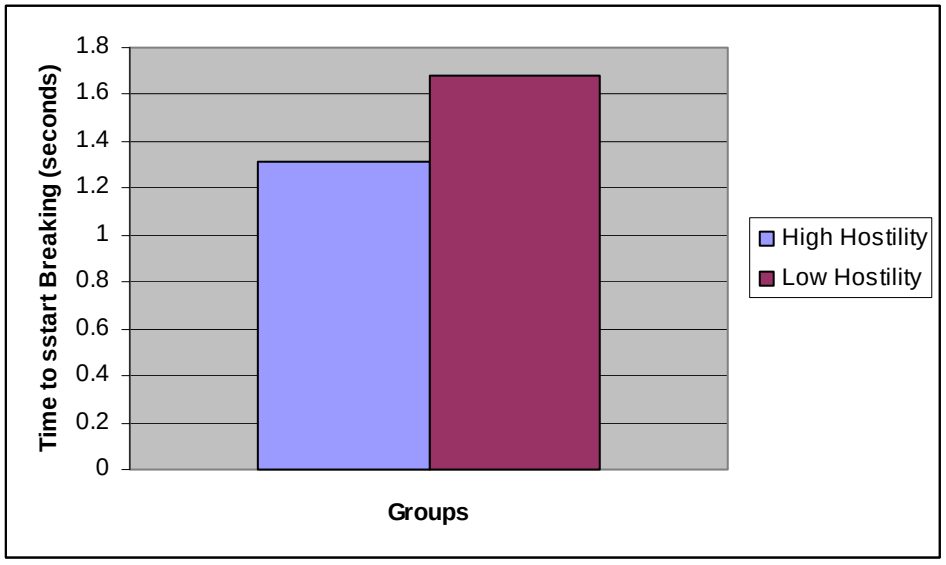

Figure 3.2. Time to start braking for the high hostility and low hostility groups.

Figure 3.2 shows that the time before high hostility group started to brake after the Jeep cut in was 1.31 seconds, while the time for the low-hostility group was 1.68 seconds.

3.2.2.4. Effect of Hostility Level and Gender on the Response Time from the Cut-in to the Initiation of the Lane Change—When we examined the distribution of the response times of the participants from the moment the Jeep cut in front of them to the moment that they initiated a lane change, we discovered that this distribution was highly positively skewed. Again we

transformed the data, using a logarithmic transform, in which *X*, the original data values, were transformed to log (*X*). The transformation normalized the data—after the transformation the skew and kurtosis values were -0.15 and -0.504, respectively. A summary of the ANOVA conducted on the transformed data is presented in Table 3.8.

Table 3.8. Summary of the ANOVA examining the effect on the response times to start changing lanes of hostility level and gender.

Source of variation	Degrees of freedom	Sum of Squares	Variance estimate	F-Value	*p*-value
Hostility Level	1	0.011	0.011	0.087	0.7706
Gender	1	0.051	0.051	0.398	0.5337
Interaction: Hostility Level x Gender	1	0.066	0.066	0.514	0.4802
Residual	25	3.207	0.128		

As Table 3.8 indicates there were no statistically significant effects related to the responses times to start changing lanes.

3.2.2.5. Effect of Hostility Level and Gender on Speed Reduction from the Cut-in to the Initiation of the Lane Change—Examination of the speed reduction data was relatively normal, with skew and kurtosis values of 0.850 and 0.739, respectively. However, there was one outlier: A female participant in the high hostility group reduced speed to a much larger extent than any other participant—her speed dropped by 67 km/h (41.6 mph), which was 30 km/h (18.7 mph) more any other participant. The data from this participant was omitted from the ANOVA conducted on the speed reduction data. A summary of this ANOVA is presented in Table 3.9.

Table 3.9. Summary of the ANOVA examining the effect on the reduction in speed of hostility level and gender.

Source of variation	Degrees of freedom	Sum of Squares	Variance estimate	F-Value	*p*-value
Hostility Level	1	64.911	64.911	1.138	0.2968
Gender	1	0.250	0.250	0.0004	0.9836
Interaction: Hostility Level x Gender	1	43.572	43.572	0.764	0.3902
Residual	25	1,369.310	57.055		

Table 3.9 indicates that there were no statistically significant differences in the reductions in speed that were related to the hostility level or the gender of the participant.

3.2.3 Event 3—Tailgating

The third event involved a vehicle approaching the rear of the participant's vehicle until it was one-car length away. After the participant had driven thirteen miles on the simulated highway, he or she approached a string of traffic traveling in the right lane at a speed approximately 5 mph slower than the participant. If the participant chose to remain behind the string of slow traffic, the tailgating event was not triggered and the participant remained behind the traffic for the rest of the scenario. On the other hand, if the participant moved into the left lane to pass the long stream of traffic, a car appeared from behind traveling at 15 mph faster than the participant. This car continued at that speed until it was one-car length behind the participant, at which point the tailgater drove at the same speed as the participant. The simulation was programmed so that if the participant drove faster, the tailgating car similarly increased speed up to 15 mph above the speed limit. If the participant pulled into a gap in the slow moving traffic in the right lane, the tailgating car increased its speed up to 15 mph above the speed limit and drove away. If the participant decreased his or her speed in the left lane, or maintained the same speed in the left lane, the slow moving traffic continued in the right lane until it reached mile 19.

To determine the effect of the tailgating vehicle we looked at the following driving measures.

- If participants reduced speed in response to the tailgating vehicle, we determined the extent to which they reduced speed.
- If participants increased speed in response to the tailgating vehicle, we determined the extent to which they increased their speed.

We analyzed of the effect of hostility and gender on these responses to the tailgating vehicle. The analyses are discussed below.

3.2.3.1. Effect of Hostility Level and Gender on Speed Reductions in Response to the Tailgating Vehicle

We found that there were 20 participants who reduced speed during the tailgating event. When we examined the distribution of the speed reduction data, we found that it had low skew and kurtosis values, so that it was not necessary to transform the data. The number of participants in the four categories of interest were relatively small—high hostility males (n=7), high hostility females (n=4), low hostility males (n=5), and low hostility females (n=4). Because the sample sizes were this small, rather than conduct an ANOVA, we conducted two t-tests—one testing the effect of hostility level (with the data collapsed across gender) and the other testing the effect of gender (with the data collapsed across hostility levels).

With the data collapsed across gender, the mean reductions in speed were 13.84 mph (22.27 km/hr) and 13.76 mph (22.15 km/hr) for the participants in the high and low hostility groups, respectively. The t-test comparing these means produced a *p*-value of 0.9696—indicating that there was no effect of hostility level on the extent to which the participants reduced speed in response to the tailgating vehicle.

When the data were collapsed across hostility levels, the mean reductions in speed were 14.24 mph (22.92 km/hr) and 13.09 mph (21.06 km/hr) for the male and female participants, respectively. When these means were compared using a t-test, we obtained a *p*-value of

0.5750—indicating that there was also no effect of gender on the extent to which the participants reduced speed in response to the tailgating vehicle.

3.2.3.2. Effect of Hostility Level and Gender on Speed Increases in Response to the Tailgating Vehicle

Thirty-five participants increased speed during the tailgating event. On examining the distribution of the speed reduction data we found that it was highly-positively skewed. We transformed the data using a log transform and then conducted two t-tests—one testing the effect of hostility level (with the data collapsed across gender) and the other testing the effect of gender (with the data collapsed across hostility levels) on the increases in speed.

Collapsing across gender, and then conducting a t-test on the transformed resulted in a *p*-value of 0.6467—indicating that there was no effect of hostility level on the extent to which the participants increased speed.

Similarly, when the data were collapsed across hostility levels and a t-test was conducted, the resultant *p*-value of 0.8757 indicated that there was also no effect of gender on the extent to which the participants increased speed in response to the tailgating vehicle.

The increases in speed of the 35 participants who did increase speed were similar in magnitude to the reductions of the 20 participants who slowed down. The increases in speed, indicated by the anti-logs of the means of the logarithmically transformed data, were 14.78 mph (23.79 km/hr) for the high hostility group, 13.91 mph (22.39 km/hr) for the low hostility group, 14.22 mph (22.89 km/hr) for the male participants, and 14.45 mph (23.26 km/hr) for the female participants who increased speed in response to the tailgating vehicle.

Chapter 4
Summary and Conclusion

4.1 Study Design

The goal of this two-phase study was to identify factors that might prompt aggressive driving behavior and to examine how those behaviors might be expressed in a simulated driving environment. During the first phase of the study, 710 people were surveyed—of these 252 were male, and 446 were female (twelve participants did not indicate their gender). The participants ranged in age from 18-45 years old (the average age was 22.05, with a standard deviation of 3.45 years). We selected the Phase 2 participants after examining the responses of the 710 participants in Phase 1. For Phase 2, we chose those participants who obtained the most extreme high and most extreme low scores with regard to hostility. Sixty-seven participants were selected—35 of them (19 female and 16 male) were classified as having high hostility, and 32 (15 female and 17 male) were classified as having low hostility. All 67 of these participants were licensed drivers

4.2 Survey

In Phase 1, the participants were asked to give information about their personality characteristics including hostility, anger expression, physical and verbal aggressiveness, competitiveness, and empathy; their emotional state including anger-provoking experiences, anger states, and negative thought patterns; and their behavioral tendencies with regard to driving.

4.2.1 Hostility

Self-reported hostility was normally distributed among the 710 participants and was negatively correlated with age suggesting that younger individuals are more hostile than older individuals. Based on a median split of this distribution, the hostility measure was used to assign the participants into either a high hostility group or a low hostility groups. Compared to the participants in the low hostility group, those in the high hostility group reported higher levels of experienced anger in response to rude gestures from other drivers; illegal driving by other drivers; the presence of the police; slow drivers; discourteous and rude driving by other drivers; and roadway obstacles. In addition, compared to those in the low hostility group, the high hostility participants reported higher levels of physically aggressive behavior; verbally aggressive behavior; driving after drinking; speeding while driving; and risky driving behavior.

4.2.2 Gender

We also compared the responses obtained from the male participants with the responses from the female participants. We found that compared to the males, the female participants reported higher levels of experienced anger in response to rude gestures from other drivers; illegal driving by other drivers; and roadway obstacles. However compared to the females, the male participants reported higher levels of hostility. The male participants also reported higher levels of physically aggressive behavior; of verbally aggressive behavior, of driving after drinking; of speeding while driving: and of risky driving.

4.2.3 Factors that Predict Driving Related Anger

We used regression analyses to determine factors that are associated with driving-related anger—including anger due to (1) rude gestures from other drivers; (2) the presence of the police; (3) slow drivers; (4) discourteous and rude drivers; (5) roadway obstructions; and (6) illegal driving by others. It should be noted that factors that apparently have little to do with driving situations emerge from these analyses: For example, romantic problems emerged as a factor associated with the first five driving-related anger measures. This suggests that individuals bring their personal situations into their vehicles when they drive, and that the strains and stresses of personal life may contribute to anger states while people are driving.

4.2.4 Factors that Predict Self-Reported Driving Behavior

We also conducted regression analyses to determine factors that are associated with self-reported driving behavior—including (1) driving after drinking; (2) speeding; and (3) risky driving. In this case, the analyses indicated that instrumental aggressiveness was associated with all three driving behaviors, and that social competitiveness was associated with both speeding and risky driving behavior. These associations suggest that a driver's affective predispositions may influence his or her driving behavior.

4.2.5 Conclusion

The survey results suggest that a complex set of factors may contribute to deviant driving. These factors include the driver's emotional and personal baggage, his or her affective and personality predispositions, and the circumstances that he or she encounters on the roadway.

4.3 Driving Simulation

In Phase 2, each participant drove for 19-miles on a simulated four-lane freeway. During the drive the participants encountered three events. In the first event, the participant was blocked by two vehicles, one in the right lane the other in the left. In the second event, the participant was passed by another vehicle which cut in and abruptly slowed down. And in the third event, a vehicle tailgated the participant. We assessed the responses to each of these events.

4.3.1 Event 1—Participant's Vehicle Blocked by Two Vehicles

We found that for the first event in response to being blocked, there were no differences that could be attributed to gender. However, the following distance for participants in the high hostility group was considerably shorter than the following distance for the participants in the low hostility group. The following distances were on average 14.77 meters (48.47 feet) for the high hostility group and 22.87 meters (75.05 feet) for the low hostility group. The obstructing vehicles were programmed to drive at 5 mph below the speed of the participant. If the participants had been driving at the speed limit of 55 mph then the obstructing vehicles would have traveled at 50 mph, and the following distance (in time) would have been 0.66 seconds for the high hostility participants—far shorter than the typically recommended 2 second following distance.

4.3.2 Event 2— Vehicle Cuts in Front of Participant
For the second event in which the participant was passed by another vehicle which cut in and abruptly slowed down, again there were no differences that could be attributed to gender. However, we found that participants in the high hostility group started breaking sooner than the participants in the low hostility group.

4.3.3 Event 3—Tailgating
For the third event, in which a vehicle tailgated the participant, in response 20 participants reduced speed and 35 increased speed—but there were no differences in the responses that could be attributed either to hostility or gender.

4.4 Conclusion

Previous studies on aggressive driving have failed to comprehensively address the factors that can precipitate aggressive driving. This study addressed that void. When drivers in the high hostility group were blocked by other vehicles ahead of them, they responded by driving much closer to the blocking vehicles than drivers in the low hostility group. This risky driving behavior, found in a driving simulator, validates the self reports given by the high hostile drivers in the surveys. This finding is likely to be of value for public safety organizations whose mission is to educate the public about potentially dangerous and risky behavior.

It is of interest that, although in the survey males self-reported higher levels of risky driving behavior than females, in the driving simulation study we did not find significant differences in the driving behavior of the male and female drivers.

It is not likely that all who are classified as high in hostility will engage in aggressive driving behavior. Further research may yield additional understanding on this point. Issues that need to be addressed by future research include: (1) whether or not people with high hostility levels who drive aggressively are amenable to self-corrective measures; (2) whether or not those with high hostility levels recognize that aggressive driving behavior is counter-productive and that they need to change their driving behavior; and (3) whether or not they can be trained to self-correct their behavior.

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