Dimensions of driving-related emotions and behaviors: An exploratory factor analysis of common self-report measures

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ABSTRACT

Objective: A wide variety of driving self-report measures are purported to assess drivers' behaviors and emotions. However, little is known about the underlying factor structure of these measures. This study examined the factor structure of several self-report measures frequently utilized in the assessment of driving-related behaviors and emotions.
Design: Cohort survey in a large sample (n = 287) of young adults (mean age = 19.91 years, SD = 1.65).
Results: Exploratory factor analysis revealed a four-factor structure that included reckless driving behaviors, negative driving-related emotions, aggressive driving behaviors in response to perceived transgressions from other drivers, and perceived aggressive driving behaviors from other drivers. Aggressive driving behaviors not performed in response to other drivers loaded onto both aggressive driving-related factors.
Conclusions: The factor structure derived in the present study suggests considerable overlap in the content across commonly administered driving self-reports, while also suggesting four distinct dimensions of self-reported driving emotions and behaviors. Whereas some of these dimensions have been explored considerably in the literature (e.g., negative emotions), others deserve further exploration (e.g., perceived aggressive driving behaviors from other drivers). Implications for clinical practice and future investigations are discussed.

1. Introduction

Over 26 million Americans under age 25 are licensed drivers, representing approximately 12% of all drivers in the United States (Office of Highway Policy Information, 2016). Young adults are also at especially high risk of collision (Williams, 2003), which can be at least partially explained by their tendencies to broadly engage in more dangerous driving behaviors, drive more aggressively and have more disregard for traffic laws and violations (Krahé and Fenske, 2002; McKnight and McKnight, 2003; Yagil, 1998).

Given the high volume of young drivers, a wide variety of driving behaviors are routinely demonstrated on the road such as courteous actions (e.g., allowing others to merge on the highway), accidental errors (e.g., backing up and nearly hitting another car), intentional transgressions (e.g., running a red light), and responses to the actions of other drivers (e.g., honking horn after being cut off). Driving behaviors vary significantly in the extent to which they may pose a safety risk to other drivers, and researchers utilize drivers' frequencies of engaging in different behaviors in order to make inferences about everyday driving-related emotions and actions. Some work has further sought to characterize drivers into risk subgroups based on these behaviors, which are

hypothesized to represent underlying personality traits manifested behind the wheel (Marengo et al., 2012). Literature in this area has helped guide societal-level changes (e.g., urban planning, traffic policies) with the ultimate goal of helping improve safety for road users and reduce collision frequency (Aarts and Van Schagen, 2006; McCartt et al., 2003).

Driving questionnaires (i.e., self-reports) are one of the most common means of assessing behaviors and emotions associated with driving. In comparison to task-based measures (e.g., driving simulators, on-road evaluations), self-report measures are relatively inexpensive or sometimes even free to acquire and administer. They are also less time-consuming, and unlike on-the-road evaluations do not require the evaluator to potentially put their own life at risk (Lajunen and Summala, 2003; Ulleberg and Rundmo, 2003). Additionally, while some have criticized self-report measures in other academic areas as being inherently subjective and prone to social desirability biases, prior work suggests that driving self-report measures (e.g., the Driving Behavior Questionnaire) are resistant to these effects (Lajunen and Summala, 2003).

A variety of questionnaires have been previously utilized to assess different aspects of driving, which reflect the multitude and complexity

of driving-related emotions and behaviors that constitute part of one's subjective experience behind the wheel. Anger and anxiety have been found to be especially salient while driving as well as linked to unsafe driving behaviors (Bernstein et al., 2017). As such, a considerable body of literature has explored these emotions via questionnaires (Dahlen et al., 2005; Deffenbacher et al., 2003; Parker et al., 2002; T. Zhang et al., 2015). Drivers may experience these emotions due to factors unrelated to driving (e.g., having a predisposition toward anger-associated behaviors more broadly) (Taubman–Ben-Ari et al., 2016), or they may be the immediate consequence of a negative interaction with or perceived slight from a fellow road user (T. Zhang and Chan, 2016). Behaviors measured using self-reports range both in terms of intentionality and severity; whereas some behaviors reported are unintentional mistakes that may or may not affect or even be noticed by nearby drivers, other behaviors are seen as intentional actions that directly impact the well-being and safety of other drivers (Özkan et al., 2006; Reason et al., 1990).

Aggressive driving behaviors are one of the most frequently assessed via self-reports (Danaf et al., 2015; Przepiorka et al., 2014; T. Zhang and Chan, 2016). However, while aggressive driving is seen as a deliberate action and most aggression researchers agree that aggressive behaviors are partially explained by the amount of anger experienced in a situation (Shinar, 1998), some driving questionnaires purported to assess aggressive driving solely measure the behaviors themselves and do not explicitly tap the emotional component (H. Zhang et al., 2017). Moreover, disagreement persists as to whether aggressive driving solely constitutes responsiveness to perceived transgressions from other drivers, or if some aggressive driving behaviors may be performed in the absence of anger-provoking stimuli and thus may be rooted in other psychological causes (Lajunen and Parker, 2001; Tasca, 2000).

Within the driving self-report literature, there is a tendency to include relatively few, if any, existing driving self-report measures when establishing the convergent or discriminant validity of a new measure (Blanchard et al., 2000; Parker et al., 1995; Wiesenthal et al., 2000). Additionally, with such a myriad of self-report measures in circulation, it may be difficult for some researchers to determine which questionnaires are most suitable to help answer their research questions. The use of so many driving questionnaires within the literature also reduces the comparability of findings across studies, as there is greater variability in the specific questionnaires being utilized between otherwise similar studies.

To date, no studies have explored whether multiple self-report driving measures examine similar or differing constructs. The present study aimed to address this gap in the literature by evaluating similarities and differences in the constructs assessed by a wider array of commonly-used measures, thus allowing for an appreciation of constructs individual measures uniquely assess, as well as constructs that are captured by multiple measures and thus show evidence of redundancy in their content. In doing so, the present study sought to enhance understanding about the specific contributions individual driving measures make toward comprehending an individual's subjective driving-related thoughts, behaviors and emotions. Equipped with such information, other researchers and clinicians might in turn be better prepared to choose the measures that most accurately assess their target facets of driving. These decisions might also reduce participant or patient time spent completing measures that may assess similar or identical constructs. Given the exploratory nature of the present study and the dearth in literature regarding the content and number of constructs that underlie driving self-report measures, no a-priori hypotheses regarding the factor analysis were proposed.

2. Materials & methods

2.1. Procedure

This study was approved by the Louisiana State University Institutional Review Board. Participants were recruited from the undergraduate student pool and offered course credit in their psychology courses in return for their participation. Inclusionary criteria included that participants be native English speakers and over the age of 18. Participants were also required to be licensed drivers and presently drive on a weekly basis at least five miles per week. To ensure high quality data, five validity check questions were included throughout the survey (e.g., "If you are reading this, select Never"). Individuals who failed any validity check questions were excluded from analyses (n = 2).

2.2. Participants

A total of 287 participants were recruited from the undergraduate student pool, met all inclusionary and exclusionary criteria and were included in analyses. Participants had a mean of 19.91 years of age (SD = 1.65, range = 11). The sample was predominantly female (84.0%) and not Hispanic or Latino (90.9%). A total of 84.2% of participants were Caucasian, while 10.5% were African-American, 4.2% were Asian, and 1.0% reported being of another race. Participants reported driving a mean of 129.6 miles (SD = 130.0, range = 995) on a weekly basis. Recruitment took place over a two-week period in March 2018.

2.3. Measures

Measures were selected based on their recent and repeated use in the literature. Each measure included in the current study was utilized in published manuscripts in peer-reviewed journals within the past ten years. Within this timeframe, each measure also appeared in two or more manuscripts beyond their initial validation publication. Only measures that were freely accessible online or from the measure's creator without monetary cost were selected. Content of all measures selected was related to either emotions experienced while driving, behaviors enacted while driving, or a combination of the two. Measures that assessed facets of driving not pertaining to previously experienced emotions or behaviors while driving were not included in order to limit the scope of the questionnaires to participants' direct observations (e.g., beliefs about driving: Driving Appraisal Inventory) (Cutler et al., 1993).

When available, brief or shortened versions of questionnaires were selected in lieu of full versions due to participant time constraints. To both avoid redundancy and examine associations between individual domains across measures, only subscale scores (and not total scores) were included in analyses when a measure included subscale scores. When a measure did not include subscale scores, the total score was used in analyses.

Brief descriptions of each of the measures used in the present study are included in Table 1. A total of 11 questionnaires were completed and included in the factor analysis. Participants completed the measures in the order they are presented in the table. All questionnaires were completed online using Qualtrics software (qualtrics.com). Questionnaires traditionally completed via paper-and-pencil means were modified to allow for online completion. The survey took approximately thirty minutes to complete.

2.4. Analyses

Statistical software Mplus was used to compute the factor structure and SPSS was used for all other data analyses. Exploratory factor analysis (EFA) was used as a statistical data reduction technique in order to determine underlying constructs that overlap across questionnaires. We expected that the resulting factors would correlate and thus elected an oblique (Geomin) rotation. Parallel analysis (Horn, 1965) was used to determine the maximum number of factors to extract. In this method, eigenvalues of a sample are compared to those generated from random data sets, thus allowing for the largest number of factors to be under

Table 1
Summary of Questionnaires Included in Factor Analysis.

Measure	Acronym	Domain	Subscales	Scoring	Items	Reliability in Previous Work	Reference	Reliability in Present Study
Aggressive Driving Behaviors Scale	ADBS	Engage in aggressive driving practices toward other drivers	Conflict; speeding	1 (Never) to 6 (Always) Likert scale	11	Alpha: Conflict .73; Speeding .68	Houston, Harris & Norman (2003)	Conflict: .87; Speeding: .81
Deffenbacher Driving Anger Scale	DAS	Anger experienced in response to typical anger-provoking situations encountered while driving	Hostile gestures; illegal driving; police presence; slow driving; discourtesy; traffic obstructions	0 (Not at all) to 5 (Very Much) Likert scale	33	Alpha: .78 to .87 across subscales	Deffenbacher, Oetting & Lynch (1994)	.76 to .88 across subscales
Distracted Driving Scale	DDS	Use devices while driving	N/A	0 (Never) to 6 (over 75% of the time) Likert scale	17	Alpha; 89	Hill, Rybar, Styler, Fram, Merchant & Eastman (2015)	.81
Driver Mobility Questionnaire-A	DMQ-A	Avoid driving in various situations	Internal environment; external environment	0 (Never Avoid) to 4 (Always Avoid) Likert scale	11	Alpha: internal environment .90, external environment .95	Baldock et al. (2006); Wong et al. (2015)	Internal: .80; External: .85
Driving Aggression Indicator Scale	DAIS	Aggressive driving behaviors (1) enacted toward others (i.e., Self), and (2) perceived from others toward self (i.e., Other)	Self hostile aggression and revenge; self aggressive warning; other hostile aggression and revenge; other aggressive warning	0 (Never) to 5 (Nearly All the Time)	24	Alpha: .75 to .89 across subscales	Ozkan & Lajunen (2000); Ozkan et al. (2011)	.82 to .87 across subscales
Driving Behavior Questionnaire	DBQ	Engage in aberrant driving behaviors	Lapses; Errors; Violations	1 (Never) to 6 (Nearly All The Time) Likert scale	24	Test-retest: .50 to .76 across subscales	Reason et al., (1990); Ozkan, Lajunen & Summala, (2006)	.86 to .89 across subscales
Driving Vengeance Questionnaire	DVQ	React to perceived threat or reckless driving on part of other drivers	N/A	4-point scale with higher values indicative of more aggressive reactions	15	Alpha: .83	Wiesenthal et al. (2000)	.78
Dula Dangerous Driving Index	DDD	Drive in dangerous manner	Aggressive driving; negative emotional driving; risky driving	0 (Never) to 5 (Always) Likert scale	31	Alpha: .83 to .85 across subscales	Dula & Ballard (2003); Dula, Adams, Miesner & Leonard (2010)	.79 to .91 across subscales
Larson's Driver's Stress Profile	LDSP	Enact negative behaviors while driving	Anger; impatience; competing; punishing	0 (Never) to 3 (Always) Likert scale	40	Test-retest: .84 to .93 across subscales	Larson (1996); Blanchard et al. (2000)	.84 to .91 across subscales
Propensity for Angry Driving Scale	PADS	Enact hostile driving behaviors due to anger	N/A	4-point scale with higher values indicative of more hostile behaviors	19	Alpha: .89	DePasquale, Geller, Clarke & Littleton (2001)	.83
Prosocial and Aggressive Driving Inventory	PADI	Engage in driving behaviors that protect other road-users and enable cooperation with other drivers	Prosocial driving; aggressive driving	1 (Never) to 6 (Always) Likert scale	17	Alpha: Prosocial driving .90, aggressive driving .81	Harris, Houston, Vazquez, Smither, Harms, Dahlke & Sachau, (2014)	.97

Note: Alpha indicates coefficient alpha and test-retest values are Pearson correlation coefficients. Figures in Reliability in Present Study column indicate coefficient alpha values.
Although the PADI includes both a prosocial driving subscale and an aggressive driving subscale, solely the former was used in this study because content included in the aggressive driving subscale was already measured via the ADBS.

Table 2
Exploratory Factor Analysis of Self-Reported Driving Measures.

Measure	Factor			
	Reckless Driving Behaviors	Negative Emotions	Enacted Aggressive Driving Behaviors in Response to Others' Transgressions	Perceived and Enacted Aggressive Driving Behaviors Without Others' Transgressions
DBQ Violations	**.80**	.02	.07	.05
DDD Risky Driving	**.62**	.00	.27	.04
DDD Negative Emotions	**.50**	**.49**	.03	−.06
DBQ Errors	**.50**	.03	−.14	.28
ADBS Speeding	**.44**	.37	.00	.14
DAS Discourtesy	−.08	**.89**	.08	−.11
DAS Traffic	−.03	**.89**	−.01	−.08
LDSP Anger	.07	**.78**	.06	.07
DAS Hostile	−.06	**.77**	−.06	.03
DAS Illegal	**−.41**	**.73**	−.04	.02
DAS Slow	.26	**.73**	.04	−.14
LDSP Impatience	.24	**.60**	.04	.12
DAS Police Presence	.14	**.60**	.07	.01
ADBS Conflict	.11	.33	**.47**	.16
PADI Total	**−.46**	.31	−.13	.03
PADS Total	−.07	.01	**.85**	.03
DVQ Total	.04	.09	**.83**	−.23
DDD Aggressive Driving	.29	.13	**.58**	−.07
DAIS Self Aggressive Warning	−.09	−.05	**.57**	**.56**
LDSP Punishing	.16	.28	**.53**	.14
LDSP Competing	.18	−.04	**.47**	.15
DAIS Others Hostile Aggression	.06	.01	.26	**.66**
DAIS Others Aggressive Warning	.02	.21	.03	**.61**
DMQ-A Internal	.14	−.02	.11	**.52**
DAIS Self Hostile Aggression	.11	.06	**.40**	**.45**
DMQ-A External	−.36	.22	−.02	.25
DDS Total	.32	.21	.06	.09
DBQ Lapses	.26	.24	−.27	.29

Note: Bold indicates a loading of 0.4 or greater on that factor.

consideration (Humphreys and Montanelli, 1975).

A small range of data was missing across scales (i.e., between 0 and 4.6%); given that this proportion represented a minimal part of the overall sample, missing data was not imputed. All available data was used for the analyses given the use of maximum likelihood.

3. Results

Results of the EFA may be found in Table 2. Parallel analysis (Horn, 1965) indicated that a four-factor solution should be estimated.

Measures with the largest loadings on the first factor of this solution were those related to reckless driving behaviors. Measures of dangerous or risky driving behaviors had positive loadings; these measures largely assessed broader dangerous driving practices and did not in detail assess drivers' tendencies to hostilely or negatively engage with particular drivers or their vehicles (e.g., tendency to drive while intoxicated, drive through yellow lights, or drive 20 miles-per-hour over the speed limit). Measures loading heavily on this factor included predominantly those assessing unsafe driving behaviors completed intentionally (i.e., DBQ Violations subscale, DDD Risky Driving subscale, ADBS Speeding subscale), however a measure of unintentional unsafe driving behaviors (i.e., DBQ Errors subscale) also loaded positively onto this factor. Additionally, two scales had negative loadings above 0.35. Greater reporting of risky driving was associated with less anger at witnessing others drive in an unlawful manner (i.e., DAS Illegal subscale) as well as less avoidance of risky driving situations (i.e., DMQA External subscale).

Measures with the largest loadings on the second factor were those related to negative emotions experienced while driving. Whereas other factors included measures designed to assess frequency or severity of behaviors, this factor solely constituted the amount of anger, irritation or impatience a participant reported experiencing in a variety of

emotion-provoking driving situations. Measures solely assessing anger (i.e., most DAS subscales) loaded more heavily than did those assessing other negative emotions or a combination of negative emotions. While many of the emotion-provoking situations were those created by particular drivers (e.g., another driver refusing to allow the participant to merge), some were the result of other aspects of the driving environment (e.g., police nearby, heavy traffic). Notably, two subscales that tap both behavioral aspects of unsafe driving as well as negative emotions associated with dangerous driving (i.e., DDD Negative Emotions subscale and DAS Illegal subscale) cross-loaded onto both the first and second factors (i.e., had loadings of greater than 0.35 on both factors).

Measures with the largest loadings on the third factor related to enacted aggressive driving behaviors in direct response to perceived hostile or dangerous actions on the part of another driver. One measure loading onto this factor (i.e., LDSP Competing subscale) includes items that assess dangerous driving behaviors that are not in response to a specific driver's transgressions, but do stem from receiving attention from other drivers that encourage dangerous driving. Among those measures that had a loading of at least 0.4 on this factor, the LDSP Competing subscale demonstrated the smallest size loading.

Measures with the largest loadings on the fourth factor were those related to perceived and enacted aggressive driving behaviors without other drivers' transgressions. This contrasts with the third factor, as measures loading on the fourth factor assess behaviors that are seemingly "out of the blue" and do not denote as a premise any actions from another driver directed toward the participant or others in the driving environment. Additionally, whereas the third factor assesses solely enacted aggressive behaviors, the fourth factor includes both behaviors the participant enacts as well as those they detect from others towards themselves. One measure loading onto this factor (i.e., DMQA Internal subscale) includes items that assess tendency to avoid driving in certain situations inherent to the internal car environment (e.g.,

when passengers are present); however, it is worth noting that among measures with a loading of at least 0.4 on this factor, the DMQA Internal subscale demonstrated the smallest size loading. Overall, the fourth factor more heavily weighted perceptions about aggression rather than actions concerning it; this is supported both by the heaviest weighting measures both relating to perceived and not enacted aggression, as well as the enacted aggression measures cross-loading onto the third factor (i.e., loading of 0.4 or greater on both the third and fourth factors).

4. Discussion

Driving questionnaires are a useful and inexpensive means of assessing a broad range of driving-related facets, including negative emotions experienced behind the wheel, as well as both intentional and accidental behaviors that may or may not pose a risk to other road users (Dahlen et al., 2005; Deffenbacher et al., 2003; Reason et al., 1990). However, numerous questionnaires have been developed to assess for similar aspects of driving (e.g., aggressive driving), and prior studies have either not assessed similarities among measures or only explored a limited number of measures in a single study. The current study employed factor analysis to explore similarities and variability in the constructs assessed via commonly utilized driving self-report measures. A four-factor solution was determined to be the most appropriate for explaining these constructs.

The first factor broadly spanned reckless driving behaviors, or a general tendency to intentionally drive in a manner that may be considered dangerous to other road-users. Importantly, most items on questionnaires loading onto this factor do not pertain to the individual's "targeting" their behaviors at a specific driver or other road-user. As such, the subscales and questionnaires that most heavily loaded onto this factor included those that do not reference the targeting of dangerous driving behaviors at a specific party (i.e., the DDD Risky Driving subscale, the ADBS Speeding subscale) or include a sufficient number of non-targeting items such that the weight of targeting items is lessened (i.e., the DBQ Violations subscale). Importantly, a number of measures and subscales from a variety of measures exhibited loadings of over 0.4 on this factor, suggesting that reckless driving behaviors were commonly assessed across questionnaires. Such results are in line with the overarching goal of many driving self-reports to identify individuals who may pose a heightened safety risk for themselves and others on the road (Dula and Geller, 2003; Parker et al., 1995). Furthermore, the presence of this factor independent from those factors assessing driver aggression (i.e., factors three and four) suggests that dangerous or risky driving behaviors may be considered a separate construct from driver aggression, which is congruent with past work (Dula and Geller, 2003).

Notably, both the PADI and DAS Illegal subscales loaded onto the first factor. Similar to other measures loading on this factor, the PADI contains content related to more general driving behaviors and does not measure prosocial behaviors directed toward specific drivers or intent of the behavior (Harris et al., 2014). The DAS Illegal subscale measures the amount of anger the participant would experience when witnessing many of the same behaviors described in the DBQ Violations, DDD Risky Driving and ADBS Speeding subscales. As such, the negative loading of the DAS Illegal subscale onto this factor may indicate that participants who endorse high levels of dangerous driving do not recognize their behaviors as posing a threat to others, and thus do not experience significant anger when they witness others drive similarly.

Given the role that emotions play in guiding behaviors behind the wheel, it is perhaps unsurprising that questionnaires and subscales specifically assessing emotional aspects of driving clustered in a distinct factor separate from the other more behaviorally oriented ones. This second factor included all DAS subscales, the sole measure included in the present study to tap solely emotional aspects of driving. Further hinting at the content of this factor, subscales that tap solely emotional aspects of driving but that are included as part of larger measures

assessing both behavioral and emotional facets loaded onto this factor, namely the DDD Negative Emotions subscale, the LDSP Anger subscale and the LDSP Impatience subscale. Negative emotions have been repeatedly shown to be associated with unsafe driving behaviors and crash risk (Deffenbacher et al., 2003; Schwebel et al., 2006). Notably, while driving anger has also been linked to aggressive driving behaviors (Deffenbacher et al., 2003; Parker et al., 2002) and many believe it to be a required precursor, meta-analytic data suggests that different types of anger (e.g., state versus trait anger) have contrasting effects on driving behaviors and negative driving outcomes (Nesbit et al., 2007). The presence of a factor primarily representing negative emotional aspects of driving provides further evidence in support of the assessment of driving anger in addition to and separately from driving behaviors (Dahlen et al., 2005; Lajunen and Parker, 2001).

The final two factors identified in the present study both included measures that assess aspects of driver aggression; however, whereas measures on the third factor primarily were related to participants' aggressive behaviors in response to perceived transgressions from other drivers, measures on the fourth factor were by contrast more related to participants' perceptions about aggressive behaviors enacted by other drivers. Although literature regarding self-perceptions of driving safety is abundant, relatively few studies have assessed perceptions about other drivers' aggression, and to our knowledge the DAIS (whose subscales loaded most heavily on the fourth factor) is the only recently used measure to explicitly do so via a distinct subscale (Özkan et al., 2011, 2006). Personality factors appear to be closely related to these perceptions; for example, increased neuroticism is associated with increased perceived aggressive warnings from other drivers (H. Zhang et al., 2017). Work utilizing the DAIS has further supported prior studies indicating a "self-enhancement bias" when participants compare their aggressive driving frequency to others (Sümer et al., 2006; Walton, 1999), however the present study is among the first to identify differential associations between the DAIS Self subscales and the DAIS Other subscales with other driving self-report measures. Overall, within the domain of driving aggression, enacted and perceived driving aggression appear to represent separate constructs and are differentially associated with other driving measures.

Interestingly, measure subscales that assessed participants' aggressive behaviors without impetus from another driver weighed almost equally on both factors, suggesting that they reflect a separate but not entirely independent construct from the provoked aggressive behaviors represented on the third factor. Thus, while it has been assumed that aggressive driving behaviors against specific drivers are almost uniformly intentional (Lennon and Watson, 2011; Neighbors et al., 2002), the present study supports other work suggesting that many such behaviors are committed by mistake (Tremblay and Belchevski, 2004; Wickens et al., 2011) and may simply be misinterpreted as deliberate by other drivers.

The four-factor structure identified in this study has a number of implications for clinical practice. Clinicians seeking to assess for a broad range of patient or informant-reported views regarding a patient's driving behaviors may wish to employ a battery of questionnaires that spans all four factors outlined. Conversely, if a particular aspect of a patient's driving is being evaluated, (e.g., enacting aggressive driving behaviors against others without their provocation), then the clinician may be advised to select measures that most heavily tap a specific factor. These decisions may save all parties considerable time and effort. In general, some driving measures (e.g., DBQ) are more frequently used in clinical research and assessment than others. The results of this study highlight the wider range of emotions and behaviors that individuals report and that may be worthy of assessing.

The present study presents several avenues for further research. Given that a variety of measures and subscales loaded onto a factor related to reckless driving broadly, future work should identify in greater depth what unique aspects of unsafe driving each of these measures captures. Additionally, consistent with past studies, negative

mood was shown to constitute a unique and independent aspect of driving separate from behavioral facets, and studies should continue to examine mood measures' independent contributions to driving outcomes above and beyond behavioral measures. Anger is the subject of considerable emotional driving measurement literature, however other emotions (e.g., anxiety) also loaded heavily onto the second factor and should be included in future driving self-report measures. Lastly, while enacted driving aggression is frequently assessed in clinical and research contexts, perceptions about other drivers' aggression are by comparison less commonly addressed. Given differences in the contributors to these two aspects of aggression, perceived aggressive driving should be assessed independently of enacted aggression with greater frequency, and should be explored as a contributor to crash risk.

4.1. Limitations

Although this study sought to examine the underlying constructs of self-report driving measures, a central limitation was its lack of inclusion of any objective driver aggression measures (e.g., legal and crash-related histories, driving simulator measures with anger-provoking stimuli such as drivers cutting the participant off). While self-reported aggressive driving behaviors have been shown to be more related to self-reported than simulator-assessed dangerous driving behaviors, self-reported aggressive behaviors are also modestly associated with the former (Chliaoutakis et al., 2002).

The questionnaires included in the present study were also limited in scope to emotional and behavioral aspects of driving; as a result, other factors that have been shown to be strongly related to driving outcomes (e.g., personality) and that may weigh onto some of the same factors identified, or weigh onto new factors, were not included. In particular, individuals with high trait aggressiveness or high neuroticism report greater aggressive driving behaviors (Jovanović et al., 2011; Tremblay and Belchevski, 2004), while those with high trait anxiety report greater aberrant driving behaviors (Shahar, 2009). Future studies should incorporate measures of personality, and driving-related personality variables in particular, to better elucidate their contributions to self-reported driving.

As is the case with many of the initial driving questionnaire validation studies mentioned, this study recruited from a convenience sample of college undergraduate students. Young adults are at especially high risk of accident involvement relative to adults more broadly. As such, the factor structure derived in this sample may not generalize to the larger adult population. Additionally, although older adults represent an additional demographic at high risk for accident involvement (Owsley et al., 1998; Schwebel et al., 2007; Sullivan et al., 2011), they differ in the types of driving errors frequently committed (McGwin and Brown, 1999). As such, future work should examine whether the factor structure derived among young adults applies to older adults as well as those of various demographics (e.g., gender, educational background, race).

References

Aarts, L., Van Schagen, I., 2006. Driving speed and the risk of road crashes: a review. Accid. Anal. Prev. 38 (2), 215–224.

Baldock, M.R.J., Mathias, J., McLean, A., Berndt, A., 2006. Self-regulation of driving and its relationship to driving ability among older adults. Accid. Anal. Prev. 38 (5), 1038–1045.

Bernstein, J.P., De Vito, A., Calamia, M., 2017. Associations Between Emotional Symptoms and Self-Reported Aberrant Driving Behaviors in Older Adults (Under Review).

Blanchard, E.B., Barton, K.A., Malta, L., 2000. Psychometric properties of a measure of aggressive driving: the Larson Driver's Stress Profile. Psychol. Rep. 87 (3), 881–892.

Chliaoutakis, J.E., Demakakos, P., Tzamalouka, G., Bakou, V., Koumaki, M., Darviri, C., 2002. Aggressive behavior while driving as predictor of self-reported car crashes. J. Safety Res. 33 (4), 431–443.

Cutler, B.L., Kravitz, D.A., Cohen, M., Schinas, W., 1993. The driving appraisal inventory: psychometric characteristics and construct validity. J. Appl. Soc. Psychol. 23 (15), 1196–1213.

Dahlen, E.R., Martin, R.C., Ragan, K., Kuhlman, M.M., 2005. Driving anger, sensation seeking, impulsiveness, and boredom proneness in the prediction of unsafe driving. Accid. Anal. Prev. 37 (2), 341–348.

Danaf, M., Abou-Zeid, M., Kaysi, I., 2015. Modeling anger and aggressive driving behavior in a dynamic choice–latent variable model. Accid. Anal. Prev. 75, 105–118.

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. Behav. Res. Ther. 41 (6), 701–718.

Dula, C.S., Geller, E.S., 2003. Risky, aggressive, or emotional driving: addressing the need for consistent communication in research. J. Saf. Res. 34 (5), 559–566.

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 behaviors. Accid. Anal. Prev. 72, 1–8.

Horn, J.L., 1965. A rationale and test for the number of factors in factor analysis. Psychometrika 30 (2), 179–185.

Humphreys, L.G., Montanelli Jr, R.G., 1975. An investigation of the parallel analysis criterion for determining the number of common factors. Multivariate Behav. Res. 10 (2), 193–205.

Jovanović, D., Lipovac, K., Stanojević, P., Stanojević, D., 2011. The effects of personality traits on driving-related anger and aggressive behaviour in traffic among Serbian drivers. Transp. Res. Part F Traffic Psychol. Behav. 14 (1), 43–53.

Krahé, B., Fenske, I., 2002. Predicting aggressive driving behavior: the role of macho personality, age, and power of car. Aggress. Behav. 28 (1), 21–29.

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. Accid. Anal. Prev. 33 (2), 243–255.

Lajunen, T., Summala, H., 2003. Can we trust self-reports of driving? Effects of impression management on driver behaviour questionnaire responses. Transp. Res. Part F Traffic Psychol. Behav. 6 (2), 97–107.

Lennon, A., Watson, B., 2011. "Teaching them a lesson?" A qualitative exploration of underlying motivations for driver aggression. Accid. Anal. Prev. 43 (6), 2200–2208.

Marengo, D., Settanni, M., Vidotto, G., 2012. Drivers' subtypes in a sample of Italian adolescents: relationship between personality measures and driving behaviors. Transp. Res. Part F Traffic Psychol. Behav. 15 (5), 480–490.

McCartt, A.T., Shabanova, V.I., Leaf, W.A., 2003. Driving experience, crashes and traffic citations of teenage beginning drivers. Accid. Anal. Prev. 35 (3), 311–320.

McGwin Jr, G., Brown, D.B., 1999. Characteristics of traffic crashes among young, middle-aged, and older drivers. Accid. Anal. Prev. 31 (3), 181–198.

McKnight, A.J., McKnight, A.S., 2003. Young novice drivers: careless or clueless? Accid. Anal. Prev. 35 (6), 921–925.

Neighbors, C., Vietor, N.A., Knee, C.R., 2002. A motivational model of driving anger and aggression. Pers. Soc. Psychol. Bull. 28 (3), 324–335.

Nesbit, S.M., Conger, J.C., Conger, A.J., 2007. A quantitative review of the relationship between anger and aggressive driving. Aggress. Violent Behav. 12 (2), 156–176.

Owsley, C., Ball, K., McGwin Jr, G., Sloane, M.E., Roenker, D.L., White, M.F., Overley, E.T., 1998. Visual processing impairment and risk of motor vehicle crash among older adults. Jama 279 (14), 1083–1088.

Özkan, T., Lajunen, T., Summala, H., 2006. Driver behaviour questionnaire: a follow-up study. Accid. Anal. Prev. 38 (2), 386–395.

Özkan, T., Lajunen, T., Parker, D., Sümer, N., Summala, H., 2011. Aggressive driving among british, dutch, finnish and turkish drivers. Int. J. Crashworthiness 16 (3), 233–238.

Parker, D., Reason, J.T., Manstead, A.S., Stradling, S.G., 1995. Driving errors, driving violations and accident involvement. Ergonomics 38 (5), 1036–1048.

Parker, D., Lajunen, T., Summala, H., 2002. Anger and aggression among drivers in three European countries. Accid. Anal. Prev. 34 (2), 229–235.

Przepiorka, A.M., Blachnio, A., Wiesenthal, D.L., 2014. The determinants of driving aggression among Polish drivers. Transp. Res. Part F Traffic Psychol. Behav. 27, 69–80.

Reason, J., Manstead, A., Stradling, S., Baxter, J., Campbell, K., 1990. Errors and violations on the roads: a real distinction? Ergonomics 33 (10-11), 1315–1332.

Schwebel, D.C., Severson, J., Ball, K.K., Rizzo, M., 2006. Individual difference factors in risky driving: the roles of anger/hostility, conscientiousness, and sensation-seeking. Accid. Anal. Prev. 38 (4), 801–810.

Schwebel, D.C., Ball, K.K., Severson, J., Barton, B.K., Rizzo, M., Viamonte, S.M., 2007. Individual difference factors in risky driving among older adults. J. Safety Res. 38 (5), 501–509.

Shahar, A., 2009. Self-reported driving behaviors as a function of trait anxiety. Accid. Anal. Prev. 41 (2), 241–245.

Shinar, D., 1998. Aggressive driving: the contribution of the drivers and the situation1. Transp. Res. Part F Traffic Psychol. Behav. 1 (2), 137–160.

Sullivan, K.A., Smith, S.S., Horswill, M.S., Lurie-Beck, J.K., 2011. Older adults' safety perceptions of driving situations: towards a new driving self-regulation scale. Accid. Anal. Prev. 43 (3), 1003–1009.

Sümer, N., Özkan, T., Lajunen, T., 2006. Asymmetric relationship between driving and safety skills. Accid. Anal. Prev. 38 (4), 703–711.

Tasca, L., 2000. A Review of the Literature on Aggressive Driving Research: Ontario Advisory Group on Safe Driving Secretariat, Road User Safety Branch. Ontario Ministry of Transportation Ontario, Canada.

Taubman–Ben-Ari, O., Kaplan, S., Lotan, T., Prato, C.G., 2016. The combined contribution of personality, family traits, and reckless driving intentions to young men's risky driving: What role does anger play? Transp. Res. Part F Traffic Psychol. Behav. 42, 299–306.

Tremblay, P.F., Belchevski, M., 2004. Did the instigator intend to provoke? A key moderator in the relation between trait aggression and aggressive behavior. Aggress. Behav. 30 (5), 409–424.

Ulleberg, P., Rundmo, T., 2003. Personality, attitudes and risk perception as predictors of

risky driving behaviour among young drivers. Saf. Sci. 41 (5), 427–443.

Walton, D., 1999. Examining the self-enhancement bias: professional truck drivers' perceptions of speed, safety, skill and consideration. Transp. Res. Part F Traffic Psychol. Behav. 2 (2), 91–113.

Wickens, C.M., Wiesenthal, D.L., Flora, D.B., Flett, G.L., 2011. Understanding driver anger and aggression: attributional theory in the driving environment. J. Exp. Psychol. Appl. 17 (4), 354.

Wiesenthal, D.L., Hennessy, D., Gibson, P.M., 2000. The Driving Vengeance Questionnaire (DVQ): the development of a scale to measure deviant drivers' attitudes. Violence Vict. 15 (2), 115.

Williams, A.F., 2003. Teenage drivers: patterns of risk. J. Safety Res. 34 (1), 5–15.

Yagil, D., 1998. Gender and age-related differences in attitudes toward traffic laws and traffic violations. Transp. Res. Part F Traffic Psychol. Behav. 1 (2), 123–135.

Zhang, T., Chan, A.H., 2016. The association between driving anger and driving outcomes: a meta-analysis of evidence from the past twenty years. Accid. Anal. Prev. 90, 50–62.

Zhang, T., Chan, A.H., Zhang, W., 2015. Dimensions of driving anger and their relationships with aberrant driving. Accid. Anal. Prev. 81, 124–133.

Zhang, H., Qu, W., Ge, Y., Sun, X., Zhang, K., 2017. Effect of personality traits, age and sex on aggressive driving: psychometric adaptation of the Driver Aggression Indicators Scale in China. Accid. Anal. Prev. 103, 29–36.