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RESEARCH PAPER

Validation of Modified Driver Behavior Questionnaire Considering Mobile Phone Usage While Driving

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ABSTRACT: Although the existing Driver Behavior Questionnaire (DBQ) covers a wide range of drivers' aberrant behaviors, advances in technology have made some questions out of date. These advancements could lead to human errors while driving, and therefore some items of DBQ need to be updated to reflect the influence of technology on driving behavior such as mobile phone usage while driving. This study aims to modify the widely used DBQ by including "mobile phone usage while driving" items and validate it in Iranian context. The impact of demographic items on each factor scale is also investigated. A shortened DBQ that include drivers' aberrant behaviors and additional questions on mobile phone usage while driving was developed. A total of 298 drivers (168 males and 130 females) between the ages of 18 and 60 participated in this study. Results showed that the mean score of two mobile phone usage items is significantly correlated with violation behaviors. Besides, younger drivers, male drivers, and drivers who were involved in an accident in the past three years behave more aberrant. Statistical analysis shows that drivers who use their mobile phones while driving are more likely to be involved in a traffic crash. Moreover, mobile phone usage while driving decreases significantly by age and males use their mobile phones more than females while driving.

Keywords: Driver Behavior Questionnaire (DBQ), Driver Distraction, Error, Factor Analysis, Mobile Phone Usage, Violation.

1. Introduction

Traffic accidents are a critical issue that has been the concern of researchers for many years (Vajari et al., 2020). Previous studies have shown that as compared to the developed countries, the Middle East countries are more vulnerable in road safety due to the higher number of vehicle crashes or severity of road traffic injury and fatality (Besharati et al., 2020; Heydari et al., 2019; Rezaei et al., 2014; Bener et al., 2008). Tehran, the capital city of Iran, with a population of about 9 million and an average 19 million daily trips, is considered as one of the most populated cities in the

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Middle East (Tehran Traffic and Transportation Organization (TTTO), 2018). According to TTTO (2018), 660 people were killed by traffic crashes in 2018 in the city of Tehran. Besides, the crash fatality rate per 100,000 populations in Tehran province increased from 8.7 people in 2016 to 9.7 people in 2018 (TTTO, 2018). Therefore, the study of traffic injuries and their causes in Tehran is of great importance.

Previous studies have considered different methods to investigate traffic accidents and their causes. One of these methods is the evaluation and analysis of road users' injury and fatality information (Nasri and Aghabayk, 2020). The study of the relationship between drivers' aberrant behavior and crash involvement is another approach (Wang and Xu, 2019; Deng et al., 2019; Gueho et al., 2014). The 50-items Driver Behavior Questionnaire (DBQ) that was developed by Reason et al. (1990) is one of the most widely used instruments to evaluate the drivers' aberrant behaviors. The questionnaire classified drivers' aberrant behaviors into three factors namely: Violations (deliberate acts), Errors (failure of planned action), and Slips and Lapses (unintentional acts). The violations category has been further refined by Lawton et al. (1997) into ordinary violations and aggressive violations. The aggressive violations concern hostile behaviors toward other users. Besides, a study by Aberg and Rimmö (1998) presented another classification of driver's aberrant behavior where they divided the errors into three types, namely dangerous errors, errors due to inattention and errors due to inexperience.

To take into account the country-specific variations and solutions and also different driving cultures, the DBQ has been applied and calibrated in several countries. Further, attempts have been made to shorten the DBQ to reduce the time required for the completion of the questionnaire and subsequently increase the completion rate (Martinussen et al., 2013). Over the years, the DBQ has been applied in Australia (Stephens and Fitzharris, 2016), France (Gueho et al., 2014), Denmark (Martinussen et al., 2017), America (Owsley et al., 2003), Canada (Koppel et al., 2019, 2018), China (Xu et al., 2018; Qu et al., 2016), Sweden (Åberg and Warner, 2008), Greece (Ersan et al., 2020; Kontogiannis et al., 2002), Netherland (Lajunen et al., 1999), Spain (Gras et al., 2006), New Zealand (Sullman et al., 2019; Sullman et al., 2000) and UK (Rowe et al., 2015; Reason et al., 1990). Furthermore, researchers in Iran (Parishad et al., 2020), Turkey (Özkan and Lajunen, 2005), Oman (Al Azri et al., 2017), Qatar, and UAE (Bener et al., 2008) conducted similar studies in the Middle East countries.

Moreover, due to the advancement of technology in recent years, some of the 50-items DBQ questions might be out of date (e.g. "attempt to drive away from traffic lights in third gear" or "lock yourself out of your car with the keys still inside"). On the other hand, some questions could be added to the DBQ to consider the influence of new technology on drivers' behaviors. Besides, technological advances could lead to the formation of new questions that may indicate human errors that may not have been captured in the previous questionnaire. Therefore, the driver behavior questionnaire needs to be updated considering the current context. For example, mobile phone usage while driving could be correlated to drivers' aberrant behaviors. A study by Arvin et al. (2016) showed that almost 10 percent of Iranian drivers use their cell phones while driving. Due to the development of mobile phone applications and social networks, and consequently increasing mobile phone usage while driving, recent studies concentrated more on investigating the impact of mobile phone usage while driving as a variable that affects traffic crashes (Qu et al., 2020; Lipovac et al., 2017). Previous studies depicted that the risk of being involved in a traffic accident could be increased by using a mobile phone while driving (Mohammadi, 2009). Furthermore, studies by Lansdown and Stephens (2013), and Holland and Rathod (2013) showed that mobile phone use while driving can lead to distraction and reduce driving performance. In Finland, Korpinen and Pääkönen (2012) showed that younger drivers and male drivers more likely to be involved in road crashes while using a mobile phone. Besides, the probability of cellphone usage while driving decreases by aging (Arvin et al., 2016). A study by Isa et al. (2012) showed that almost 70 percent of Indonesian drivers using their mobile phones while driving do not use a hands-free device. Although many drivers perceived that using hands-free devices has advantages to hand-held mobile phone use, previous studies showed that hands-free device reduces driving performance as well (Lipovac et al., 2017).

The focus of recent studies is more on investigating mobile phone usage while driving from behavioral aspects that attempt to elucidate the relation between mobile phone usage and crash involvement (Qu et al., 2020; Hill et al., 2019). Nevertheless, mobile phone usage while driving as a deliberate act which violates the driving laws has not been categorized in any drivers' aberrant behaviors subscales in the past DBQ researches. Furthermore, although the study by Parishad et al. (2020) calibrated the DBQ for Iran and presented a shortened DBQ, the reliability of the shortened version has not been tested and validated. It should be noted that the DBQ calibrated by Parishad et al. (2020) has been used in other studies as well (Aghabayk et al., 2020). Moreover, aberrant behaviors were assessed for other types of road users such as pedestrians (Esmaili et al., 2021) and motorcycle drivers (Haqverdi et al., 2015). However, none of them investigate the impact of mobile phone usage while driving.

The goal of this study is threefold. First, the shortened version of DBQ presented by Parishad et al. (2020) for the city of Tehran was validated. Second, the DBQ was updated using "mobile phone usage while driving" questions and the impact of mobile phone usage while driving from a behavioral aspect was investigated. Finally, the effect of the demographic variables (age, gender, crash history, average driving time per day) will be assessed for various driver behaviors.

2. Method

2.1. Survey Instrument

To assess the reliability of the shortened version of the DBQ on Iranian sample and update the DBQ, a survey instrument was used with three sections: demographic questions (4 items), a shortened version of drivers' aberrant behaviors questions (24 questions), and mobile phone usage while driving questions (2 questions).

The first part of the questionnaire consists of some demographic questions including the participants' age, gender, crash history in three past years, and average driving time per day. The second section contains the DBQ questions. The study by Parishad et al. (2020) provided a shortened version of DBQ for Iranian drivers using the conceptual framework of 50-items Manchester drivers' aberrant behaviors (Reason et al., 1990). The shortened version consists of 20 items that are extracted in four factors namely; Violations (6-items), Errors (6-items), Lapses (6-items), and Aggressive behaviors (2-items). The shortened version that was used in this study has 24 items including 20 items extracted by Parishad et al. (2020) and four additional aggressive behavior questions developed by Lawton et al. (1997). These four additional aggressive behavior questions are: 1) "stay in a lane that you know will be closed", 2) "pull out of a junction", 3) "sound your horn", and 4) "race away from traffic lights". The participants were asked to answer questions on a six-point Likert scale (1: very infrequently, 2: quite infrequently, 3: infrequently, 4: frequently, 5: quite frequently, 6: very often). The third section was designed to update the questionnaire and investigate the mobile phone usage while driving from the behavioral aspect. This section includes two questions related to using a mobile phone while driving. Since calling, texting and using mobile phone apps are the most frequent activities while driving, the participants were asked to answer 1) "How often do you use your mobile phone for calling or texting while driving?", and 2) "How often do you use your mobile phone applications (e.g., bank, navigation, games, etc.) while driving?". These questions were answered on the 6-point Likert scale as well. The survey instrument was translated into Farsi using the back-translation method. It was first translated into Farsi, then back to English again to assure similar meaning. Moreover, a pilot study was conducted on 10 people to evaluate participants' reactions to the translated questionnaire and eliminate possible problems. The complete survey questionnaire is attached in the Appendix.

2.2. Data Collection

A study by Mundfrom et al. (2005) stated that the required sample size for a factor analysis depends on the ratio of variables to factors (p/f). Since the p/f ratio in the present study is equal to six, the maximum sample size recommended by Mundfrom et al. (2005) equals to 260 people. Moreover, according to a rule of thumb, 5 to 10 samples are needed for each variable. Since there are 26 variables in this study, the maximum required sample size equals to 260 people. Therefore, to collect the data, 325 questionnaires were divided equally between five different districts of the city (center, east, west, north, and south parts of the city) to represent various drivers of Tehran. The questionnaires were distributed during a week in five different malls of the city in November 2019. The participants were provided with the information necessary to make voluntary informed decisions about participating in the survey, how the data will be stored and used, and what are their rights and responsibilities as participants before conducting the questionnaire survey. The survey took, on an average, eight minutes to complete. At first, participants were asked about their driving time per day and whether they hold a driving license. Participants who responded that they do not have a car driving license or drive less than 15 minutes per day on average were excluded from the study. Since this study needs just participants' general impressions or perceptions (Reason et al., 1990), they were asked to provide the first response that came to their minds and answer the questions accordingly. Out of 325 participants, 27 participants' responses were omitted from analysis because of a high number of missing data (more than six questions) or low standard deviation of answers (less than 0.2). Finally, the analysis was conducted with 298 participants.

The sample includes 168 male and 130 female participants. The age of participants ranged from 18 to 60 (M = 34.18, SD = 10.91). Among 298 participants, 91 (30.5%) participants reported that they were involved in car accidents as a driver in the past three years, while most of the participants (69.2%) reported that they drive less than 2 hours per day. Table 1 shows the data description.

3. Results

The model development was conducted using AMOS version 24.0 (IBM, 2016). In addition, the effect of demographic variables and mobile phone usage on each factor scores were examined using SPSS version 25.0 (IBM, 2017).

Table 2 depicts the descriptive statistics, Means (M), and Standard Deviations (SD), ranked in descending order by the mean value for 24 behavioral items plus two mobile phone usage items. The most frequently reported behaviors (mean response ≥ 3) involved mobile phone usage: i) "calling/texting while driving", and ii) "using mobile apps while driving". The most frequent driver aberrant behavior reported are violations and aggressive violations respectively: i) “Become impatient with a slow driver in the outer lane and overtake on the inside”, and ii) “Race away from traffic lights with the intention of beating the driver next to you”. Moreover, the least frequently reported behaviors on the errors were related to other road users: i) “Fail to notice pedestrians crossing when turning into a side street from a main road”, and ii) “Misjudge speed of oncoming vehicle when overtaking”.

Table 1. Sample size by gender, car ownership, crash history, and average driving time per day for each age groups

Variables		Age group			Total
		18-30	30-45	More than 45	
Gender	Male	68	59	41	168
	Female	59	48	23	130
Car ownership	Yes	70	91	57	218
	No	57	16	7	80
Crash history	Involved	49	29	13	91
	Not involved	78	78	51	207
Average driving time per day	Less than 1 hr	56	38	15	109
	1-2 hr	38	27	32	97
	2-4 hr	27	31	13	71
	More than 4 hr	6	11	4	21

Table 2. Means and standard deviations of the DBQ behavior items (n = 298)

Pedestrian behavior item (How often do you …)	M	SD
Use your mobile phone for calling/texting while driving	3.18	1.517
Use your mobile phone applications (bank, navigation, games, …) while driving	3.02	1.624
Become impatient with a slow driver in the outer lane and overtake on the inside	2.98	1.577
Race away from traffic lights with the intention of beating the driver next to you	2.74	1.508
Sound your horn to indicate your annoyance to another driver	2.66	1.466
Miss your exit on a motorway and have to make a lengthy detour	2.64	1.093
Overtake a slow-moving vehicle on the inside lane or hard shoulder of a motorway	2.55	1.428
Distracted or preoccupied, realize belatedly that the vehicle ahead has slowed, and have to slam on the brakes to avoid a collision	2.46	1.152
'Wake up' to realize that you have no clear recollection of the road along which you have just travelled	2.42	1.243
Have an aversion to a particular class of road user, and indicate your hostility by whatever means you can	2.42	1.361
Deliberately disregard the speed limits late at night or very early in the morning	2.35	1.490
Stay in a lane that you know will be closed ahead until the last minute before forcing your way into the other lane	2.26	1.262
Forget where you left your car in a multi-level car park	2.22	1.342
Intending to drive to destination A, you 'wake up' to find yourself en route to B, where the latter is the more usual journey	2.20	1.198
Pull out of a junction so far that the driver with right of way has to stop and let you out	2.20	1.343
Deliberately drive the wrong way down a deserted one-way street	2.13	1.225
Fail to notice someone stepping out from behind a bus or parked vehicle until it is nearly too late	2.12	1.237
Get involved in unofficial 'races' with other drivers	2.12	1.457
Hit something when reversing that you had not previously seen	2.10	1.146
Intend to switch on the windscreen wipers, but switch on the lights instead, or vice versa	2.08	1.273
Overtake a single line of stationary or slow-moving vehicles, only to discover that they were queueing to get through a one lane gap or roadwork lights	2.07	1.315
Misjudge your crossing interval when turning right and narrowly miss collision	2.05	1.198
In a queue of vehicles turning left on to a main road, pay such close attention to the traffic approaching from the right that you nearly hit the car in front	2.00	1.203
Angered by another driver's behavior, you give chase with the intention of giving him/her a piece of your mind	2.00	1.361
Fail to notice pedestrians crossing when turning into a side street from a main road	1.97	1.069
Misjudge speed of oncoming vehicle when overtaking	1.93	1.183

3.1. DBQ Validation

Confirmatory factor analysis (CFA) was conducted for the four-factor structure presented by Parishad et al. (2020). Since previous studies used the maximum likelihood estimation procedure (Gueho et al., 2014; Stephens and Fitzharris, 2016), the authors conducted a similar approach in the present study. Modification indices, factors load estimation, and standardized residual covariance were used to improve the model fit. Due to the low factor loading (less than 0.4), one of the aggressive behavior items was dropped from the model: "race away from traffic lights with the intention of beating the driver next to you". Besides, the standardized residual covariance suggested eliminating another aggressive behavior item due to a high correlation with the violation questions: "sound your horn to indicate your annoyance to another driver". The modification indices suggested adding error covariance between items V5 and V6, L4, and L5. This can be due to the similarity of the content of these items. After applying these minor changes, the model fit indices showed better results. Model fit outcomes presented in Table 3 in terms of a) absolute fit, using the Root Mean Square Error of Approximation (RMSEA); b) the chi-square test statistic comparative fit, using the Comparative Fit Index (CFI); and c) parsimonious fit, using parsimony normed CFI (PCFI) as were used in previous studies (Deb et al., 2017).

Figure 1 displays the model structure and standard regression weights. The factor loadings (standard regression weight) for all 22 items are statistically significant ($p < 0.0001$). Given the good fit of the model, four composite scores were computed by calculating the mean score of responses for each of the subscales for driver behavior. Besides, the internal reliability of the resulting subscales was tested using Cronbach's alpha (α). The alpha values were found as: Violations (6 items) = 0.823, Errors (6 items) = 0.836, Lapses (6 items) = 0.733, Aggressive violations (4 items) = 0.769. Based on a study by George and Mallery (2003), these values indicated that all the scales had acceptable internal reliability ($0.7 \leq \alpha \leq 0.9$).

Table 3. Model fit indices of the confirmatory factor analysis

Model	χ^2	df	χ^2/df	Absolute fit RMSEA	Comparative fit CFI	Parsimonious fit PCFI
Model: Violations, Aggressive, Lapses, Errors	385.5	201	1.918	0.056	0.92	0.81

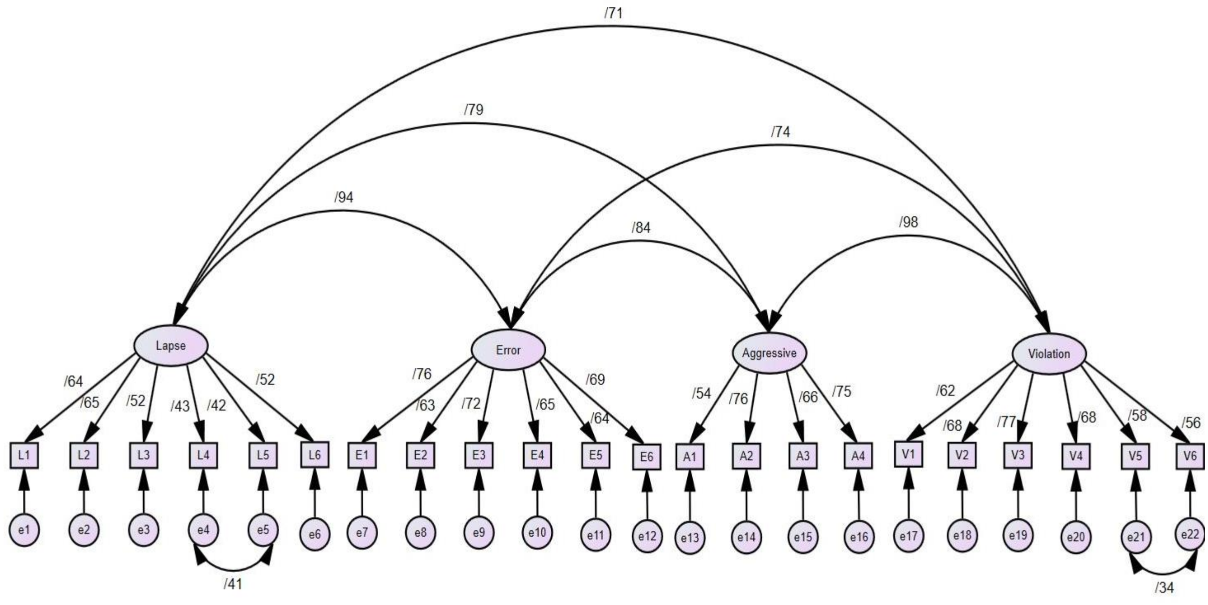

Fig. 1. Standardized solution for the four-factor confirmatory factor model

3.2. Mobile Phone Usage

For updating the DBQ using "mobile phone usage while driving" questions, the association between mobile phone usage items score and various behavioral subscales scores were assessed. After that, a new model containing mobile phone usage items was developed to assess the reliability and validity of the new model including the added items.

3.2.1. Effect of Mobile Phone Usage While Driving on Drivers' Aberrant Behavior

To investigate the relationship of drivers' aberrant behaviors and mobile phone usage questions, bivariate Pearson's correlation was calculated between each of the four subscale scores and the mobile phone usage score. Since mobile phone usage while driving, is a deliberate deviation of laws, it is expected to correlate more with violation questions. As was expected, Table 4 shows that the mean score of two mobile phone usage items is more correlated with violation behaviors. Furthermore, all of the correlations are statistically significant ($p < 0.0001$).

3.2.2 Development of New DBQ Including Mobile Phone Usage Items

Considering mobile phone usage questions as violations, another CFA was conducted. Modification indices suggested adding an error covariance between two mobile phone usage questions due to the similarity of the content of these items. Figure 2 illustrates the model structure and Table 5 exhibits the model fit outcomes. Cronbach's alpha (α) was calculated for new violations (containing mobile phone usage) to test internal reliability (α = 0.87). Results show that two added items are valid ($p < 0.0001$). Moreover, adding two mobile phone items in violation subscale increased the reliability of subscale, and improved the model fit indices as well.

Table 4. Bivariate Pearson's correlation results

Driver aberrant behavior	Mobile phone usage
Violation	0.668*
Error	0.407*
Lapse	0.330*
Aggressive	0.527*

*p < 0.0001

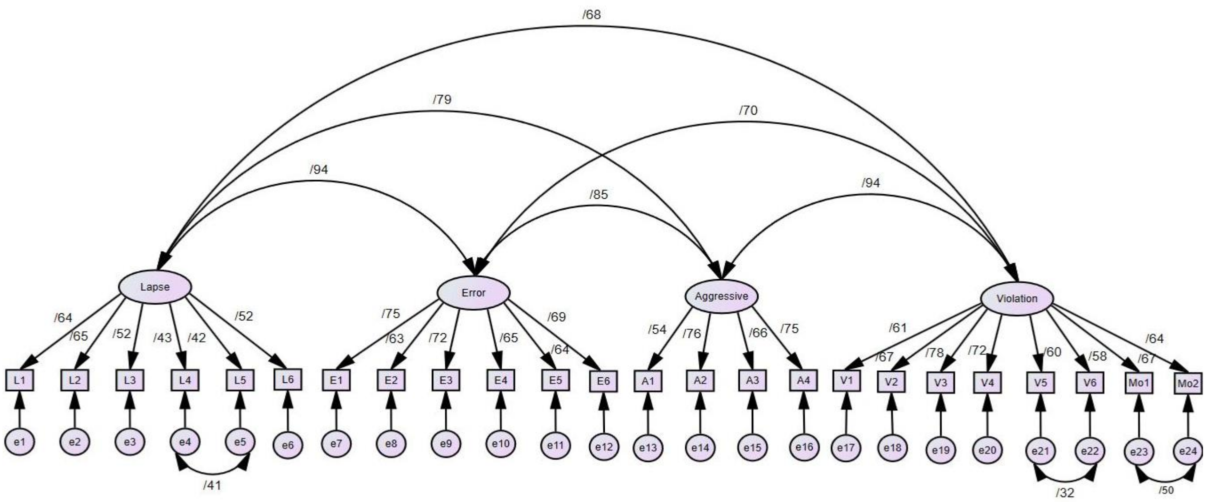

Fig. 2. Standardized solution for the four-factor confirmatory factor model containing mobile phone usage items

Table 5. Model fit indices of confirmatory factor analysis on a shortened version of DBQ containing mobile phone items

Model	χ2	df	χ2/df	Absolute fit RMSEA	Comparative fit CFI	Parsimonious fit PCFI
Model: Violations, Aggressive, Lapses, Errors	457	243	1.882	0.054	0.93	0.82

3.3. Effect of Demographic Variables

3.3.1. Analysis of Variance (ANOVA) Test

Analysis of Variance (ANOVA) was conducted to determine the impact of age (3 levels: 18-30, 31-46, and 45+), gender (2 levels: male and female), crash history (2 levels: involved, not involved), and driving time per day (4 levels: less than 1 hour, 1-2 hours, 2-4 hours, more than 4 hours) on each of the four subscale scores.

The ANOVA test revealed a significant influence of age and crash history on all the subscale scores. The results show that there are no statistically significant differences between males and females on violation and lapses scores. However, the mean score of errors and aggressive behaviors are statistically different by gender ($p < 0.05$). Moreover, investigating the impact of driving time on each factor scores shows that prolonged driving does not have a statistically significant impact on lapses score, while long time driving can affect errors and aggressive behaviors ($p < 0.05$). Although driving time has no significant impact on violations scores at a 95% level, it is significant at a 90% level of confidence ($p < 0.1$). Table 6 presents the ANOVA results.

3.3.2. T-Test Analysis

The means and standard deviations of each subscale score for gender, age, crash history, and driving time groups are presented in Table 7. According to Table 7, male drivers have more score in all the subscales than females. However, errors and aggressive behaviors are only statistically significant ($p < 0.05$). It means that male participants have more aggressive behavior and do more errors while driving.

Furthermore, using an independent sample t-test, the mean score of elder drivers (+45) on entire subscales is significantly lower than middle-aged and young drivers ($p < 0.001$). Moreover, the mean score of middle-aged participants is lower than young participants on entire subscales ($p < 0.001$). It means that aging significantly decreases drivers' aberrant behaviors ($p < 0.001$). Table 7 shows that those drivers who were involved in a crash accident in the past three years have significantly higher factor score on entire aberrant behaviors ($p < 0.001$).

Furthermore, the driving time has a direct relationship with all of the factor scores, and driving more per day can lead to more aberrant behavior. However, the independent sample t-test depicted that the mean score of drivers who drive less than one hour per day and drivers who drive more than four hours per day in violations, errors, and aggressive behaviors are only statistically different at a 95% level of confidence.

Table 6. ANOVA results

Demographics	F statistics from ANOVA (p-value)			
	Violations	Errors	Lapses	Aggressive behaviors
Gender	2.18 (0.14)	4.26 (0.04)	1.32 (0.25)	3.693 (0.04)
Age	39.43 (< 0.001)	16.21 (< 0.001)	7.72 (0.001)	17.07 (< 0.001)
Crash history	42.74 (< 0.001)	12.98 (< 0.001)	6.18 (0.013)	33.7 (< 0.001)
Driving time	2.24 (0.065)	2.41 (0.04)	1.7 (0.148)	2.87 (0.023)

Table 7. Means (standard deviation) of all subscale scores

Variables	Subgroup (n)	Mean (Standard deviation)			
		Violations	Errors	Lapses	Aggressive behaviors
Gender	Male (168)	2.57 (1.122)	2.12 (0.909)	2.38 (0.762)	2.32 (1.081)
	Female (130)	2.38 (0.965)	1.91 (0.806)	2.28 (0.842)	2.09 (0.935)
Age	18-30 (127)	3.04 (1.069)	2.34 (0.871)	2.54 (0.777)	2.59 (1.035)
	30-45 (107)	2.15 (0.833)	1.80 (0.793)	2.23 (0.752)	1.98 (0.880)
	45+ (64)	1.94 (0.845)	1.77 (0.803)	2.11 (0.834)	1.86 (0.993)
Crash history	Involved (91)	3.05 (1.016)	2.30 (0.903)	2.51 (0.761)	2.71 (1.129)
	Not involved (207)	2.24 (0.980)	1.91 (0.804)	2.26 (0.804)	2.00 (0.895)
Driving time	Less than 1hr (109)	2.33 (0.987)	1.90 (0.752)	2.24 (0.825)	2.03 (0.881)
	1-2 hr (97)	2.43 (1.042)	2.01 (0.910)	2.33 (0.795)	2.25 (1.049)
	2-4 hr (71)	2.69 (1.152)	2.11 (0.910)	2.39 (0.712)	2.27 (1.087)
	More than 4 hr (21)	2.86 (1.035)	2.51 (0.992)	2.65 (0.903)	2.81 (1.180)

3.3.3. Effect of Mobile Phone Usage

To investigate the impact of mobile phone usage as a demographic variable, the mean score of two mobile phone usage items was calculated. According to Table 8, drivers who were involved in a crash in three past years, use their mobile phones more while driving as compared to the drivers who were not involved in a traffic crash ($p < 0.0001$). Furthermore, there are significant differences between the mean score of mobile phone usage while driving by young (18-30 years), middle-aged (30-45 years), and elder (+ 45 years) drivers. Table 8 shows that mobile phone usage while driving decreases significantly by age ($p < 0.0001$). Besides, males use their mobile phones more while driving than females. However, this is not statistically significant at 95% level of confidence.

4. Discussions

Consistent with previous studies, the most frequent response to the 24 items of DBQ was "quite infrequently" (Reason et al., 1990; Stephens and Fitzharris, 2016). However, in general, the mean responses of Iranian drivers were higher than European countries such as England (Reason et al., 1990), Australia (Stephens and Fitzharris, 2016), France (Gueho et al., 2014) and Turkey (Özkan and Lajunen, 2005). Furthermore, four-factor-solution supports previous studies in Iran (Mehdizadeh et al., 2018). Moreover, the mean response of two mobile phone usage items was "infrequently". This shows the necessity of investigating mobile phone usage while driving. Table 2 depicted that, the most frequent responses are violations and aggressive behaviors, while the least frequent responses were related to the errors and lapses questions. This means that although Iranian drivers tend to violate the traffic rules and drive aggressively, they are conscious while driving.

The results of confirmatory factor analysis show that, although the shortened version of DBQ is reliable and valid, it could be further shortened due to the error covariance suggested by modification indices. These covariances are suggested to apply between the two lapses items ("'Wake up' to realize that you have no clear recollection of the road along which you have just traveled" and "Forget where you left your car in a multi-level car park") and two violations items ("Become impatient with a slow driver in the outer lane and overtake on the inside" and "Overtake a slow-moving vehicle on the inside lane or hard shoulder of a motorway"). This can be due to the similarity of the content of these items.

It was observed that aggressive behaviors factor is highly correlated with violations and errors factor is strongly interrelated with lapses. Therefore, two second-order underlying factors may exist. However, additional second-order CFA analysis showed less model fit indices than the first-order four-factor structure model. Therefore, the results of the second-order model were not shown. Moreover, another model structure with the two first-order underlying factors (errors and lapses united in one factor, and violations and aggressive behaviors united in one factor) also showed less model fit indices.

Table 8. The mean (standard deviations) of mobile phone usage items in each demographic subgroup

Variable	Subgroup	Mean score of mobile phone usage
Gender	Male	3.04 (1.602)
	Female	2.83 (1.508)
Age	Young	3.59 (1.559)*
	Middle	2.66 (1.438)*
	Elder	2.17 (1.250)*
Crash history	Involved	3.52 (1.562)*
	Not involved	2.69 (1.499)*

*p < 0.0001

The results show that participants who declared to be involved in a crash in three past years use their mobile phones more while driving. It supports previous findings by Mohammadi (2009) that increasing mobile phone usage while driving could increase the risk of being involved in a traffic accident. Furthermore, younger drivers and male drivers use their mobile phones more while driving. These results also support previous findings of Korpinen and Pääkönen (2012) and Arvin et al. (2016).

It should be noted that given the results of the behavioral assessment are based on the drivers' perceptions, there could be a difference between the drivers' perceptions and reality. A study conducted by van Huysduynen et al. (2018) depicted that there is a moderate correlation between self-reported driving style and the driver behavior in the driving simulator. Therefore, updating the DBQ by increasing indicators of errors and violations in a way that be more consistent with daily events can increase the correlation between self-reported driver behaviors and real-life observations.

5. Conclusions

The primary aim of this article was to validate the shortened version of the driver behavior questionnaire that included mobile phone usage. The results of this study confirmed four-factor structure presented by Parsihad et al. (2020). Moreover, four additional aggressive behaviors questions that were developed by Lawton et al. (1997), and not considered in the study by Parishad et al. (2020), were included and assessed in our model. Two of them were added to the final model. The final model consists of four subscales, namely, Violations (6 items), Errors (6 items), Lapses (6 items), and Aggressive behaviors (4 items). The results showed that young drivers, male drivers, drivers who were involved in a traffic crash in the past three years, and drivers who drive more during the day behave more aberrantly.

Furthermore, due to technology advancement, the other goal of this study was to improve and update the DBQ. As a new addition, mobile phone usage while driving was assessed from the behavioral aspect. Bivariate Pearson’s’ correlation depicts that mobile phone usage while driving is highly correlated to violations subscale as was expected. Placing mobile phone usage items in the violations subscale, a new model was developed, and presented a better model fit indices and subscale reliability. The results showed that mobile phone usage while driving as a deliberate act, which violates the driving laws, could be assessed on the violations subscale and impact on drivers’ aberrant behaviors. Moreover, supporting previous studies (Mohammadi, 2009; Korpinen and Pääkönen, 2012; Arvin et al., 2016), the results of this study showed that young drivers, male drivers, and drivers who were involved in a traffic crash in the past three years use their mobile phones more than the others while driving. As vehicle technology evolves with an increase in the level of automation, in the future, the DBQ may need to be modified and adapted to suit the drivers' behaviors in a highly automated vehicle.

6. Limitations and Future Studies

A conducted study by Özkan and Lajunen (2005) developed a new driver behavior scale namely positive behaviors. The positive behaviors focus on “taking care of smooth traffic flow or paying attention to other road users” (Özkan and Lajunen, 2005). Since this study used the 50-items Manchester drivers’ aberrant behaviors (Reason et al., 1990), the positive behaviors scale was not assessed in the present study. Therefore, investigating the positive behaviors in future studies is suggested.

Since the impact of mobile phone usage from a behavioral aspect was not addressed in the literature, this study considered the drivers' perceptions on the influence of mobile phone usage on their driving behavior. It was observed that there is an error covariance between the two mobile phone usage items. It means people do not differentiate between those two mobile phone usage items a lot. Therefore, the author(s) suggest developing other additional items for mobile phone usage in future studies. Furthermore, the effect of other car technology advancements such as radar cruise control, Bluetooth technology, assisted steering, blind-spot monitoring, head-up displays, voice command, the autonomous cars technology, etc. can be investigated in future studies.

7. References

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Appendix

Shortened Driver Behavior Questionnaire

Lapses (L)

1) Distracted or preoccupied, realize belatedly that the vehicle ahead has slowed, and have to slam on the brakes to avoid a collision.
2) Intend to switch on the windscreen wipers, but switch on the lights instead, or vice versa.
3) Intending to drive to destination A, you 'wake up' to find yourself in route to B, where the latter is the more usual journey.
4) 'Wake up' to realize that you have no clear recollection of the road along which you have just travelled.
5) Forget where you left your car in a multi-level car park.
6) Miss your exit on a motorway and have to make a lengthy detour.

Errors (E)

1) Misjudge your crossing interval when turning right and narrowly miss collision.
2) Hit something when reversing that you had not previously seen.
3) Fail to notice pedestrians crossing when turning into a side street from a main road.
4) In a queue of vehicles turning left on to a main road, pay such close attention to the traffic approaching from the right that you nearly hit the car in front.
5) Fail to notice someone stepping out from behind a bus or parked vehicle until it is nearly too late.
6) Misjudge speed of oncoming vehicle when overtaking.

Violations (V)

1) Deliberately drive the wrong way down a deserted one-way street.
2) Overtake a single line of stationary or slow-moving vehicles, only to discover that they were queueing to get through a one lane gap or roadwork lights.
3) Get involved in unofficial 'races' with other drivers.
4) Deliberately disregard the speed limits late at night or very early in the morning.
5) Become impatient with a slow driver in the outer lane and overtake on the inside.
6) Overtake a slow-moving vehicle on the inside lane or hard shoulder of a motorway.

Aggressive violations (AV)

1) Have an aversion to a particular class of road user, and indicate your hostility by whatever means you can.
2) Angered by another driver's behavior, you give chase with the intention of giving him/her a piece of your mind.
3) stay in a lane that you know will be closed ahead until the last minute before forcing your way into the other lane.
4) Pull out of a junction so far that the driver with right of way has to stop and let you out.
5) sound your horn to indicate your annoyance to another driver.
6) race away from traffic lights with the intention of beating the driver next to you.

Mobile phone usage (MU)

1) Use your mobile phone for calling/texting while driving.
2) Use your mobile phone applications (bank, navigation, games, …) while driving.