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Self-reported violations, errors and lapses for older drivers: Measuring the change in frequency of aberrant driving behaviours across five time-points

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A R T I C L E I N F O

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A B S T R A C T

The current study aimed to: 1. to confirm the 21-item, three-factor Driver Behaviour Questionnaire (DBQ) structure suggested by Koppel et al. (2018) within an independent sample of Canadian older drivers; 2. to examine whether the structure of the DBQ remained stable over a four-year period; 3. to conduct a latent growth analysis to determine whether older drivers' DBQ scores changed across time. Five hundred and sixty Canadian older drivers (males = 61.3%) from the Candrive/Ozcandrive longitudinal study completed the DBQ yearly for four years across five time-points that were approximately 12 months apart. In Year 1, the average age of the older drivers was 76.0 years (SD = 4.5 years; Range = 70–92 years). Findings from the study support the 21-item, three-factor DBQ structure suggested by Koppel and colleagues for an Australian sample of older drivers as being acceptable in an independent sample of Canadian older drivers. In addition, Canadian older drivers' responses to this version of the DBQ were stable across the five time-points. More specifically, there was very little change in older drivers' self-reported violations, and no significant change for self-reported errors or lapses. The findings from the current study add further support for this version of the DBQ as being a suitable tool for examining self-reported aberrant driving behaviours in older drivers. Future research should investigate the relationship between older drivers' self-reported aberrant driving behaviours and their performance on functional measures, their responses to other driving-related abilities and practice scales and/or questionnaires, as well their usual (or naturalistic) driving practices and/or performance on on-road driving tasks.

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1. Introduction

Older drivers are one of the highest risk road user groups in terms of motor vehicle crash-related deaths and serious injuries (Langford and Koppel, 2006). While recent statistics indicate that older drivers are involved in relatively few crashes in terms of absolute numbers, they are over-represented in motor vehicle crashes involving serious injury and death per number of drivers and per distance travelled (Koppel et al., 2011). This over-representation has largely been attributed to older drivers' greater physical frailty and reduced tolerance to injury (Augenstein, 2001; Dejeammes and Ramet, 1996; Eberhard, 1996; Evans, 1991; Li et al., 2003; Mackay, 1998; Padmanaban, 2001; Viano et al., 1990), as well as declines in their sensory, cognitive, and physical abilities due to ageing, increased medical conditions and increased medication use (Marshall, 2008).

Detailed analyses of older driver crashes have revealed significantly different crash epidemiology compared to middle-aged and younger drivers. For example, older drivers are more likely to crash: during daylight hours; at low speeds; with low Blood Alcohol Concentration (BAC) levels; at intersections; and involve other vehicles (i.e., multi-vehicle crashes) (Catchpole et al., 2005; Koppel et al., 2011; Langford and Koppel, 2006; OECD, 2001). In addition, the types of aberrant driving behaviors that lead to older driver crashes tend to be related to problems with driver attention (e.g., errors or lapses) as opposed to deliberate or intentional behaviours (e.g., violations) that are more common among younger drivers, such as speeding, red-light running or drunk driving (Eberhard, 1996). Given older drivers represent a unique cohort of drivers (Koppel and Berecki-Gisolf, 2015), it would be useful to have a specific instrument identifying types of aberrant driving behaviours that are common in this cohort.

Recently, Koppel et al. (2018) tested a modified version of the Driving Behaviour Questionnaire (DBQ; Reason et al., 1990) in a population of older drivers (aged 75 years and over) enrolled in the Australian Ozcandrive longitudinal study. The DBQ is a subjective measurement of broad types of aberrant driving behaviour that may be associated with crash risk. These behaviours include violations, errors and lapses and as such, relate to the main areas identified as being specifically associated with older driver crash risk (Eberhard, 1996). According to Reason et al. (1990), 'violations' are defined as deliberate driving behaviours that directly contravene road laws and increased crash risk (e.g., disobeying the speed limit), 'errors' are defined as behaviours that do not contravene road laws directly but, as with violations, increase crash risk (e.g., misjudge the speed of an oncoming vehicle when turning), and 'lapses' represent minor mistakes that are not considered to be associated with increased crash risk (e.g., driving on usual route by mistake) (Reason et al., 1990).

Koppel et al. (2018) found support for a 21-item, three-factor version of the DBQ. This instrument was a modified version of the DBQ suggested by Obriot-Claudel and Gabaude (2004) to be appropriate for older drivers (i.e., aged between 55 and 91 years). Obriot-Claudel and Gabaude (2004) used exploratory factor analysis to determine three main types of aberrant driving behaviours which they defined as 'inattention errors', 'dangerous errors' and 'dangerous violations'. In contrast, Koppel and colleagues were able to retain the three commonly used factors (i.e., errors, lapses and violations) proposed by Martinussen and colleagues as appropriate for older drivers (i.e., aged between 50 and 85 years) (Martinussen et al., 2013).

Given that older drivers represent a unique cohort of drivers, and the importance of their safe mobility, it is important to understand not only how frequently older drivers report driving errors and lapses or commit violations, but the extent to which the frequency of these change over time. For this cohort particularly, age-related declines in sensory, cognitive, and physical abilities are likely to be reflected in increasing frequency of reported lapses and errors while driving (Koppel et al., 2018).

Very little research has examined how the frequencies of errors, violations or lapses change over time using the DBQ. Recently, Roman et al. (2015) examined changes in self-reported aberrant behaviours (i.e., DBQ scores for errors, slips, violations and aggressive violations) for young novice drivers across six monthly intervals and reported that scores for each type of aberrant behaviours increased across the time-points. Koppel et al. (2018) performed a similar analysis of change in mean DBQ scores for errors, lapses and violations across three time-points (i.e., a 2-year period) for their older drivers and reported that DBQ scores were stable across the three time-points; and that violations, errors, and lapses frequencies remained relatively similar across the three time-points with only marginal decreases evident for violations and lapses. The authors concluded that the DBQ is a reliable tool to measure older drivers' self-reported aberrant driving behaviours and that these behaviours do not show much change across time. However, it is possible that changes might be observed over a longer period of time, particularly in a cohort of drivers or with those nearing the end of their driving period.

The aims of the current study were threefold: 1. to confirm the 21-item, three-factor DBQ structure suggested by Koppel et al. (2018) within an independent sample of Canadian older drivers; 2. to examine whether the structure of the DBQ remained stable over time across a longer time period (i.e., across 5 time-points [or 4 years]); 3. to conduct a latent growth analysis to determine whether older drivers' DBQ scores changed across time.

2. Method

2.1. Participants

Participants were Canadian older drivers participating in the Candrive/Ozcandrive study. The Candrive/Ozcandrive study is a longitudinal, multi-centre international research program with the core objective of identifying solutions to promote older drivers' safe mobility (Marshall et al., 2013). The Candrive/Ozcandrive study involves 928 drivers aged 70 years and over in Canada and 302 drivers aged 75 years and older in Australia (n = 257) and New Zealand (n = 45). Using a longitudinal study design, the project tracked this cohort of older drivers across five time-points (i.e., a 4-year period), assessing changes in their functional abilities, driving practices (e.g. exposure and patterns), as well as crashes and citations for violations of driving regulations. Participants' usual (or naturalistic) driving practices (e.g., trip distance, duration, type of road, speed) were recorded through in-car recording devices (ICRD) installed in participants' own vehicles, and measures of participants' functional ability, medical conditions and self-reported driving-related abilities and practices were documented annually.

Candrive participants completed annual assessments across five time-points in seven Canadian cities/university sites located in four provinces: Montreal (Quebec), Ottawa, Toronto, Hamilton, Thunder Bay (Ontario), Winnipeg (Manitoba) and Victoria (British Columbia). All participants were required to meet the following inclusion criteria: a) aged 70 years or older; b) held a general class driver's licence; c) had been actively driving for at least one year; d) drove at least four times per week (i.e., 4 round trips), e) agreed to undergo an annual physical and cognitive assessment; f) agreed to be contacted at least quarterly for vehicle data pick-up and interview; g) resided in the local region of one of the study cities for at least ten months of the year; h) was followed actively by their family physician; i) intended to continue driving for the next five years; j) was fluent in English; and k) did not have an absolute contraindication to driving, as defined by the Canadian Medical Association (2006).

From the initial 927 participants enrolled in the Candrive study, and due to participant withdrawals and site closures in Winnipeg and Toronto (see Fig. 1) across the five time-points (Year 1: n = 0; Year 2: n = 49; Year 3: n = 56; Year 4: n = 81; Year 5: n = 181)[1], full data sets from 560 older drivers were available for analysis.

[1] Note some participants withdrew from the study after completing their annual assessment.

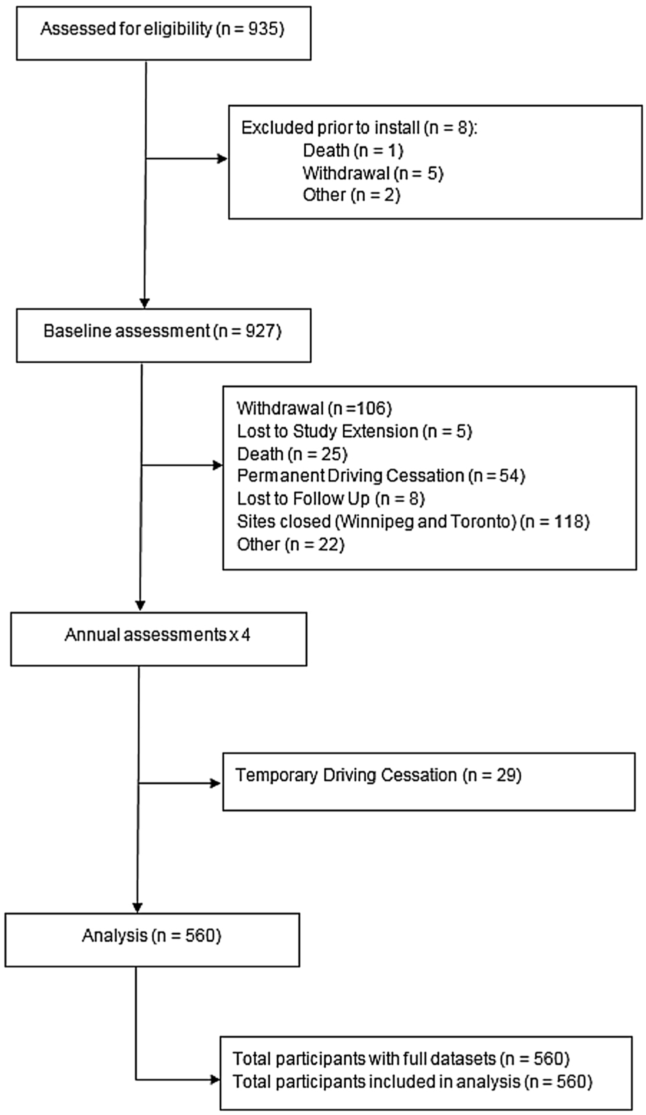

Fig. 1. Consort diagram of study participation across five time-points.

2.2. Procedure and materials

All study sites received ethics approval from their respective institutions and all participants provided written informed consent prior to their first (Year 1/baseline) annual assessment.

All participants completed a baseline (Year 1) and four annual assessments (Years 2–5). The time between annual assessments for Candrive older drivers was approximately 12 months. Each assessment incorporated a range of demographic and driving patterns questions, as well as a range of functional performance measures, medical conditions, and self-reported abilities and practices related to driving (Marshall et al., 2013), including the DBQ (Reason et al., 1990).

2.2.1. DBQ

A 47-item DBQ was administered to participants at each time point. As described above, the original DBQ contained 50-items relating to self-reported aberrant driving behaviours that are likely to increase crash risk. However, given that the Candrive/Ozcandrive study protocol was designed for older drivers in Canada, as well as older drivers in Australia and New Zealand, two DBQ items relating to driving behaviour at roundabouts were removed as road infrastructure in Canada rarely includes roundabouts. In addition, given that most participants drove an automatic vehicle, the DBQ item relating to driving off in third gear was also removed. The final version of the DBQ contained 47-items. For each item, participants were asked to rate the frequency of the aberrant driving behaviour on a five-point scale of engagement (where: 1 = never, 6 = nearly all the time). The 21-item, three-factor DBQ structure (errors, violations and lapses) suggested by Koppel et al. (2018) was tested for suitability to the data. This was previously found to be suitable for older drivers (χ^2 (186) = 264.39, $p < 0.001$; CFI = 0.90, TLI = 0.89, RMSEA = 0.04 (90% CI: 0.03, 0.06, pclose > 0.05).

2.2.2. Data handling

Data were analysed with SPSS v.23 and AMOS v.22. Only full data sets were included in the analysis, meaning that participants who did not complete the DBQ at all five time-points were excluded (see Fig. 1). In total, there were 367 participants who did not complete the DBQ at all five time points and were excluded. For the remaining 560 participants, there were no cases where missing data exceeded 10% of the DBQ items and for cases where less than 10% of the item responses were missing (i.e., 1 or 2 cells), 5% trimmed mean imputation was used. This reduction occurred in a negligible number of instances (< 1%) and was incorporated to satisfy the full data requirement for AMOS.

The structure of the 21-item, three-factor DBQ was examined using Confirmatory Factor Analysis (CFA). A number of indices were used to determine model fit, including the chi-square statistic, comparative fit index (CFI) and the root mean square of approximation (RMSEA) with 90% confidence interval and pclose value. While traditionally model fit has been determined by a non-significant chi-square statistic, researchers have shown this is sensitive to sample size and can lead to falsely rejecting models (see Byrne, 2013), therefore significant chi-square statistics were allowed in the current analysis, but only when the other fit indices were deemed satisfactory. This determination was based on a CFI value > 0.90 (Hu and Bentler, 1999), an RMSEA value < 0.06 and a non-significant pclose value (> 0.05) (Browne and Cudeck, 1993). Composite reliabilities for factors were calculated manually using the formula for Jerskog rho (Fornell and Larcker, 1981).

The stability of the modified DBQ as an instrument to measure errors, lapses and violations over time was examined using Multigroup Confirmatory Factor Analysis (MGCFA). This analysis is performed across a number of stages, with more restrictions placed on the data at each stage. Therefore, results are reported in terms of configural, metric and scalar invariance. Configural invariance requires the simultaneous analysis of the structure of each model. One set of goodness of fit indices are produced for the nested models and the same criteria was used to determine model fit as reported above (Chi-square, CFI > 0.90; RMSEA < 0.06, pclose > 0.05). The establishment of configural invariance shows that the structure of the 21-item DBQ is similar across the five time-points. Metric invariance then determines whether the pattern of loadings on the factors is equal across each time point. Accordingly, metric invariance requires the factor loading to be constrained to be equal across the groups. The resulting goodness of fit statistics are then compared to the configural model and the metric model accepted if the change in chi-square is non-significant (Byrne, 2013) and/or the change in the CFI value is < 0.01 (Cheung and Rensvold, 2002). Scalar invariance is the last and most restrictive stage and requires that the factor loadings and intercepts are constrained to be equal across groups. Scalar invariance is also confirmed by non-significant change in chi-square and/or change in CFI < 0.01. Acceptable MGCFA shows that participants are interpreting the DBQ items and underlying factor structure in the same way at each time point, specifically that the latent structure of the DBQ is reliable across time. It is only after this has been determined that any comparisons of means scores can be examined.

To examine any changes in factor means over time, a latent growth curve (LGC) analysis was performed on scores for violations, errors and lapses across the five time-points. The LGC provides information on change by regressing the intercept and slope for each factor containing

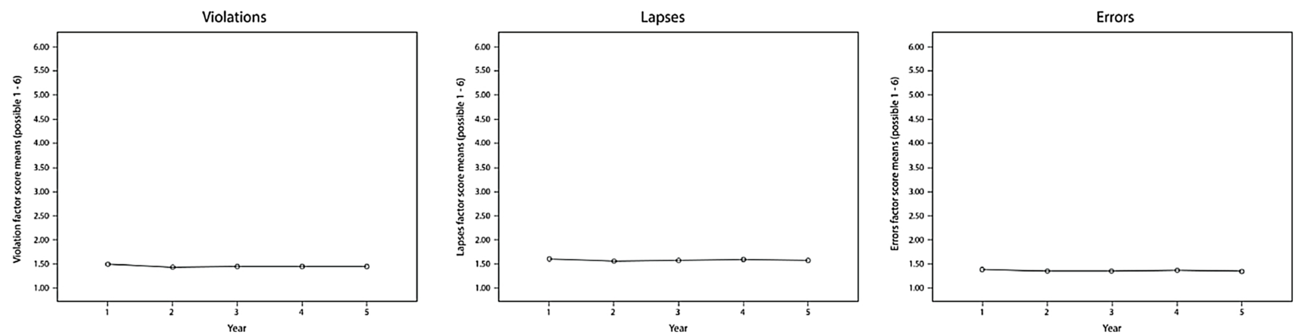

Fig. 2. DBQ factor means across the five time-points.

the scores for each time point. This analysis shows the average mean starting score for each factor, the degree of change across time as well as the relationships between starting mean and change within and between each factor. Significance is determined by significant p values set at < 0.05. LGC assumes a linear change and therefore mean values across the five time-points are included in Fig. 2 (see 3.2).

3. Results

3.1. Demographic and self-reported driving patterns

At baseline (Year 1), the average age of participants was 76 years (SD = 4.5 years; Range = 70–92 years). As shown in Table 1, most older drivers: were aged between 75–79 years (45.3%); were male (61.3%); were married or in a defacto/common-law relationship (62.0%); had completed an undergraduate (25.0%) or postgraduate degree (23.2%); were not employed (85.2%); volunteered in their community (59.8%); reported that they drove daily (51.5%), and estimated that they had driven between 5,001–15,000 km in the previous year (59.1%).

Table 1
Older drivers' demographic and driving patterns[a].

Demographic and Driving Patterns		Percentage (N)
Age group[b]	70-74 years	9.30% (52)
	75-79 years	45.3% (253)
	80-84 years	31.1% (174)
	85-89 years	11.3% (63)
	90-94 years	2.7% (15)
	95-99 years	0.4% (2)
Gender	Male	61.3% (343)
	Female	38.7% (217)
Marital status	Single (never married)	3.6% (20)
	Married / defacto /	62.0% (347)
	Common-law	9.5% (53)
	Divorced / separated	25.0% (140)
	Widowed	
Highest level of education	Primary/Grade school	9.3% (52)
	High school	23.9% (134)
	Trade/Technical	7.9% (44)
	certificate	10.7% (60)
	Diploma	25.0% (140)
	Degree	23.2% (130)
	Postgraduate	
Employment status	No	85.2% (477)
	Yes	14.8% (83)
Volunteering status	No	40.2% (225)
	Yes	59.8% (335)
Frequency of driving[c]	Daily	51.5% (287)
	4-6 times per week	36.3% (202)
	2-3 times per week	12.2% (68)
Estimated kilometers driven in past year[d]	0-5,000 km	15.3% (85)
	5001-15,000 km	59.1% (329)
	15,001 + km	25.7% (143)

[a] Based on information provided by participants in Year 1.
[b] Note that data for n = 1 participant was missing.
[c] Note that data for n = 3 participants was missing.
[d] Note that data for n = 3 participants was missing.

3.2. DBQ item mean scores

Table 2 shows the factor and item mean scores for the 21-item, three-factor version of the DBQ. Across the three-factors, all aberrant driving behaviours were reported infrequently. For example, lapses were the most frequently reported type of driving behaviour, where the mean scores ranged from 1.55 to 1.58 (SD range: 0.35 to 0.37). However, given that the possible range was 1.00 (never) to 6.00 (nearly all the time), it is important to note that lapses were reported infrequently by participants. 'Forgetting where the car was left in the parking lot' and 'Missing an exit on the highway' were the most frequently reported lapses, where the mean scores ranged between 1.88 to 1.96 and 1.71 to 1.85 respectively. 'Forgetting which gear the car was in' was the least frequently reported lapse (mean scores ranged from 1.25 to 1.27). This may be a result of the type of transmission in the vehicles driven by this group of older drivers.

Violations were the second most frequently reported driving behaviour, where the mean scores ranged from 1.43 to 1.49 (SD range: 0.35 to 0.39). The most frequently reported violation was 'Passing a slow driver in the right lane after becoming impatient with their vehicle speed' (mean scores ranged from 1.92 to 2.08). This was the also the most frequently reported aberrant driving behaviour overall. The least frequently reported violation was 'Racing another vehicle for a one-car gap on a narrow or obstructed road', where the mean scores ranged from 1.03 to 1.05, suggesting this to be a rare behaviour and the least frequently reported aberrant driving behaviour for this group of older drivers.

Errors were the least frequently reported type of driving behaviour, where the mean scores ranged from 1.33 to 1.37 (SD range: 0.79 to 0.82). The most frequently reported errors were 'Misjudging the speed of an oncoming vehicle when passing' (mean scores ranged from 1.41 to 1.48) and 'Being lost in thought or distracted and failing to notice someone waiting at a crosswalk light that has just turned red' (mean scores ranged from 1.39 to 1.46).

Fig. 2 shows the factor score means across each time-point for the three DBQ factors. As can be seen, the scores within each factor remain similar across each time-point.

3.3. Confirmatory factor analysis (CFA) on the structure of the 21-item, three-factor version of the DBQ

A CFA on the 21-item, three-factor version of the DBQ using scores from Year 1, showed the model to have good fit to the data, chi-square $(186) = 347.95$, $p < 0.001$, CFI = 0.93, RMSEA = 0.04 (90%CI = 0.03; 0.05), pclose > 0.05. All factor loadings were significant and ranged from 0.34 to 0.63. There were significant moderate positive correlations between the three-factors: errors and violations

Table 2
DBQ factor and item mean scores (standard deviations in brackets) at each time-point (n = 560).

Item		Year 1 M (SD)	Year 2 M (SD)	Year 3 M (SD)	Year 4 M (SD)	Year 5 M (SD)
	Violations: Total mean (SD; Cronbach's alpha)	***1.49 (0.39; 0.64)***	***1.43 (0.35; 0.62)***	***1.44 (0.35; 0.61)***	***1.47 (0.37; 0.60)***	***1.43 (0.37; 0.62)***
4	Become impatient with a slow driver in the right lane and pass in the right lane	2.08 (0.86)	2.03 (0.82)	2.02 (0.85)	1.99 (0.85)	1.92 (0.85)
5	Driving along country roads, you drive as fast with lights on low beam as you would with lights on high beam	1.74 (0.95)	1.57 (0.79)	1.04 (0.21)	1.69 (0.94)	1.71 (0.95)
7	Drive especially close to and flash the car in front as a signal to drive faster or get out of your way	1.28 (0.60)	1.24 (0.54)	1.25 (0.53)	1.24 (0.55)	1.21 (0.48)
16	Stuck behind a slow-moving vehicle on a two-lane highway, you are driven by frustration to try to pass under risky circumstances	1.31 (0.55)	1.28 (0.51)	1.23 (0.46)	1.28 (0.52)	1.29 (0.51)
21	Deliberately disregard the speed limits late at night or very early in the morning	1.57 (0.79)	1.53 (0.81)	1.56 (0.78)	1.55 (0.82)	1.57 (0.79)
45	Drive with only half-an-eye on the road while looking at a road map, dialling/text messaging on a cells phone, changing a cassette/CD or radio channel	1.42 (.62)	1.35 (.55)	1.36 (.55)	1.34 (.58)	1.31 (.55)
48	Race oncoming vehicles for a one-car gap on a narrow or obstructed road	1.03 (0.19)	1.04 (0.22)	1.04 (0.22)	1.04 (0.21)	1.05 (0.24)
	Errors: Total mean (SD; Cronbach's alpha)	***1.37 (0.34; 0.81)***	***1.33 (0.32; 0.79)***	***1.34 (0.33; 0.82)***	***1.36 (0.34; 0.82)***	***1.33 (0.33; 0.82)***
11	Turn left on to a main road into the path of an oncoming vehicle that you hadn't seen or who's speed you had misjudged	1.33 (0.49)	1.30 (0.48)	1.32 (0.51)	1.34 (0.51)	1.31 (0.50)
20	Try to pass a car without first checking in your mirror, and then get honked at by the car behind you which has already begun to pass	1.34 (0.50)	1.31 (0.51)	1.34 (0.50)	1.34 (0.51)	1.33 (0.51)
28	Lost in thought or distracted, you fail to notice someone waiting at a crosswalk light that has just turned red	1.46 (0.57)	1.45 (0.56)	1.46 (0.57)	1.46 (0.56)	1.39 (0.54)
30	Misjudge the speed of an oncoming vehicle when passing	1.48 (0.54)	1.41 (0.55)	1.41 (0.54)	1.46 (0.56)	1.42 (0.54)
32	Fail to notice someone stepping out from behind a bus or parked vehicle until it is nearly too late	1.29 (0.47)	1.26 (0.46)	1.26 (0.45)	1.27 (0.46)	1.27 (0.46)
41	Fail to check your mirror before pulling out, changing lanes, turning etc.	1.40 (0.57)	1.32 (0.51)	1.35 (0.53)	1.37 (0.52)	1.36 (0.53)
42	Attempt to pass a vehicle that you hadn't noticed was signalling its intention to turn right	1.21 (0.45)	1.17 (0.40)	1.16 (0.39)	1.16 (0.38)	1.16 (0.39)
46	Fail to notice pedestrians crossing when turning into a side-street from a main road	1.42 (0.53)	1.44 (0.53)	1.43 (0.54)	1.45 (0.55)	1.42 (0.54)
	Lapses: Total mean (SD; Cronbach's alpha)	***1.58 (0.36; 0.60)***	***1.54 (0.35; 0.57)***	***1.55 (0.36; 0.63)***	***1.56 (0.37; 0.64)***	***1.55 (0.37; 0.64)***
8	Forget where you left your car in a parking lot	1.96 (0.75)	1.88 (0.74)	1.92 (0.74)	1.93 (0.73)	1.92 (0.85)
10	Intend to switch on the windshield wipers, but switch on the lights instead or vice versa	1.38 (0.64)	1.36 (0.59)	1.36 (0.59)	1.38 (0.61)	1.40 (0.61)
14	Miss your exit on a highway and have to make a lengthy detour	1.85 (0.59)	1.77 (0.61)	1.76 (0.62)	1.73 (0.58)	1.71 (0.61)
15	Forget which gear you are currently in and you have to check	1.27 (0.52)	1.25 (0.52)	1.25 (0.48)	1.28 (0.54)	1.27 (0.53)
17	Intending to drive to destination A, you wake up and realise you are driving to destination B	1.46 (0.61)	1.43 (0.59)	1.46 (0.60)	1.47 (0.60)	1.47 (0.62)
38	Get into the wrong lane to make a left or right hand turn at an intersection	1.57 (0.64)	1.53 (0.62)	1.53 (0.64)	1.56 (0.62)	1.53 (0.62)

Table 3
Multigroup analysis of measurement invariance across the five time-points.

Stage	Chi-square	df	CFI	RMSEA	90% CI RMSEA	Δ Chi-square (Δdf)	Δ CFI
Single models:							
Year 1 (baseline)	341.27***	186	0.93	0.04	0.03 - 0.05	na	na
Year 2	358.30***	184	0.91	0.04	0.04 - 0.05	na	na
Year 3	420.25***	186	0.90	0.05	0.04 - 0.05	na	na
Year 4	409.36***	186	0.90	0.05	0.04 - 0.05	na	na
Year 5	376.98***	186	0.92	0.04	0.04 - 0.05	na	na
Configural model (models nested by unconstrained	1966.19***	930	0.90	0.02	0.02 - 0.02	na	na
Metric (factor loadings constrained to be equal)	2020.78***	1002	0.91	0.02	0.02 - 0.02	54.52 (72)	< 0.01
Scalar (intercepts & covariances constrained)	2043.46	1026	0.91	0.02	0.02 - 0.02	77.28 (96)	< 0.01

*** $p < 0.001$.

(r = 0.61), violations and lapses (r = 0.55) and errors and lapses (r = 0.77). Composite reliabilities for each factor were acceptable (errors = 0.81; violations = 0.67; lapses = 0.60).

3.4. Multi-group confirmatory factor analysis (MGCFA) on all five time-points

Table 3 shows the goodness of fit statistics for each stage of the MGCFA analysis. Initially single models were conducted on DBQ responses for each time-point. With the exception of Year 2, all models showed good fit to the data without modifications. For Year 2, good model fit was achieved after covarying the error pairs for items 20 and 41, and items 28 and 46.

Configural invariance was confirmed when all models were nested and unconstrained, showing that the 21-item, three-factor structure of the DBQ remained similar across the five time-points. Metric invariance and Scalar invariance were both confirmed through a non-significant change in chi-square and CFI change no greater than 0.01 (see Table 3). The results of the MGCFA support full measurement invariance suggesting that the three-factor version of the DBQ remained conceptually similar for participants across the five time-points.

3.5. Latent growth curve

A latent growth curve was established for the 21-item, three-factor version of the DBQ using factor scores from all five time-points (see Fig. 3). An initial model was allowing all factor intercepts and slopes to covary. A final model was conducted with only the significant covariances. The model showed good fit to the data: Chi-square (104) = 465.20, $p < 0.001$, CFI = 0.95, RMSEA = 0.08 (90%CI = 0.07–0.08, pclose < 0.001). Whilst the RMSEA values are outside of the bounds for goodness of fit as reported above, they are within what is acceptable for a LGC analysis (Byrne, 2013). The means for the DBQ factor intercepts were all significant, showing (as reported above) that the average score for lapses was higher than violations (1.46) and errors (1.35). However, only the slope for violations was significant, showing that the average scores for self-reported errors and lapses did not change across the five time-points, while self-reported violations showed a very marginal decrease in frequency (−0.01) across that period.

As can be seen in Fig. 3, there were no significant factor covariances between the intercepts and slopes for each factor indicating that the any change was independent of the starting score. Factor scores covaried between the factors, with covariances between all three-factors and their slopes as well as their intercepts. This shows that the DBQ factor score starting means are related across factors. Finally, the inter-individual differences were examined through the variances for the intercept and slope of each factor. Of particular interest is that the variance for the violations slope was not significant, indicating that the change in frequency of self-reported violations over time was relatively consistent across the sample.

4. Discussion

The findings from the current study support the 21-item, three-factor DBQ structure suggested by Koppel et al. (2018) for an Australian sample of older drivers (aged 75 years and older) as being acceptable in an independent sample of Canadian older drivers (aged 70 years and older). As the sample of the drivers in this study is representative of the wider population of older drivers in Canada in terms of socio-

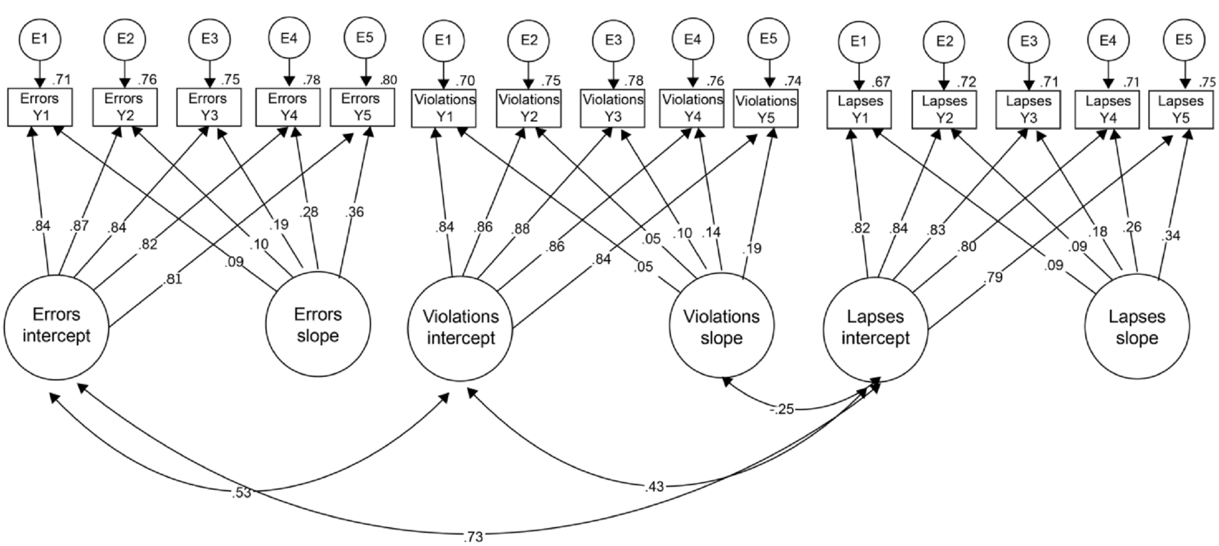

Fig. 3. Multiple domain latent growth curve on the 3-factor DBQ over the five time-points.

demographic and health variables (however not on driving frequency) (Gagnon et al., 2016), the results provide further support for the 21-item, three-factor DBQ as being suitable for older drivers. In addition to fitting the data, and consistent with that reported by Koppel and colleagues across three time-points (Koppel et al., 2018), the measurement remained stable across five time-points (i.e., a 4-year period) showing that the latent factor structure is invariant over time.

Mean scores for errors, lapses and violations showed that, overall, these behaviours were reported infrequently by older drivers. However, this is consistent with previous research using the DBQ (Martinussen et al., 2013; Stephens and Fitzharris, 2016). In addition, the pattern of mean scores for items and factors correspond with previously published research both by others who used different factor configurations (Stephens and Fitzharris, 2016) and with that recently reported by Koppel et al. (2018) who reported results using the same factor configurations. More specifically, errors tended to be the least frequently self-reported aberrant driving behaviour, while lapses tended to be the most frequently self-reported aberrant driving behaviour. It should also be noted that several DBQ items were reported very infrequently and suggest their removal; for example: ‘Forgetting which gear the car was in’ and ‘Racing another vehicle for a one-car gap on a narrow or obstructed road’ were items rarely endorsed.

When factor scores were examined over time, older drivers' self-reported violations showed very little change over time, and older drivers' self-reported errors and lapses showed no significant change over time. This is in line with the Australian data, where no significant change in errors was observed across three time-points and only marginal decreases in violations and lapses were reported (Koppel et al., 2018). While, these findings are consistent with that of Koppel and colleagues, they extend the research by using an independent and larger sample of older drivers (n = 560 vs. n = 227) and cover a longer time period (5 time-points vs. 3 time-points).

The findings of the current study make a significant contribution to the current published literature on the DBQ. While the DBQ is a widely used instrument, it suffers from the problem of inconsistent factor structure and there are a large number of published studies that report different configurations, both in terms of number of items and factors as well as item-to-factor loadings (e.g., Bener et al., 2008; Mesken et al., 2002; Özkan et al., 2006; Rimmö and Åberg, 1999; Zhang et al., 2015). In a meta-analysis, De Winter and Dodou (2010) provide a comprehensive examination of the numerous DBQ versions adopted by researchers. They reported that the number of items included in DBQ studies has ranged from 10 to 112, while the number of extracted factors has ranged from one to seven. One reason for this inconsistency is the diverse samples used, highlighting the need for versions of the tool appropriate for specific types of drivers. Our data show the 21-item version is not only suitable for older drivers across different countries and is reliable within these drivers over time.

Further research using objective data is warranted to examine the degree to which older drivers' aberrant driving behaviours (i.e., violations, errors, lapses) change across time and the extent to which these objective changes correspond to self-reported changes. The Candrive/Ozcandrive study has the potential to examine this using participants' usual (or naturalistic) driving practices (e.g., speeding), which are recorded through ICRD installed in participants' own vehicles (Marshall et al., 2013). In addition, older drivers' self-reported aberrant driving behaviours will be compared to specific driving behaviours observed during older driver's actual behind-the-wheel performance (see Koppel et al., 2016, 2017). In addition, the Candrive/Ozcandrive study has the potential to examine the relationship between older drivers' self-reported aberrant driving behaviours and their official citations. Indeed, recent research has shown a significant relationship between self-reported errors (using a different scale and structure of errors) and official citations (Cordazzo et al., 2016). Although scores for all DBQ factors were related, the relationships were moderate enough to show these are still independent constructs. Older drivers with higher mean scores for errors and lapses also had higher mean scores for violations. Therefore, there appears to be a relationship between intentional and unintentional driving behaviours whereby the motivations are different, but more frequent reports of one type of behaviour are related to more frequent reports in others. Interestingly, the change over time for each of these driving behaviours was unrelated to the starting frequency of them; older drivers with higher self-reported violations showed no more or less of a decrease than older drivers with lower self-reported violations.

Some study limitations should be noted. First, participants in the current study were older drivers participating in Candrive which is a longitudinal study designed to track older drivers for a period of up to five years. It is possible that only older drivers who perceived themselves as being ‘safe’ or as having low-levels of self-reported aberrant driving behaviour agreed to participate in this study. It will be important to explore these relationships in clinical samples (e.g., drivers with mild cognitive impairment or dementia etc.). Second, the aberrant driving behaviour reported in this study are based on self-report. It is possible that older drivers with age-related cognitive declines are unlikely to remember unintentional, or even intentional, aberrant driving behaviours. It will be important to validate these self-reported findings with participants' functional performance (e.g., performance on cognitive assessments), as well as with objective data sources (e.g., official crashes and citations, real-world driving / naturalistic driving study [NDS] data, etc.). Third, only full data sets were included in the analysis (n = 560, see Fig. 1), meaning that remaining participants who did not complete the DBQ at all five time-points were excluded (n = 367). However, it should be noted that baseline (Year 1) DBQ scores for errors, lapses and violations did not significantly differ across participants included and excluded in the analysis (errors: U = 99,594.50, p = 0.42; lapses: U = 99,094.50, p = 0.35; violations: U = 97,331.50, p = 0.17).

5. Conclusions

The findings of the current study have shown that the 21-item, three-factor version of the DBQ is a suitable tool to measure older drivers' self-reported aberrant driving behaviours across time. In addition, the findings have shown that older drivers' self-reported aberrant driving behaviour has remained relatively similar over the five time-points. Future research should investigate participants' self-reported aberrant driving behaviour in relation to their participation status (i.e., participating vs. withdrawn), as well as their performance on functional measures, their responses to other driving-related abilities and practices scales and/or questionnaires, as well their usual (or naturalistic) driving practices and/or performance on an on-road driving task.

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