Journal	MSP No.	Dispatch: August 29, 2015	CE: Anjana
AB	13-205.R3(21627)	No. of Pages: 11	PE: Adrianne Cook

AGGRESSIVE BEHAVIOR
Volume 9999, pages 1–11 (2015)

Psychometric Examination and Validation of the Aggressive Driving Scale (ADS) (Accepted)

Q1 Q1Yiqi Zhang[1], Rebecca J. Houston[2], and Changxu Wu[3]*

[1]Department of Industrial and Systems Engineering, the State University of New York (SUNY)-Buffalo, Buffalo, NY
[2]Research Institute of Addiction, the State University of New York (SUNY)-Buffalo, Buffalo, NY
[3]Department of Industrial and Systems Engineering, the State University of New York (SUNY)-Buffalo, Buffalo, NY

Aggressive driving behavior is an important cause of traffic accidents. Based on the recent view that aggressive driving is one way that trait aggression manifests itself, a growing research area has focused on the development of scales to assess aggressive driving. The aggressive driving scale (ADS) analyzed in the present study consists of 24 items. A sample of 276 participants was analyzed to obtain the factor structure and reliability of the ADS and 67 of them participated in the behavioral experiment in order to examine the construct and predictive validity of the scale. Results indicated a 3-factor structure (interference with other drivers, violations/risk taking, and anger/aggression expression behavior) with high item loadings. The ADS had high internal consistency and test–retest reliability. Construct validity of the ADS was established as the ADS subscale scores correlated significantly with trait measures of anger and aggression. Predictive validity of the ADS was verified as most items were significantly correlated with behavioral measures derived from a driving simulator. The ADS was a significant predictor of behavioral measures both in the simulated environment (i.e., frequency of driving off the road, red light running behavior, frequency of colliding with a vehicle, frequency and distance of over speeding, frequency and distance of central crossing) and reported real world situations (i.e., annual moving violations and accidents). These results suggest that the ADS is a reliable and valid tool in evaluating aggressive driving behavior as the current study provides behavioral support for the effectiveness of the ADS in measuring aggressive driving behavior. Aggr. Behav. 9999:1–11, 2015.

Keywords: aggressive driving scale; aggressive driving behavior; factor structure; scale validation

INTRODUCTION

Aggressive driving is a major cause of traffic accidents and injury. US Statistics indicated 55.7% of fatal crashes from 2003 to 2007 involved one or more actions associated with potentially aggressive driving (American Automobile Association, 2009). Among the list of aggressive actions, speeding was identified as the number one driver-related factor that contributed to crashes reported in Fatality Analysis Reporting System (FARS, American Automobile Association, 2009). Because aggressive driving has become a serious problem in the United States, research has focused on the development of instruments for measuring aggressive driving behavior (Deffenbacher, Getting, & Lynch, 1994; Deffenbacher, Lynch, Oetting, & Swaim, 2002; DePasquale, Geller, Clarke, & Littleton, 2001; Dula & Ballard, 2003; Harris et al., 2014; Mouloua, Brill, & Shirkey, 2007).

Driving aggression was defined by Hennessy and Wiesenthal (2001) as "any behavior intended to physically, emotionally, or psychologically harm another within the driving environment" (p. 661). In an effort to formulate consistent definitions of aggressive driving, Dula and Geller (2003) reviewed relevant works and summarized three dimensions of aggressive driving behavior: intentional acts of aggression toward others, negative emotions experienced while driving, and risk-taking behavior. Soole, Lennon, Watson, and Bingham (2011) summarized the definitional and operational inconsistencies of aggressive driving behavior in the literature and proposed the definition of aggressive driving that can be distinguished from Q2 the definition of Q2

*Correspondence to: Changxu Wu, Department of Industrial and Systems Engineering, the State University of New York (SUNY)-Buffalo, Buffalo, NY 14260. E-mail: seanwu@buffalo.edu

Received 21 October 2013; Revised 4 August 2015; Accepted 12 August 2015

DOI: 10.1002/ab.21627
Published online XX Month Year in Wiley Online Library (wileyonlinelibrary.com).

risky driving. In the current study, aggressive driving behavior refers to "any behavior directed at another road user and intended to cause a negative physical or psychological impact (such as injury, distress, or discomfort, even if only mild) in an attempt to achieve a goal and that is accompanied by negative affect such as anger or rage" (Soole et al., 2011, p.75). Examples of aggressive driving behavior include rude gesturing, flashing high beams at slower traffic, racing from traffic lights or through traffic, and intentionally tailgating, speeding, and honking (Soole et al., 2011). It is worth noting that some driving behavior may have multiple motivations that can be categorized to either aggressive driving behavior or risking driving behavior in different circumstances. Driving behaviors such as tailgating, speeding, and honking were examples of aggressive driving behavior only when there was hostility, reactivity, or intent to harm involved.

Considerable research efforts have been made toward exploring the relation between general aggression and driving aggressive behavior. Lajunen and Parker (2001) studied the relation between general aggressiveness, driver anger, and aggressive driving and concluded that the relationship between driver anger and aggressive behavior was influenced by the characteristics of the traffic situation. Specifically, verbal driver aggression was mediated by driver anger, whereas physical driver aggression was related to general aggressive behavior directly. A later study suggested that general aggression showed little to moderate association with accident and traffic violations (Herzberg & Schlag, 2006). Nesbit, Conger, and Conger (2007) found a moderate and positive association between anger and aggressive driving. In terms of the effect of different types of anger, the study concluded that different types of anger (trait-based, state-based, or situation-specific) did not have differential influences on aggressive driving behavior. Following this study, Abdu, Shinar, and Meiran (2012) specifically examined the relation between state anger and driving behavior. They found driving behavior was associated with state anger with an increase in risk taking. In general, anger has also been associated with aggressive driving responses to offensive drivers (Blankenship, Nesbit, & Murray, 2013; Wickens, Wiesenthal, Flora, & Flett, 2011). Although previous studies have suggested an association between general aggression and aggressive driving, researchers are still examining the extent to which drivers express their aggression through driving behavior. Therefore, research has turned to the development of traffic-related aggression measurements to measure aggressive driving behavior directly.

Since the aggressive driving questionnaire of Parry's (1968), several subsequent scales have referred to it as a source for items on their inventories (Glendon et al., 1993; Krahé & Fenske, 2002; Lawton, Parker, Manstead, & Stradling, 1997; Turner, Layton, & Simons, 1975). This scale was built on the premise that aggressive thoughts and behavior was provoked by vehicles; however, it has been argued by other investigators that aggressive driving is a reflection of a more general trait that leads individuals to be aggressive in a variety of situations (e.g., Macmillan, 1975).

The driver behavior questionnaire (DBQ; Reason, 1990) was originally developed as a general instrument to assess errors and violations in driving behavior. Errors refer to factors that can limit driving performance such as those related to perception, attention, and information processing capability, while violations reflect the style and habits developed after years of driving. Errors and violations resulted from different psychological processes and should be treated differently (Lajunen, Parker, & Summala, 2004). Subsequently, new items were added into the violation scales (Lawton et al., 1997) and the factor analysis of this extended scale indicated three factors: errors, highway code violations, and more interpersonally aggressive violations. The propensity for angry driving scale (PADS) measures the relationship of trait driving anger to state driving anger, aggressive and risky behavior, and accident-related outcomes (DePasquale et al., 2001). The PADS (2001) was established to develop an assessment tool to identify individuals with the greatest propensity to become angry with others while driving (DePasquale et al., 2001). Factor analysis suggested only one factor and the validity of the original scale was established by the authors and other researchers who have used the scale in different nations, such as British (Maxwell, Grant, & Lipkin, 2005) and Australian (Leal & Pachana, 2009). The Dula dangerous driving index (DDDI) was developed to measure the likelihood of dangerous driving (Dula & Ballard, 2003). It has three subscales that evaluate (i) aggressive driving, (ii) negative emotional driving, and (iii) risky driving. The reliability and construct validity of the scale have been tested in different cultures, including Chinese (Qu, Ge, Jiang, Du, & Zhang, 2014), French (Richer & Bergeron, 2012), and Romanian (Iliescu & Sârbescu, 2013).

The aggressive driving behavior questionnaire (ADBQ; Mouloua et al., 2007) is a scale developed to estimate the likelihood of engaging in aggressive driving behavior. The scale comprised 20 items which were selected from five existing driving behavior scales, including the driver behavior questionnaire (DBQ; Parker, Lajunen, & Stradling, 1998), driver anger expression inventory (DAEI; Deffenbacher et al., 2002), the driving angry thoughts questionnaire (DATQ; Deffenbacher, Deffenbacher, Lynch, &

Richards, 2003), and the driver anger scale (DAS; Deffenbacher et al., 1994). A factor analysis indicated six factors: anger/aggression, absentmindedness, speeding/minor infractions, judgment of other drivers, overt expression, and miscellaneous (Brill & Mouloua, 2011). The predictive validity of this questionnaire was tested in a simulated environment, which indicated several aggressive behavior measurements were significantly correlated with the composite scores of the ADBQ (Brill, Mouloua, Shirkey, & Alberti, 2009).

The aggressive driving scale (ADS), examined in the present study, was developed by Krahé and Fenske (2002). This scale focuses almost exclusively on observable behavior and, therefore, relies less on an individual's self-perception. The ADS consists 24 items, including 11 items from the extended version of DBQ (Lawton et al., 1997), 3 items from Macmillan (1975), 6 items from Parry (1968), and a further 4 items added through authors' observation of aggressive driving behavior. The response format for the ADS is a 5-point scale on which respondents indicated how often they show a particular driving behavior ranging from "0" = never to "4" = very often. The original study (Krahé & Fenske, 2002) with 154 men participated indicated good internal consistency ($\alpha = .83$) as did a later study of 256 women with $\alpha = .87$ (Krahé, 2005). This scale was also included in a summary on road rage and aggressive driving questionnaires (van Rooy, Rotton, & Burns, 2006). However, further psychometric work is needed to assess and explore the structure and validity of this scale.

The goal of the current study was to extend the extant information on the psychometric properties and validation of the ADS in a community sample of both men and women. We conducted the factor analysis to determine whether the ADS contains subscales that might be useful in determining those factors associated with and contributing to aggressive driving behavior. Internal consistency and test–retest reliability of the ADS was also verified. Construct validity was established by correlating ADS scores with scores on previously well-validated measures, including the Buss–Perry aggression questionnaire (BPAQ; Buss & Perry, 1992) which evaluates aggression expression, and the state-trait anger expression inventory (STAXI; Spielberger, Gorsuch, & Lushene, 1970) which assesses situational anger expression. We examined predictive validity of the ADS by performing an empirical study with respect to aggressive driving behavior in the simulated environment and using measures of self-reported real world violations. In order to test the predictive validity of the measurement of aggressive driving behavior, previous studies have mainly relied on other self-report measures, which is a limitation in this kind of research (Dahlen & Ragan, 2004). A previous investigation has also suggested measures taken in a simulated environment could be used to assess whether the questionnaire predicts aggressive driving (Brill et al., 2009). Thus, the current study was designed to extend the research in this area by validating a self-report measure of aggressive driving behavior using both self-report and behavioral measures to examine predictive validity.

METHODS

Participants

Phone interview. The phone interview was completed by 286 participants (125 males and 161 females) located in the western New York area before the recruitment of the behavioral experiment. Participants were recruited via newspaper and radio advertisements. All participants reported having driven a vehicle in the past year and were between the ages of 21 and 53 years ($M = 33.7$; $SD = 8.0$). In terms of race/ethnicity, 67.8% identified themselves as Caucasian, 27.3% African-American, 1.4% answered with Hispanic, .7% Asian, and 2.8% identified themselves as a different race or multiple races. Participants were not paid to complete the phone interview.

Laboratory study and in-person evaluation. Sixty-seven participants (25 males and 42 females) located in the western New York area participated in the empirical laboratory portion of the study. Participants were recruited through the phone interview if they were eligible for the laboratory study. Inclusion criteria for the laboratory study included age 22–45 years, English speaking, valid US driver's license, and having driven a vehicle within the past 6 months. The age range for this study was restricted to minimize effects of lack of driving experience (for younger drivers) and aging effects related to aggressive behavior and behavioral indices (e.g., reaction time) during the driving simulation (Krahé, 2005; Krahé & Fenske, 2002). Participants with a history of seizures, neurosurgery, head injury with a loss of consciousness >10 min, mental retardation, report of serious psychiatric disorder, or serious medical disorders, self-reported drug dependence (excluding nicotine), and current use of psychoactive medications were excluded from the current experiment to avoid confounds on behavioral measures of driving behavior. Participant ages ranged from 22 to 45 years with an average age of 30.7 years ($SD = 7.99$) and an average education level of 14.8 years ranging from 12 to 18 years ($SD = 1.92$). In terms of race and ethnicity, the sample was 72.6% Caucasian, 22.6% African-American, 1.6% Native American, and 3.2% other. Participants were compensated with a total of $30 in completing the laboratory session.

Materials

All participants completed the following self-report measures before performing the driving task.

Demographic questionnaire. This questionnaire included information about participants' demographic background, such as age, gender, education level, and estimated annual household income.

Driving history survey. This contained questions regarding driving history such as estimated annual mileage, the year a US driver's license was first issued, and prior crash or violation history as well as information on the participant's vehicle such as horsepower.

Aggressive driving scale (ADS). This 24-item scale was developed by Krahé & Fenske (2002) and assesses aggressive driving behavior. Participants were asked to indicate the frequency of aggressive behavior they engage in by rating each statement on a 5-point scale ("0" = never to "4" = very often). An example item is "How often do you become angered by another driver and give chase with the intention giving him/her a piece of your mind?" The ADS was administered as part of the phone interview and as part of the empirical laboratory study.

Buss–Perry aggression questionnaire (BPAQ). This questionnaire was designed to measure an individual's propensity for aggressive behavior and related factors such as anger and hostility. Although the items on the BPAQ are not necessarily specific to driving behavior, it is possible that respondents could consider the driving context an ideal setting for experiences addressed by specific items. Given this and prior research demonstrating associations between the BPAQ and aggressive/angry driving, we have included it as a measure of construct validity. It is a 29-item questionnaire in which participants rank certain statements along a 5-point continuum from "extremely uncharacteristic of me" to "extremely characteristic of me." In the current sample, Cronbach's α for the BPAQ total score = .86. Four subscales are also derived: physical aggression ($\alpha = .79$), verbal aggression ($\alpha = .77$), anger ($\alpha = .78$), and hostility ($\alpha = .76$) (Buss & Perry, 1992).

State-trait anger expression inventory (STAXI). The STAXI is a self-report scale measuring anger. Participants were asked to complete part 3 of the STAXI which involves rating 32 items according to how they generally react when angry or furious on a 4-point scale ("1" = almost never to "5" = almost always). Four kinds of anger scores were obtained: anger expressed outward ($\alpha = .74$), anger expressed inward ($\alpha = .78$), anger controlled outward ($\alpha = .85$), and anger controlled inward ($\alpha = .84$) (Spielberger, 1983).

Apparatus

The driving task was completed using a STISIM® driving simulator (STISIMDRIVE M100K, Systems Technology, Inc., Hawthorne, CA; see Fig. 1). The driving simulator consists of a Logitech Momo® steering wheel with force feedback, a gas, and a brake pedal (Longitech, Inc., Fremont, CA). The driving scenario was presented on a 27-inch LCD with 1920×1200 pixels resolution.

Procedure

Phone interview. Participants were assessed through a brief set of questions administered over the phone in order to be recruited for the laboratory study. Participants provided verbal consent. The interview contained questions regarding demographic information (e.g. age, education, and race/ethnicity), driving history, and primary vehicle characteristics. Participants were also administered the aggressive driving scale (ADS) during the phone interview.

Laboratory study. Upon arrival at the laboratory, participants were asked to sign an informed consent form, completed the questionnaires, and then performed the driving simulation task. As noted, 67 participants completed the in-person evaluation, which included a re-administration of the ADS as well as questions on demographic information, driving history, the BPAQ, and the STAXI. Mean time between phone interview and in-person evaluation was 93.8 days ($SD = 42.4$; Range: 2–144; Median = 113). Next participants were trained for the driving task by completing a practice block. Participants were asked to operate the driving simulator by following normal traffic laws as if they were driving a vehicle in the real world. During this training session, participants were required to drive for a one-mile distance with normal road events to familiarize them with the driving environment and the types of road

Fig. 1. The driving simulator used in the experiment.

events. This also allowed them to learn to operate the driving simulator including the steering wheel, speedometer, brake, and gas pedal. After the training segment, they completed the test block which involved driving an eight-mile distance in a two-lane local environment. Normal road events included pedestrians crossing the road, barriers in the road, intersections with traffic lights, and speed limit signs. Each type of event occurred 15 times during the test block and was randomly arranged throughout the block without overlapping. Ten behavioral measures were obtained from the driving simulation task including average speed, lane deviation frequency, frequency of collision with a barrier, a pedestrian, or a vehicle, running against a red traffic light, frequency and distance of speeding, and frequency and distance of central crossing.

RESULTS

Descriptive Analyses

Demographic measurements and driving information for telephone interview and empirical study are provided in Tables I and II, respectively. Ten participants from the phone interview sample ($N = 286$) were excluded in further analyses because they had either no valid US driving license or no driving experience in the last 6 months. The remaining sample ($N = 276$) was used for the factor analysis and internal consistency analysis. The assessment sample from the empirical study was used in the test–retest reliability analysis and validity analyses.

Factor Analysis ($N = 276$)

Using data from the phone interview sample ($N = 276$), a principal component analysis (PCA) was conducted on the 24 ADS items with oblique rotation. The Kaiser–Meyer–Olkin measure verified the sampling adequacy for the analysis (KMO = .91), which falls into the range of being superb (Hutcheson & Sofroniou, 1999). Bartlett's test of sphericity χ^2 (276) = 2535.32, $P < .001$, indicated that correlations between items were sufficiently large enough for PCA. Five components were obtained with the eigenvalues over 1.0 according to Kaiser's criterion (1960) and in combination explained 56.38% of the variance.

A 3-factor solution was suggested by the scree plot and parallel analysis (see Fig. 2). This solution accounted for 47.38% of the variance with communalities (i.e., percentage of indicator variance accounted for by the solution) ranged from .30 to .64. The 2-factor extraction accounted for 41.27% of the variance with communalities ranging from .27 to .64 and 3-item cross-loadings. The 1-factor extraction accounted for 33.18% of the variance with communalities range from .17 to .51, which explained less of the variance. Based on Costello and Osborne's (2005) criteria for factor extraction the 3-factor solution was selected because it had the least item cross-loadings and no factors with fewer than three items. Table III shows the initial eigenvalues and variance explained by each factor. The summary of the loadings values of each item in the rotated factor matrix was also provided with loading values less than .30 being suppressed (Costello & Osborne, 2005). By examining the item loading on these factors, specific themes were defined based on the content of items among each factor. The first factor, defined as interference with other driver (interference), included ten items with the item "Get so annoyed by another driver passing you on a fast road

TABLE I. Demographic and Driving Information for Phone Sample (Mean [SD])

	Men ($n = 125$)	Women ($n = 161$)
Age (years)	33.27 (7.49)	34.06 (8.40)
Education (years)	14.74 (2.25)	14.78 (2.03)
% White/Caucasian	68.8%	67.1%
% Married	42.4%	36.0%
% Employed full-time	75.2%	52.2%
ADS total scores	25.8 (12.9)	22.6 (12.8)
Annual mileage		
<5,000 miles	2.4%	8.1%
5,000–7,500 miles	8.8%	16.8%
7,501–12,000 miles	17.6%	31.1%
12,001–20,000 miles	39.2%	34.8%
>20,000 miles	32.0%	9.3%
Total ADS score	25.84 (12.86)	22.63 (12.75)
Interference	5.26 (4.69)	4.23 (4.34)
Violations/risk taking	13.13 (5.71)	11.37 (6.40)
Anger/aggression expression	7.45 (4.39)	7.03 (4.19)

TABLE II. Demographic and Driving Information for Assessment Sample (Mean [SD])

	Men ($n = 25$)	Women ($n = 42$)
Age (years)	30.7 (8.1)	30.7 (8.0)
Education (years)	14.5 (2.1)	15.0 (1.8)
% White/Caucasian	68.0%	69.0%
% Married	20.0%	28.6%
% Employed full-time	72.0%	52.4%
ADS total scores	30.0 (20.4)	25.9 (14.8)
Annual mileage		
<5,000 miles	4.0%	19.1%
5,000–7,500 miles	4.0%	16.7%
7,501–12,000 miles	20.0%	14.3%
12,001–20,000 miles	44.0%	47.6%
>20,000 miles	28.0%	2.4%
# of years licensed	13.5 (8.2)	11.9 (8.2)
# moving violations	4.7 (7.8)	1.6 (2.1)
% reporting past involvement in traffic accident(s)	64.0%	59.5%

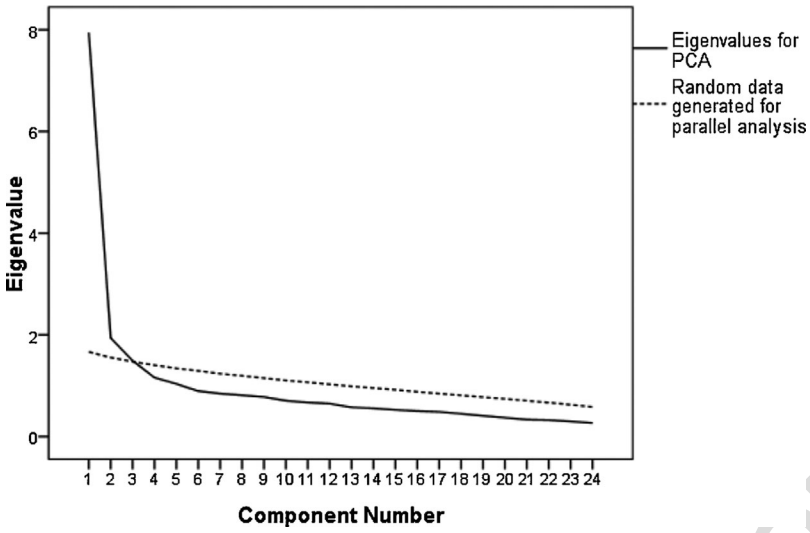

Fig. 2. The scree plot from the principal components analysis.

blowing his horn that you might chase him?" holding the strongest loading (.77). Nine items loaded on the second factor interpreted as violation of road rules/risk taking (violation/risk taking) with the item "Disregard the speed limit on a residential road" obtaining the strongest loading (.84). The final factor contained five items common to "Anger/aggression expression." The item "Swear out loud at other drivers" best described this factor with loading value (.80). This 3-factor solution fulfilled the criteria for factor extraction because it had the only two item cross-loadings and no factors with fewer than three items (Costello & Osborne, 2005).

Descriptive Statistics ($N = 276$)

The mean total ADS score for the phone interview sample was 24.03 ($SD = 12.88$). With regard to gender, an ANOVA indicated that on the total ADS score men ($M = 25.84$, $SD = 12.86$) scored significantly higher than women ($M = 22.63$, $SD = 12.75$; $F(1, 284) = 1.02$, $P < .01$; $d = .25$). Based on the above factor structure, the mean scores for the three ADS subscales (interference, violation/risk taking, anger/aggressive expression) for the whole sample were 4.68 ($SD = 4.52$), 12.14 ($SD = 6.16$), and 7.21 ($SD = 4.27$), respectively. As shown in Table I, ANOVA results indicated that men scored significantly higher than women on violation/risk taking subscale ($F(1, 284) = 5.82$, $P < .05$, $d = .29$), but there were no significant gender differences of scores on interference ($F(1, 284) = 3.72$, $P = .055$; $d = .23$) or anger/aggressive expression ($F(1, 284) = .67$, $P = .41$; $d = .10$).

Reliability

Internal consistency ($N = 276$). In terms of the internal consistency, the internal consistency (Cronbach's α) was .91 for the original 24 items of ADS. Internal consistency values for the three retained subscales derived from the PCA were good with Cronbach's α values ranging from .80 to .85 (Table III).

Test–retest reliability ($N = 67$). Test–retest reliability was conducted for the 67 participants who completed the ADS both during the phone interview and the laboratory evaluation. Test–retest reliability for the ADS total scores was high with a reliability coefficient of .93. The test–rest reliability for three subscales (interference, violation, and anger/aggression expression) were .89, .88, .89, respectively.

Construct Validity ($N = 67$)

Construct validity was examined for the 67 participants that completed the ADS, the BPAQ, and the STAXI during the laboratory study. The intercorrelation between interference and violation subscales was $r = .62$ ($P < .01$). That between interference and anger expression was $r = .67$ ($P < .01$) and between violation and anger expression was $r = .55$, ($P < .01$). Table IV presents correlations between the three ADS subscales and total scores and other anger/aggression measures. In general, the ADS total scores were significantly correlated with the physical aggression, verbal aggression, and anger scores on the BPAQ and all anger indices on the STAXI with moderate associations. As expected, anger expression factors on the STAXI were positively related to aggressive driving behavior, whereas measures of anger control on the STAXI were negatively associated with such behavior on the ADS with moderate correlation coefficients. The ADS interference scores were significantly correlated with BPAQ Verbal

TABLE III. Loading Values of Items on Aggressive Driving Questionnaire ($N = 276$)

Scale Item (Number)	Factor 1	Factor 2	Factor 3
How often do you get so annoyed by another driver passing you on a fast road blowing his horn that you might chase him? (14)	.77		
How often do you get into fights with other drivers? (20)	.76		
How often do you try to edge another car off the road? (17)	.72		
How often do you become angered by another driver and give chase with the intention of giving him/her a piece of your mind? (1)	.56		
How often do you get so annoyed at another driver that you pull in front of him, braking suddenly to show him/her your annoyance? (24)	.54		
If the driver behind you has his/her lights shining in your mirror, how often to you try to pay him back in some way? (21)	.51		
How often do you get angry at being overtaken and accelerate while the other driver is overtaking you? (7)	.44		
How often do you pull out of a junction so far that the driver with right of way has to stop and let you out? (4)	.42		
How often do you flash your headlights at other drivers to make faster progress? (22)	.42		
How often do you try to get the better of other drivers? (15)	.40		
How often to you disregard the speed limit on a residential road? (11)		.85	
How often do you disregard the speed limit on a motorway? (13)		.80	
How often do you drive so close to the car in front that it would be difficult to stop in an emergency? (6)		.70	
How often do you overtake a slow driver on the inside? (3)		.57	
How often do you race away from traffic lights with the intention of beating the driver next to you? (9)		.51	
How often to you stop another car from pulling into your lane in front of you? (23)		.47	
How often do you cross a junction knowing that the traffic lights have already turned against you? (5)		.46	
How often do you take a chance to arrive on time? (16)		.45	
How often do you stay in a lane that you know will be closed ahead until the last minute before forcing your way into the other lane? (2)		.44	
How often do you swear out loud at other drivers? (19)			−.80
How often do you swear under your breath at other drivers? (12)			−.80
How often do you sound your horn to indicate your annoyance to another driver? (8)			−.66
How often do you become angered by a certain type of driver and indicate your hostility by whatever means you can? (10)			−.55
How often do you make rude signs at other motorists when you were provoked? (18)	.46		−.49
Initial eigenvalues	7.96	1.94	1.47
Variance explained (%)	33.18	8.09	6.12
Cronbach's α	.85	.82	.80

aggression whereas the ADS anger/aggression expression scores were significantly negatively correlated with BPAQ verbal aggression. The interference scores were also significantly correlated with the anger scores on the BPAQ.

Predictive Validity ($N = 67$)

Predictive validity based on behavioral experiment. Separate regression analyses were further performed to determine whether the ADS total scores predicted aggressive driving behavior in a simulated environment. ADS total scores were calculated by summing the scores for all the 24 items. Two regression models were run for each behavioral variable from the driving simulation task, and in each age and gender were entered first followed by the ADS total scores. Table V showed the results of these regressions. ADS total scores significantly predicted frequency of driving off the road ($t(63) = 3.245$, $P < .01$), frequency of colliding with a vehicle ($t(63) = 3.651$, $P < .001$), running red light ($t(63) = 4.423$, $P < .001$), over speeding frequency ($t(63) = 4.854$, $P < .001$) and distance of over speeding ($t(63) = 6.404$, $P < .001$), central crossing frequency ($t(63) = 4.298$, $P < .001$), and distance of central crossing ($t(63) = 2.795$, $P < .01$), respectively. Separate regression analyses were performed for each behavioral variable with age and gender were entered first followed by the three subscale scores of ADS. The results suggested that violation/risk taking subscale scores significantly predicted horn duration ($t(61) = 2.395$, $P < .05$). Anger/aggression expression subscale scores marginally predicted central crossing frequency ($t(61) = 1.961$, $P = .05$).

Predictive validity based on self-report. Stepwise multiple regression analysis was then conducted to determine whether the ADS total scores and subscale scores could significantly predict the number of reported real world violations and number of times being involved in an accident. Gender and age were entered at Step 1, scores of subscale of BPAQ and STAXI were then entered at Step 2 and Step 3, respectively, and the ADS total score was entered at Step 4 in each analysis.

TABLE IV. Relation Between ADS Subscales and Aggression/Anger Measures ($N = 67$)

	Interference	Violations/Risk Taking	Anger/Aggression Expression	ADS Total Score
BPAQ				
Physical aggression score	.14	−.10	−.11	.41**
Verbal aggression score	.26*	−.16	−.28*	.33**
Anger score	.24*	−.08	−.14	.47***
Hostility score	.11	−.17	−.13	.15
STAXI				
Expression out score	.20	−.08	.01	.44***
Anger expression in score	.05	.03	−.22	.44***
Anger control out score	−.17	.14	.12	−.39**
Anger control in score	−.05	−.01	−.01	−.48***

Note. *$P < .05$; **$P < .01$; ***$P < .001$.

The results of the analyses are shown in Table VI and indicate that the ADS total score significantly predicted the annual moving violation frequency ($t(36) = 2.81$, $P < .01$) and the number of accidents involved ($t(36) = 2.24$, $P < .05$). When the subscale scores were entered at Step 4 instead of ADS total scores, interference was a significant predictor of annual moving violation frequency ($t(34) = 2.85$, $P < .01$). Neither violations/risk taking ($t(34) = 1.06$, $P = .30$) nor anger/aggression expression ($t(34) = -.59$, $P = .56$) were significant predictors of annual moving violation frequency. None of subscale scores were significant predictors of number of accidents involved: interference ($t(34) = 1.14$, $P = .26$), violation/risk taking ($t(34) = -.81$, $P = .43$), and anger/aggression expression ($t(34) = .19$, $P = .85$).

TABLE V. Prediction of Aggressive Behavior in Simulated Environment Using ADS Total Scores ($N = 67$)

Variables	Standardized β (Std. Error)	R^2	ΔR^2	t
DV: Frequency of driving off the road				
Gender	.28 (.11)			2.43*
Age	.02 (.01)	.06	.06	.21
ADS total score	.38 (.00)	.20	.14	3.26**
DV: Frequency of vehicle hit				
Gender	−.14 (.18)			−1.27
Age	−.34 (.01)	.12	.12	−3.09**
ADS total score	.41 (.01)	.27	.16	3.65**
DV: Red light running				
Gender	−.15 (.66)			−1.50
Age	−.43 (.04)	.17	.17	−4.12***
ADS total score	.46 (.02)	.37	.20	4.42***
DV: Over speed frequency				
Gender	−.04 (.89)			−.41
Age	−.52 (.05)	.20	.20	−5.21***
ADS total score	.48 (.03)	.42	.22	4.85***
DV: Over speed distance				
Gender	−.26 (3.75)			−3.04**
Age	−.48 (.23)	.27	.27	−5.63***
ADS total score	.56 (.11)	.56	.29	6.40***
DV: Central cross frequency				
Gender	−.16 (.90)			−1.45
Age	−.31 (.06)	.11	.11	−2.88**
ADS total score	.47 (.03)	.31	.21	4.30***
DV: Central cross distance				
Gender	−.16 (.69)			−1.37
Age	−.35 (.04)	.13	.13	−3.01**
ADS total score	.32 (.02)	.23	.10	2.80**

Note. *$P < .05$; **$P < .01$; ***$P < .001$.

TABLE VI. Prediction of Frequency of Annual Moving Violations ($N = 67$)

Variables	Standardized β (Std. Error)	t	R^2	ΔR^2
DV: Frequency of annual moving violation				
Gender	.04 (.22)	.24		
Age	−.33 (.01)	−2.35**	.06	.01
BPAQ physical aggression	.04 (.23)	.18	.24	.13
BPAQ verbal aggression	−.00 (.03)	−.01		
BPAQ anger	.29 (.04)	1.11		
BPAQ hostility	.35 (.02)	2.05*		
STAXI anger expression out	.02 (.04)	.11	.29	.10
STAXI anger expression in	−.13 (.02)	−.88		
STAXI anger control out	.45 (.04)	1.95		
STAXI anger control in	−.01 (.03)	−.06		
ADS	.47 (.01)	2.81**	.42	.24
DV: Number of accidents being involved				
Gender	.46 (.69)	2.75*		
Age	−.15 (.04)	.90	.07	.01
BPAQ physical aggression	.59 (.07)	2.69*	.32	.19
BPAQ verbal aggression	−.14 (.12)	− .68		
BPAQ anger	.03 (.11)	.11		
BPAQ hostility	.21 (.08)	1.19		
STAXI anger expression out	.23 (.13)	.91	.42	.20
STAXI anger expression in	−.23 (.08)	− 1.27		
STAXI anger control out	.76 (.14)	2.35*		
STAXI anger control in	−.19 (.10)	− .88		
ADS	.48 (.03)	2.24*	.51	.30

Note. *$P < .05$; **$P < .01$.

DISCUSSION

In recent years, the topic of aggressive drivers has received increasing attention. The aggressive driving scale (ADS) is one of the current questionnaires designed to measure aggressive driving behavior. Unfortunately, little work has been done to explore the structure and validity of the ADS. Therefore, the current study examined the factor structure and predictive validity of ADS using a driving simulation task. A 3-factor solution was found to provide good internal consistency and explained 56.52% of the variance. The three factors were identified as Interference with other drivers, violations/risk taking, and anger/aggression expression behavior.

This study indicated excellent internal consistency for the ADS total score ($r = .91$), similar to previous studies (Krahé, 2005; Krahé & Fenske, 2002). In addition, this extends evidence of the internal consistency to a mixed gender sample as the prior studies examined men and women separately. The internal consistency values for the three ADS subscales were also very high, suggesting that they may each be useful for assessing specific aspects of aggressive driving behavior. Test–retest reliability of the ADS total score, which had not been previously demonstrated, was also excellent ($r = .93$).

In the examination of the construct validity of ADS, the anger/aggression expression factor was significantly negatively correlated with verbal aggression. The items on this factor refer more to actual behavioral expression (e.g. sounding the horn, making rude gestures, and flashing the headlights) rather than verbal expression (e.g., swearing at other drivers). There are only two items related to verbal expression compared to seven items related to anger expression using behavior on the anger/aggression expression subscale. The sample used in the empirical study was composed of nearly twice as many women (62.6%) as men. Thus, replication and extension of the construct validity results would be beneficial to our understanding of potential gender difference with regard to the assessment of aggressive driving behavior.

Furthermore, a main focus of the study was on the predictive validity of the ADS by measuring and recording participants' driving behavior in a simulated environment. Regression analyses were performed that examined whether ADS total scores and each subscale of the ADS predicted the aggressive driving behavior exhibited in the driving simulation tasks. The ADS total scores significantly predicted seven aggressive behavior criteria measured in the simulated environment, which suggested a good predictive validity of the scale for aggressive behavior. Violation/risk taking subscale scores significantly predicted one of the aggressive

driving behavior criteria, whereas anger/aggression expression subscale scores marginally predicted one of the aggressive driving behavior criteria when controlling for age and gender. Subscale scores predicted fewer aggressive behavior criteria than the ADS total scores might be due to the fact that aggressive behavior indicators measured in the study were not uniquely related to one of the subscales, but related to multiple subscales. These results support the predictive validity of the ADS and suggest it is an appropriate tool to measure aggressive driving behavior. This predictive validity is further strengthened by the assessment of driving behavior in a simulation task given the systematic response biases and social desirability issues that may limit self-report measures.

The additional finding that the ADS total score is a significant predictor of real world moving violations and accidents, controlling for demographic, and trait anger and aggression, also supports the validity of the scale. Age was found to be negatively associated with the total scores which was consistent with previous studies reporting that aggressive driving behavior declines with age (Krahé, 2005; Krahé & Fenske, 2002). A limitation of the present study is that the simulated driving session did not capture other real world aggressive driving behavior (such as verbal expressions or non-verbal gestures). Future work should determine if the ADS is predictive of actual aggressive driving on the road. Another potential limitation of the current study is that participants' driving behavior in the simulator task could have been influenced by completing the ADS prior to the task. Future work examining the relation between the ADS and simulated or real-world driving behavior should consider and control for possible priming effects.

In general, the ADS could be used to identify, study, and intervene on drivers prone to drive aggressively. An advantage of the ADS is that it focuses exclusively on observable behavior and thus relies less on an individual's self-perception. Therefore, the psychometric information from the current study should add to the literature in this area.

REFERENCES

Abdu, R., Shinar, D., & Meiran, N. (2012). Situational (state) anger and driving. *Transportation Research Part F: Traffic Psychology and Behaviour*, *15*, 575–580.

American Automobile Association. (2009). Aggressive driving: Research update. Foundation for Traffic Safety. Retrieved from: http://www.aaafoundation.org/pdf/AggressiveDrivingResearchUpdate2009.pdf.

Blankenship, K. L., Nesbit, S. M., & Murray, R. A. (2013). Driving anger and metacognition: The role of thought confidence on anger and aggressive driving intentions. *Aggressive Behavior*, *39*, 323–334.

Brill, J. C., & Mouloua, M. (2011). Exploration of the factor structure and internal consistency of the aggressive driving behavior questionnaire (ADBQ). *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *55*, 1361–1365. doi: 10.1177/1071181311551283

Brill, J. C., Mouloua, M., Shirkey, E., & Alberti, P. (2009). Predictive validity of the aggressive driver behavior questionnaire (ADBQ) in a simulated environment. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *53*, 1334–1337. doi: 10.1177/154193120905301836

Buss, A. H., & Perry, M. (1992). The aggression questionnaire. *Journal of Personality and Social Psychology*, *63*, 452. doi: 10.1037/0022-3514.63.3.452

Costello, A. B., & Osborne, J. W. (2005). Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis. *Practical Assessment Research & Evaluation*, *10*, Available online: http://pareonline.net/getvn.asp?v=10&n=7.

Dahlen, E. R., & Ragan, K. M. (2004). Validation of the propensity for angry driving scale. *Journal of Safety Research*, *35*, 557–563. doi: 10.1016/j.jsr2004.09.002

Deffenbacher, J. L., Deffenbacher, D. M., Lynch, R. S., & Richards, T. L. (2003). Anger, aggression, and risky behavior: A comparison of high and low anger drivers. *Behaviour Research and Therapy*, *41*, 701–718. doi: 10.1016/S0005-7967(02)00046-3

Deffenbacher, J. L., Getting, E. R., & Lynch, R. S. (1994). Development of a driving anger scale. *Psychological Reports*, *74*, 83–91. doi: 10.2466/pr0.1994.74.1.83

Deffenbacher, J. L., Lynch, R. S., Oetting, E. R., & Swaim, R. C. (2002). The driving anger expression inventory: A measure of how people express their anger on the road. *Behaviour Research and Therapy*, *40*, 717–737. Retrieved from: http://www.ncbi.nlm.nih.gov/pubmed/12051489.

DePasquale, J. P., Geller, E. S., Clarke, S. W., & Littleton, L. C. (2001). Measuring road rage: Development of the propensity for angry driving scale. *Journal of Safety Research*, *32*, 1–16. doi: 10.1016/S0022-4375(00)00050-5

Dula, C. S., & Geller, E. S. (2003). Risky, aggressive, or emotional driving: Addressing the need for consistent communication in research. *Journal of Safety Research*, *34*, 559–566. doi: 10.1016/j.jsr2003.03.004

Dula, C. S., & Ballard, M. E. (2003). Development and evaluation of a measure of dangerous, aggressive, negative emotional, and risky driving. *Journal of Applied Social Psychology*, *33*, 263–282. doi: 10.1111/j.1559-1816.2003.tb01896.x

Glendon, A. I., Dorn, L., Matthews, G., Gulian, E., Davies, D. R., & Debney, L. M. (1993). Reliability of the driving behavior inventory. *Ergonomics*, *36*, 719–726. doi: 10.1080/00140139308967932

Harris, P. B., Houston, J. M., Vazquez, J. A., Smither, J. A., Harms, A., Dahlke, J. A., & Sachau, D. A. (2014). The prosocial and aggressive driving inventory (PADI): A self-report measure of safe and unsafe driving behavior. *Accident Analysis & Prevention*, *72*, 1–8.

Hennessy, D. A., & Wiesenthal, D. L. (2001). Gender, driver aggression, and driver violence: An applied evaluation. *Sex Roles*, *44*, 661–676. doi: 10.1023/A:1012246213617

Herzberg, P. Y., & Schlag, B. (2006). Brennpunkt: Aggression und aggressivität im straßenverkehr [aggression and aggressiveness on the road]. *Zeitschrift für Sozialpsychologie*, *37*, 73–86. doi: 10.1024/0044-3514.37.2.73

Hutcheson, G. D., & Sofroniou, N. (1999). *Factor analysis. The multivariate social scientist: Introductory statistics using generalized linear models (pp 217–249)*. London: SAGE Publications. Retrieved from: http://books.google.com/books?id=NiF4-8lvf0C.

Houston, J., Harris, P., & Norman, M. (2003). The aggressive[Q5] driving behavior scale: Developing a self-report measure of unsafe driving practices. *North American Journal of Psychology*, *5*, 269–278. Retrieved from: http://www.najp.8m.com.

Q5

Iliescu, D., & Sârbescu, P. (2013). The relationship of dangerous driving with traffic offenses: A study on an adapted measure of dangerous driving. *Accident Analysis & Prevention*, *51*, 33–41. doi: 10.1016/j.aap.2012.10.014

Krahé, B. (2005). Predictors of women's aggressive driving behavior. *Aggressive Behavior*, *31*, 537–546. doi: 10.1002/ab.20070

Krahé, B., & Fenske, I. (2002). Predicting aggressive driving behavior: The role of macho personality, age, and power of car. *Aggressive Behavior*, *28*, 21–29. doi: 10.1002/ab.90003

Lajunen, T., & Parker, D. (2001). Are aggressive people aggressive drivers? A study of the relationship between self-reported general aggressiveness, driver anger and aggressive driving. *Accident Analysis & Prevention*, *33*, 243–255. doi: 10.1016/S0001-4575(00)00039-7

Lajunen, T., Parker, D., & Summala, H. (2004). The manchester driver behaviour questionnaire: A cross-cultural study. *Accident Analysis & Prevention*, *36*, 231–238. doi: 10.1016/S0001-4575(02)00152-5

Lawton, R., Parker, D., Manstead, A. S. R., & Stradling, S. G. (1997). The role of affect in predicting social behavior: The case of road traffic violations. *Journal of Applied Social Psychology*, *27*, 1258–1276. doi: 10.1111/j.1559-1816.1997.tb01805.x

Leal, N. L., & Pachana, N. a. (2009). Validation of the Australian propensity for angry driving scale (Aus-PADS). *Accident Analysis & Prevention*, *41*, 1112–1117. doi: 10.1016/j.aap.2009.06.023

Macmillan, J. (1975). *Deviant drivers (p. 272)*. Westmead, UK: Saxon House. Retrived from: http://trid.trb.org/view.aspx?id=141822.

Maxwell, J. P., Grant, S., & Lipkin, S. (2005). Further validation of the propensity for angry driving scale in British drivers. *Personality and Individual Differences*, *38*, 213–224. doi: 10.1016/j.paid.2004.04.002

Mouloua, M., Brill, J. C., & Shirkey, E. (2007). Gender differences and aggressive driving behavior: A factor analytic study. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *51*, 1283–1286. doi: 10.1177/154193120705101850

Nesbit, S. M., Conger, J. C., & Conger, A. J. (2007). A quantitative review of the relationship between anger and aggressive driving. *Aggression and Violent Behavior*, *12*, 156–176. doi: 10.1016/j.avb.2006.09.003

Parker, D., Lajunen, T., & Stradling, S. (1998). Attitudinal predictors of interpersonally aggressive violations on the road. *Transportation Research Part F: Traffic Psychology and Behaviour*, *1*, 11–24. doi: 10.1016/S1369-8478(98)00002-3

Parry, M. H. (1968). *Aggression on the road: A pilot study of behaviour in the driving situation*. London: Tavistock Publications. Retrived from: http://trid.trb.org/view.aspx?id=1211097.

Qu, W., Ge, Y., Jiang, C., Du, F., & Zhang, K. (2014). The Dula dangerous driving index in China: An investigation of reliability and validity. *Accident Analysis & Prevention*, *64*, 62–68. doi: 10.1016/j.aap.2013.11.004

Reason, J. (1990). *Human error*. New York, NY: Cambridge University Press. Retrived from: http://books.google.com/books?id=WJL8NZc8lZ8C&printsec=copyright#v=onepage&q&f=false.

Richer, I., & Bergeron, J. (2012). Differentiating risky and aggressive driving: Further support of the internal validity of the Dula dangerous driving index. *Accident Analysis & Prevention*, *45*, 620–627. doi: 10.1016/j.aap.2011.09.014

Schroeder, P., Kostyniuk, L., & Mack, M. (2013). *2011 national survey of speeding attitudes and behavior* (No. DOT HS 811 865). Retrived from: http://trid.trb.org/view.aspx?id=1280998.

Spielberger, C. D., Gorsuch, R. L., & Lushene, R. E. (1970). Manual for the state-trait anxiety inventory. Retrived from: http://hdl.handle.net/10477/2895.

Soole, D. W., Lennon, A. J., Watson, B. C., & Bingham, C. R. (2011). Towards a comprehensive model of driver[Q6] aggression: A review of the literature and directions for the future. In C. N. Ferraro (Ed.), *Traffic safety* (pp 69–97). Nova Science Publishers.

Turner, C. W., Layton, J. F., & Simons, L. S. (1975). Naturalistic studies of aggressive behavior: Aggressive stimuli, victim visibility, and horn honking. *Journal of Personality and Social Psychology*, *31*, 1098.

van Rooy, D. L., Rotton, J., & Burns, T. M. (2006). Convergent, discriminant, and predictive validity of aggressive driving inventories: They drive as they live. *Aggressive Behavior*, *32*, 89–98. doi: 10.1002/ab

Wickens, C. M., Wiesenthal, D. L., Flora, D. B., & Flett, G. L. (2011). Understanding driver anger and aggression: Attributional theory in the driving environment. *Journal of Experimental Psychology: Applied*, *17*, 354.