An Application of the Driver Behaviour Questionnaire in a Large Australian Organisational Fleeting Setting: Can it Predict Crashes and Demerit Point Loss?

Darren Wishart, James Freeman, Jeremy Davey, Bevan Rowland and Peter Barraclough

Centre for Accident Research and Road Safety - Queensland
Queensland University of Technology
Kelvin Grove, Australia

ABSTRACT

This study reports on the utilisation of the Manchester Driver Behaviour Questionnaire (DBQ) to examine the self-reported driving behaviours of a large sample of Australian fleet drivers (N = 3414). Surveys were completed by employees before they commenced a one day safety workshop intervention. Factor analysis techniques identified a three factor solution similar to previous research, which was comprised of: (a) *errors*, (b) *highway-code violations* and (c) *aggressive driving violations*. Two items traditionally related with highway-code violations were found to be associated with aggressive driving behaviours among the current sample. Multivariate analyses revealed that exposure to the road, errors and self-reported offences predicted crashes at work in the last 12 months, while gender, highway violations and crashes predicted offences incurred while at work. Importantly, those who received more fines at work were at an increased risk of crashing the work vehicle. However, overall, the DBQ demonstrated limited efficacy at predicting these two outcomes. This paper outlines the major findings of the study in regards to identifying and predicting aberrant driving behaviours and also highlights implications regarding the future utilisation of the DBQ within fleet settings.

Keywords: Driver Behaviour Questionnaire (DBQ), fleet drivers, road safety.

INTRODUCTION

An enormous amount of on-going research effort is directed towards understanding and preventing the 1.3 million traffic crashes that result in fatalities each year world-wide (WHO, 2010). As a result, an array of self-report measurement tools are currently utilised that attempt to predict those at greatest risk of crash involvement, in part because self-report data offers a number of advantages associated with economy and simplicity of use (af Wåhlberg, Dorn & Kline, 2011). Assessment tools can take many forms and focus on a variety of driving behaviours as well as attitudes to such behaviours. However, the Manchester Driver Behaviour Questionnaire (DBQ) (Reason et al., 1990) is the most popular self-reported driving assessment tool globally (Mattsson, 2012). It has been extensively utilised in the prediction of individual differences in crash involvement, and to a lesser extent, predicting those who will incur demerit points. For example, a recent meta-analysis of the DBQ by de Winter and Dodou (2010) revealed that the scale had been used in 174 published studies (with 45,000 respondents), many of which focused on self-reported crash involvement.

Historically, the original DBQ was developed by Reason et al (1990) and focused on two distinct behaviours classified as either errors or violations. Errors consisted of actions on the part of the driver that are not planned while violations were those behaviours deemed to be deliberate deviations from safe driving practices. While both groups of behaviours are recognized as being potentially dangerous, the main distinction between the two concepts is the extent to which the actions are held to be deliberate or accidental (Lajunen et al., 2003). An additional factor, named “slips and lapses” has also been employed by researchers. This factor focuses on attention and memory failures that do not directly affect driver safety (Lajunen & Summala, 2003). Modifications to the original DBQ scale (Lawton et al., 1997) have facilitated the analysis of other factors found to contribute to driver violations. One new factor, ‘*aggressive violations*” has been identified and can be understood to be those actions associated with an interpersonally aggressive component as opposed to “ordinary” violations which, while still considered deliberate,

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do not have an aggressive element (Lajunen et al, 2003). More specifically, the scale distinguishes two classes of violations: "*highway code violations*", such as speeding and running red lights; and interpersonal "*aggressive violations*" which include behaviours such as sounding one's horn or chasing another motorist when angered (Lawton et al, 1997).

The DBQ has been utilised extensively in many countries in a wide variety of settings. Areas of road safety research include age differences, gender, novice drivers, vehicle type, survey bias, driver education programs, mental health issues, cross cultural studies, fleet safety and the behaviour of professional drivers [see de Winter and Dodou (2010) and Harrison, W. (2009) for an overview of the many areas of research in which the DBQ has been employed]. Studies utilising the DBQ have identified associations between self-reported aberrant driving practices and; unsafe driving behaviours or traffic offences (e.g. Mesken et al, 2002; Stradling, 2007); aggressive behaviours (e.g. Van Rooy et al, 2006); and assessing the risk of crash involvement (e.g. af Wåhlberg et al, 2011; Mesken et al., 2002; Parker et al., 1995; Reason et al, 1990).

Previous research employing the DBQ has tended to confirm either the original three factors of errors, violations and lapses (Blockey & Hartley, 1995; Parker et al, 1995), four factors that are errors, lapses, aggressive and ordinary violations (Sullman et al, 2002), or five factors (Parker et al., 2000; Shi et al., 2010). Distinct elements within the factor structure have also been noted although a high level of crossing loadings for some items across the factors is also quite common (Davey et al, 2007; Freeman et al, 2009). For the Australian context, Blockey and Hartley (1995) and Dobson, Brown, Ball, Powers, & McFadden, (1999) reported the same three original factors as Reason et al (1990), although Blockey & Hartley (1995) named the factors as general errors, dangerous errors and dangerous violations. In their studies of professional drivers, both Davey et al, (2007) and Freeman et al, (2009) identified a three factor solution, being *errors*, *highway code violations* and *aggressive driving violations*. In both studies, a number of the items traditionally related with *highway code violations* were found to be associated with aggressive driving acts.

Professional Drivers and Fleet Safety

Despite the large number of professional drivers on public roads, a comparatively small number of studies have used the DBQ to examine the self-reported driving behaviours of those who drive company sponsored vehicles and/or spend long periods of time behind the wheel (Davey et al, 2007; Freeman et al, 2009; Newnam et al, 2002, 2004; Sullman et al, 2002; Xie & Parker, 2002). This is surprising given that professional drivers not only have different driving demands, but they also have higher exposure to risk (Öz, Özkan, & Lajunen, 2010). More specifically, drivers of company vehicles have been found to have a greater risk of accident involvement (Newnam et al, 2002; Sullman et al, 2002), due not only to higher levels of exposure to the road environment, but also as a result of time and scheduling pressures and other distractions (Stradling et al, 2000). In fact, occupational driving crashes are the most common form of injury or death in the workplace (Haworth et al., 2000) with studies in Australia showing that over a quarter of work-related fatalities were the result of road crashes (NOHSC, 1998). In Queensland, around 37% of all fatal crashes in the period 1999 to 2000 were found to involve a commercial vehicle (Meers, 2001). As a result, researchers have begun examining professional drivers' self-reported behaviours in order to develop effective (and proactive rather than reactive) interventions. On occasion efforts have been made to develop an alternative to the DBQ that focuses on specific professional driver groups, such as the Bus Driver Risk Index (Dorn, Stephen, af Wåhlberg & Gandolfi, 2010), developed to address safety issues related to driver stress and fatigue.

Not surprisingly, the DBQ has featured prominently in studies of professional drivers. For example, Newnam, Watson & Murray (2002) investigated the work-driving behaviours of 204 Australian drivers and found that participants reported higher crash involvement in their work vehicle compared to their private vehicle usage, and were also less likely to conduct vehicle safety checking practices, e.g. tyre pressure on their work vehicle. Freeman et al (2009) and Davey et al (2007), utilised the DBQ to examine two samples of professional drivers' self-reported driving behaviours which revealed that a combination of *highway code violations* and *aggressive violations* predicted crash involvement. Öz et al (2010) examined the self-reported driving behaviours of 230 male professional drivers and reported those with low work orientation scores (e.g. culture) reported significantly more DBQ related-violations than those with high scores for work orientation. The DBQ has also previously been used to examine taxi, bus and company drivers in China (Xie & Parker, 2002), as well as truck drivers aberrant driving behaviours (Sullman et al, 2002). However, it is noted that other Australian studies that have employed the DBQ scale have focused on either the driving characteristics of women only (Dobson et al, 1999), applied abbreviated DBQ measures (Newnam et al, 2002) or contained small sample sizes, e.g. <150 (Blockey & Hartley (1995). Therefore, a need remains to utilise the DBQ within larger fleet samples.

Methodological Issues with the DBQ

Despite the wide-spread popularity of the DBQ, researchers have questioned the psychometric properties of the tool as well as its ability to accurately predict those most likely to be involved in a crash (af Wåhlberg, 2009; af Wåhlberg, Dorn & Freeman, 2012; Newman & VonSchuckmann, 2012). For example, de Winter and Dodou's (2010) meta-analysis of the DBQ revealed that violations predicted crashes with an overall correlation of .13 (based on zero-order effects reported in tabular form) which the authors believed was evidence of the usefulness of the tool to obtain insight into driving behaviours for various populations. However, a commentary of this meta-analysis by af Wåhlberg, Dorn & Freeman (2012) highlighted that this correlation may in fact be spuriously inflated due to common method variance, self-report bias and other methodological limitations associated with self-report data. For fleet settings, Newman and VonSchuckmann (2012) suggested the following three limitations of the DBQ: (a) varying factor structure, (b) non-focus on factors that impact upon professional drivers, and (c) ambiguous items such as "near-misses". The authors went on to publish results on an Occupational Driver Behaviour Questionnaire (ODBQ) and reported that the new scale accounted for a significantly greater proportion of the variance in a sample of 248 occupational driver's self-reported behaviours than the original DBQ. This study is yet to be replicated on larger samples nor has this new tool been used to predict actual self-reported crashes. However, a similar endeavour to develop a new work-related driving assessment tool by Wishart et al. (2012) that did attempt to predict self-reported crash involvement proved less successful. Nevertheless, additional concerns have also been expressed in regard to the stability of the DBQ over time, e.g. test-retest reliability (Harrison, 2009; Özkan et al., 2006). Furthermore, it has been suggested that the very low mean scores present on some factors limits the usefulness of the tool to accurately measure the impact of safety-related interventions (Harrison, submitted for publication). This problem is further amplified when correlations are drawn with relatively rare dependent variable events such as crashes. In fact, it has been shown that exposure to the road is more effective at predicting crashes within fleet settings than any of the DBQ factors (Davey et al, 2007; Freeman et al, 2009). Finally, Mattsson (2012) has questioned the suitability of methods often employed to determine the obtained facture structure, chiefly principal components analysis and maximum likelihood factor analysis, arguing that they are not ideal methods by which to properly analyse non-normally distributed categorical data.

Taken together, the DBQ remains the most widely used driving assessment tool in the world and continues to be implemented in a wide variety of settings. However, its application within work-related environments has been comparatively restricted, and researchers are now developing new scales in an attempt to overcome perceived shortcomings with the instrument. As a result, the present research endeavoured to utilise the DBQ to examine the self-reported driving behaviours of a large group of Australian drivers within a light fleet setting. More specifically the study aimed to investigate:

(a) the factor structure and generalisability of the DBQ to a sample of professional drivers; and
(b) the ability of the DBQ to predict self-reported crash involvement and traffic offences.

METHOD

Participants

A total of 3,458 individuals, all employees of a large state-funded organisation in Queensland, completed a survey before they participated in a half-day work-safety intervention that was implemented throughout the State of Queensland. After removing 44 completed surveys in which key data were missing (or in which respondents indicated that they did not drive a work vehicle), a sample size of 3,414 was obtained. Participating in the study were 1,841 (53.9%) males and 1,549 (45.4%) females[1]. The average age of the sample was 43 years (range 17-70 yrs). Participants were located throughout Queensland in both urban and rural areas. The largest proportion drove operational vehicles (95.2%), with a smaller proportion of vehicles described as salary sacrificed (4.8%). Vehicles used by participants for work were most likely to be reported to be sedans, hatchbacks, station wagons or utilities (67.8%), four wheel drive vehicles (23.0%), trucks (3.4%) or other (5.7%). In regard to the location in which most work related driving occurred, close to half reported that they drove primarily on city and suburban roads (44.5%), with slightly less participants driving on a combination of city, suburban and country roads (41.9%). On average, participants had held their licence for 25 years (range 1–54yrs). The largest proportion drove between 1 and 10 hours per week (59.9%), while just under a quarter (23.7%) drove between 11 and 20 hours per week. Over half the participants drove between 1 and 10,000kms per year at work (54.4%) while another fifth (19.8%) reported driving between 10,000km and 20,000km annually.

[1] 24 participants did not respond to this question.

Table 1 provides a breakdown of all self reported crashes and traffic offences[2] in a work context as well as outside of work in the previous 12 months. Of these participants, 361 drivers reported involvement in a crash of which 360 occurred while driving for work, while 809 drivers reported fines or demerit points for traffic related offences, of which 299 were incurred while at work. The sample reported involvement in an average of 0.12 crashes that occurred while at work in the past 12 months. Drivers who actually reported involvement in a work-related crash during this period had on average 1.12 crashes. The average number of traffic offences issued whilst at work in the 12 months was 0.10, with those who reported receiving demerit points lost or fines received averaging 1.19 offences during this period.

Table 1. Frequency of all self-reported crashes and traffic offences in previous 12 months

	Work Related		**Outside of Work**	
CRASHES	Frequency	Valid %	Frequency	Valid %
None	3,040	89.4	3095	91.1
1 crash	325	9.6	273	8.0
2 crashes	28	0.8	23	0.7
3 or more crashes	7	0.2	5	0.1
Total	3,400	100	3396	100
OFFENCES				
None	3,094	91.2	2893	85.0
1 offence	252	7.4	424	12.5
2 offence s	37	1.1	65	1.9
3 or more offences	10	0.3	21	0.6
Total	3,393	100	3403	100

Participants, Demographics and Procedure

A modified version of the DBQ was used in the current study, consisting of 20 items. Questions relating to lapses were omitted as this factor has not been found to have significant associations with crash involvement. The authors of the current paper also made minor modifications to some DBQ questions to ensure the questionnaire was representative of driving conditions as experienced by the study participants. For example, references to the specific direction that another car may be turning ("left" or "right") were removed with the more general term "turning" deemed to be sufficient for the purposes of this study[3]. Respondents were required to indicate on a 7 point scale (1 = never to 7 = always) how often they commit each of the *errors* (8 items), *highway code violations* (8 items) and *aggressive violations* (4 items). 7 of the 8 survey questions that constitute the *highway code violations* cohort are either associated with speeding or a desire on the part of the driver to improve the position of the car in relation to other cars, the exception being a question on alcohol use. As such, the factor *highway code violations* can also be understood as representing attitudes towards speeding.

A number of socio-demographic questions were included in the questionnaire to determine participants' age, gender, driving history (e.g. years experience, number of traffic offences and crashes) and their weekly driving exposure (e.g. type of car driven, driving hours). A series of half-day workshops, focusing on fleet driving behaviours, were held throughout Queensland, with attendance arranged by the participants' employers. Work-shop attendees were invited to complete the survey before participating in the workshop activities. Only a small number of attendees were unable to effectively complete the survey, with 3,414 of the 3,458 surveys completed by participants utilised for this study, indicating a response rate of over 98%.

Results

[2] Traffic offences indicates a loss of demerit points or fines incurred as a result of a traffic violation but does not include parking offences.

[3] The DBQ has been shown to be robust to minor changes to some items, altered to reflect specific cultural and environmental contexts (Blockey & Hartley, 1995; Davey et al, 2007; Freeman et al, 2009; Ozkan & Lajunen, 2005; Parker et al, 2000).

The internal consistency of the DBQ scale scores were examined through calculating Cronbach's alpha reliability coefficients, which are presented in Table 2. Similar to previous Australian research (Blockey & Hartley, 1995; Dobson et al, 1999), and professional drivers (Davey et al, 2007; Freeman et al, 2009; Sullman et al, 2002), the factors appear to exhibit relative internal consistency. Examination of the scores reveal that the items coded as Errors had the highest reliability coefficients (.78) while factors traditionally associated with *highway code violations* had a similar reliability coefficient (.77) and *aggressive violations*, which consisted of only 4 items, had the lowest reliability (.61). It is interesting to note that a smaller range was present within the *Errors* factor (1 to 4.63) than was found for the *highway code violations* (1 to 6.13) and *aggressive violations* (1 to 5.50). Table 2 provides a comparison of the factor scores obtained in the current study with those found in selected Australasian studies utilising the DBQ to examine self-reported driving behaviours: Freeman et al (2009), which reports responses of 4,792 professional drivers in an Australian fleet setting; Davey et al (2007) who sampled 443 Australian fleet drivers and; Sullman et al (2002) who surveyed 378 New Zealand truck drivers.

Table 2. *Alpha reliability coefficients of the DBQ scale*

	Current Sample	**Freeman et al (2009)**	**Davey et al (2007)**	**Sulman et al (2002)**
Errors (8 items)	.78	.78	.77	.71
Highway Code Violations (8 items)	.77	.77	.80	.62
Aggressive Violations (4 items)	.61	.56	.60	.57

A series of t-tests of the 3 factors found that the mean of *highway code violations* (i.e. speeding) is significantly greater than the mean of *Errors* [t (3413) = -31.47, $p < .001$] and also significantly greater than the mean of *aggressive violations* [t (3413) = 30.94, $p < .001$]. The average means for *error* and *aggressive violation*s are not significantly different, t (3413) < 1, ns. The findings suggest that speeding is the most common driving behaviour reported by the current sample, and similar to previous research on professional drivers (Davey et al, 2007; Newnam et al, 2004; Sullman et al, 2002), speeding remains the major road safety concern. In addition, Table 3 reports the mean and standard deviation scores for the 3 highest ranked items, which were: *Exceed the speed limit on a highway* (M = 2.93, SD = 1.37); *Become angered by another driver and show anger* (M = 2.02, SD = 1.04); and *Stay in a closing lane and force your way into another* (M = 1.95, SD = 1.05). The results reinforce that *highway code violations* are the most common form of aberrant behaviour reported by fleet drivers in the current sample. A series of between group analyses revealed no meaningful differences in the recorded responses to the DBQ in regard to type of vehicle driven; indicating that some level of driving stability across common vehicle types was present.

Table 3 Mean Scores for the DBQ factors

	Sample	
	M	SD
Errors (8 items)	1.60	.49
Highway Code Violations (8 items)	1.89	.64
Aggressive Violations (4 items)	1.60	.58
Highest Ranked Items		
1. Exceed the speed limit on a highway	2.93	1.37
2. Become angered by another driver and show anger	2.02	1.04
3. Stay in a closing lane and force your way into another	1.95	1.05

Factor analysis was administered on the 20 item questionnaire. Principle components analysis with oblique rotation was implemented to determine the factor structure of the DBQ, which revealed a 3-factor solution that accounted for 43.23% of the total variance. The first factor accounted for 29.81% of the total variance and contained 11 items, consisting of all 8 original *error* items, 2 *highway code violation* items and 1 *aggressive driving* behaviour item. The second factor comprised 5 items, all of which were drawn from the *highway code violations* scale. The third factor contained 4 items, these being the remaining *aggressive violations* items and 1 *highway code violation* item.

Of the 20 items, 3 cross-loaded and were all drawn from the original *highway code violation* scale. These cross-loading *highway code violation* items could be reasonably considered to have an association with the other factors. For example, to *cross a junction knowing traffic lights have already turned* could be viewed as a driver error. Similarly, both to *drive especially close to car in front* and *race away from the traffic lights to beat driver beside you* could be considered as aggressive acts in some circumstances within Australia. These cross-loadings are consistent with previous Australian DBQ-based fleet research (Davey et al, 2007). In this study, these 3 items cross-loaded on

one other factor only, with relatively similar weightings across the factors. Items that were allocated by the analysis to another factor could also be said to have valid linkages with the new grouping. For example, to *pull out of a junction and disrupt the flow of traffic* was originally assigned as an aggressive action but could also be understood to occur as a result of driver error. All items and factors for the 20-item DBQ are reported in Table 4. Cronbach's alpha reliability coefficients were calculated for the 3 new factors. Again, errors had the highest reliability coefficients (.81), with *highway code violations* slightly lower (.73) and *aggressive violations* the lowest reliability (.66).

Table 4. *Factor structure of the modified DBQ*

Items	F1	F2	F3
Fail to notice pedestrians are crossing in your path of traffic	.66		
Pull out of a junction so far that you disrupt the flow of traffic	.65		
Nearly hit car in front while queuing to enter a main road	.63		
When overtaking underestimate the speed of an oncoming vehicle	.62		
Nearly hit cyclist while turning	.61		
Miss 'Stop' or 'Give Way' signs	.60		
Fail to check rear-view mirror before pulling out or changing lanes	.59		
Skid while braking or cornering on a slippery road	.52		
Attempt to overtake someone you hadn't noticed turning	.51	-.35	
Cross junction knowing traffic lights have already turned	.38	-.35	
Drive even though you suspect you are over legal blood alcohol limit	.33		
Exceed the speed limit on a highway		-.80	
Disregard the speed limit on a residential road		-.65	
Drive especially close to car in front to signal to driver to go faster		-.48	-.41
Race away from the traffic lights to beat driver beside you		-.47	-.37
Stay in a closing lane and force your way into another		-.39	
Sound your horn to indicate your annoyance to another driver			-.74
Become angered by another driver and show anger			-.72
Become angered by another driver and give chase			-.57
Become impatient with slow driver ahead and overtake on inside			-.47
Amount of variance explained	29.8	5.6	7.9

The bivariate relationships between participants' self-reported driving exposure, work crashes, offences and DBQ factors are presented in Table 5. While the actual predictive relationship between participants' self-reported driving outcomes (e.g. crashes, fines) and the DBQ factors will be examined through multivariate analyses in the following section, some noteworthy bivariate relationships (and lack thereof) are reported in the proceeding section. In contrast to previous published Australian-fleet research, a strong positive relationship was not found between exposure to the road and drivers' age (Davey et al, 2007). Therefore, within the current sample, older drivers did not necessarily drive further distances. Consistent with previous international and Australian research (Davey et al, 2007; Freeman et al, 2009; Lajunen et al., 1998; Sullman et al, 2002), age and years driving experience was identified to have a significant negative relationship with *errors*, *highway and aggressive violations*. This indicates that as drivers gain more experience, they are less likely to engage in aberrant driving behaviours on public roads, and the strongest negative relationship was between age and *highway code violations*. Consistent with previous research (Lajunen et al, 1998; Parker et al, 1995; Sullman et al, 2002) a positive relationship was identified between the number of kilometers driven each year and the presence of errors and violations. However, these correlations were quite small. In addition, a number of significant bivariate relationships were evident between the self-reported number of crashes, number of demerit point losses and participants' DBQ scores or driving exposure. These relationships will remain the major focus of the following predictive analyses.

Table 5. Pearson correlations between the major driving variables

	1	2	3	4	5	6	7	8	9
1. Age	--	.96***	.07***	-.02	-.11***	-.26***	-.19***	-.03	-.04*
2. Years licensed		--	.08***	.00	-.11***	-.23***	-.18***	-.03	-.05**
3. Hours driving per week			--	.59***	.09***	.08***	.09***	.16***	.12***
4. Kilometers per year				--	.07***	.12***	.09***	.15***	.12***
5. Errors					--	.56***	.50***	.13***	.14***
6. Highway code violations						--	.57***	.14***	.14***
7. Aggressive violations							--	.07***	.09***

8. Crashes past 12 months	--	.12***
9. Offences last 12 months		--

Note: 8 and 9 use the full range of the crashes and offences while at work variables rather than the dichotomous coded version created for the logistic regression.

The final series of analyses focused on identifying the factors predictive of being involved in a crash or incurring demerit point loss (e.g. fine) over the past 12 months. Due to the relatively low incidence of reported crashes and offences, composite variables for total number of work crashes and total number of work fines were created. The largest proportion of respondents reported having no crashes at work (89.0%), while 9.6% reported one crash and 1% reported having two crashes. Similarly, 91.2% of participants reported incurring no offences while at work in comparison to those who reported one offence (7.4%), or two or more offences (1.4%). To allow for a more meaningful analysis to be conducted, dichotomous crashes and offences variables were created.

To better understand the relationship between self-reported offences and driving behaviours, and between self-reported crashes and behaviours, two logistic regression analyses were implemented. A model was created assessing the contribution of participants' gender, recent driving exposure (kms driven per annum), the key groupings of DBQ factors (*errors*, *highway code violations* and *aggressive violations*) and traffic infringement history (whether or not they reported incurring demerit points or fines and whether they reported having a crash in the past 12 months while at work). Table 6 displays the coefficients, standard errors, Wald statistics, odds ratios (OR) and 95% confidence intervals for crashes and traffic offences while at work.

The first logistic regression aimed to determine the above mentioned variables' contributions to the prediction of crashes. The number of kilometers driven per year and gender was entered in the first step to examine, as well as control for, their influence before the inclusion of the DBQ factors. The model at step one was a significant predictor of the outcome variable ($\chi^2(2) = 67.44$, $p < .001$). Taken together, 4.1% of the variance was accounted for in the model, 89.3% of the sample who did not have a crash correctly classified. Consistent with previous research (Davey et al, 2007), those with greater exposure to the road reported more crashes (OR = 1.38, $p < .001$). The second step involved the inclusion of the 3 DBQ factors as well as incurring demerit point loss at work in the last 12 months, which also proved to be significant [$^2(4)=78.92$, $p < .001$] and accounted for an additional 4.7% of the variance. The overall model was also significant [$^2(6)=146.36$, $p < .001$] with the model accounting for 8.8% of the total variance according to the Nagelkerke R^2 statistic. Four items were found to be significant predictors of crashes: *annual kilometers driven* (wald = 46.95, $p = .000$); *driver errors* (wald = 14.88, $p < .001$); *self-reported offences occurring at work* in the previous 12 months (wald = 28.30 , $p < .001$); and *highway code violations* (wald = 5.82, $p < .05$). Taken together, 8.8% of the variance was accounted for in the model, 99.9% of the sample who did not have a crash were correctly classified, however only 2% (n = 7) of those who did report a work crash were correctly identified.

The second logistic regression analysis examined the contribution of gender, kilometers travelled per annum, the new groupings of driver error, *highway code violations* and *aggressive driving* and the number of *self-reported crashes* in the past 12 months to the prediction of offences. Similar to above, the number of kilometers driven per year and gender was entered in the first step to examine, as well as control for, their influence before the inclusion of the DBQ factors. The model at step one was a significant predictor of the outcome variable ($\chi^2(2) = 50.67$, $p < .001$). Taken together, 3.4% of the variance was accounted for, and 100% of the sample who did not have a fine was correctly classified. Gender was found to be a predictor. At step one, men are 1.14 times more likely than women to commit an offence, ($p < .05$). Consistent with previous research (Davey et al, 2007), those with greater exposure to the road reported more fines (OR =1.23, $p <.001$). The second step involved the inclusion of the 3 DBQ factors as well as being involved in a crash while at work in the last 12 months, which collectively also proved to be significant [$^2(4)=73.875$, $p < .001$] and accounted for an additional 4.8% of the variance. The overall model was significant [$^2(6)=124.55$, $p < .001$], with 8.2% of the variance was accounted for in the model, although similar to above 99.9% of the sample who did not receive a fine were correctly classified, however only .3% (n = 1) of those who did receive a fine at work were correctly identified.

Table 6. *Logistic regressions with self reported crashes and traffic offences while at work in previous 12 months as the dependent variable at step two*

	Crashes					**Offences**				
					95% C.I. Exp(B)					95% C.I. Exp(B)

	B	S.E.	Wald	Odds Ratio	Lower	Upper	B	S.E.	Wald	Odds Ratio	Lower	Upper
Km per year	.28	.04	46.95***	1.33	1.26	1.44	.20	.05	19.80***	1.23	1.12	1.34
Gender	.04	.12	.11	1.04	.82	1.32	.33	.13	6.14*	1.40	1.07	1.82
Errors	.55	.14	14.88***	1.73	1.31	2.28	.396	.15	6.90**	1.50	1.11	2.00
Highway code violations	.22	.09	5.82*	1.24	1.04	1.48	.33	.09	12.37***	1.39	1.16	1.66
Aggressive violations	-.01	.10	.697	.92	.75	1.12	-.12	.11	1.19	.87	.71	1.10
Crashes at work	-	-	-	-	-	-	.84	.16	28.79***	2.32	1.70	3.15
Offences at work	.84	.16	28.30***	2.31	1.70	3.14	-	-	-	-	-	-
	Model Chi-Squire = 146.36 $p < .001$						Model Chi-Squire = 124.55 $p < .001$					

*$p < .05$, ** $p < .01$, ***$p < .001$

Discussion

The present research utilised the DBQ to examine the behaviours of a large sample of Australian motorists within a light fleet setting and also to allow comparisons with other studies that have focused on professional drivers. Compared to previous fleet studies, the larger sample size also provided an opportunity for a more robust analysis into the ability of the DBQ to predict crashes and demerit point loss. The DBQ is the most widely used self-reported driving assessment tool globally (af Wåhlberg, 2009), however comparably little research has been conducted that has examined the self-reported driving behaviours of those who drive company sponsored vehicles (Newnam et al, 2004). Furthermore, little research has investigated the factor structure and predictive ability of the DBQ within this road safety field (Sullman et al, 2002; Xie & Parker, 2002, Davey et al, 2007; Freeman et al, 2009). Despite this, attempts are already underway to develop alternative driving assessment tools (Newman & VonSchuckmann, 2012; Wishart et al, 2012). The utilisation of the DBQ in the current fleet setting presented a number of interesting findings.

First, DBQ reliability coefficients were found to be relatively robust and similar to both earlier Australian research (Blockey & Hartley, 1995; Dobson et al, 1999) and recent fleet safety findings (Davey et al, 2007; Freeman et al, 2009; Sullman et al, 2002). The reliability of the scale appears acceptable despite making minor alterations to the DBQ to reflect Australian driving conditions, which again provides support for the tool to be modified to accommodate different cultures and driving environments. Second, examination of the overall mean scores with the original DBQ factors revealed similar scores, and *highway code violations* was again reported to be the most frequent driving behaviour exhibited. This finding is consistent with previous research that has found speeding to be the most frequently reported aberrant driving behaviour on public roads (Lajunen et al, 2003; Parker et al, 2003) and also is in line with official traffic infringement histories for the surveyed regions which showed speeding to be the most common form of traffic violation (Watson, Armstrong, Watson, Livingstone & Wilson, 2011). Additionally, and in regards to fleet settings, speeding (for whatever reason) again appears to be the most common form of aberrant driving behaviour (Davey et al, 2007; Freeman et al, 2009; Wishart et al, 2012). Given this, and the hypothesised additional time pressures placed on many professional drivers, it is to be expected that speeding violations are the most common form of aberrant behaviour both exhibited and reported by fleet drivers. This result may also reflect a belief on the part of many drivers, that minor speeding violations are acceptable in some circumstances and may not be regarded as a serious road safety risk. Further research is required to test this assumption, although the current findings have clear fleet safety implications in regards to addressing speeding behaviours.

Third, and again consistent with previous fleet research (Davey et al, 2007; Freeman et al, 2009) older drivers with more experience were less likely to report *errors*, *highway code violations*, *aggressive violations*, and to a lesser extent, offences in the past 12 months. Sullman et al, (2002) also found older drivers were less likely to report a high rate of violations, crashes in the past 3 years and to a lesser extent *aggressive violations*. Interestingly, the current research and that of Freeman et al, (2009), both with large sample sizes, found older drivers to be slightly less likely to report having a crash in the past 12 months at the same rate (-0.3), although this figure was significant only in the

2009 study. While the older and more experienced drivers in this study were less likely to report aberrant driving behaviours, it is not clear whether this may be due in part to a higher level of driving conduct present within this cohort or that they are less likely to report aberrant driving behaviours. Future research that focuses on comparing self-reported lapses and official crash and offence data would be most valuable in this regard, which may lead to the development of interventions specifically designed to address risky driving behaviours among younger (less experienced) driving cohorts.

Factor analytic techniques were implemented to assist with the interpretation of the scale scores. The current study successfully identified three factors that generally consisted of *errors*, *highway code violations* and *aggressive violations*. The three factor model was relatively consistent with previous research that has found distinctions between the different aberrant driving behaviours (Sullman et al, 2002; Lajunen et al, 2003; Davey et al, 2007; Freeman et al, 2009). Driving errors was the clearest factor to interpret and appeared to be associated with failures of observation and judgement, while general highway violations were characterised by items that break social norms in regard to driving behaviours but do not involve hostility to any one individual. Consistent with previous research (Davey et al, 2007), *aggressive violations* consisted of a mixture of emotion-oriented responses to driving situations and traditional *highway code violations*. It is noted that the two highway violations that cross loaded could also be interpreted as *aggressive violations*, especially for experienced professional drivers. In this instance, *driving especially close to a car in front of you to indicate for them to drive faster* and to *race away from the traffic lights to beat the driver beside you* could constitute an aggressive behaviour or at least indicate some degree of frustration. Accordingly, behaviours regarded as highway violations may be also classified as aberrant or aggressive, or at least, may originate from emotions associated with frustration. Given this, in seeking to better understand and explain the behaviours of professional drivers, earlier distinctions identified between *highway code violations* (i.e. gaining advantage) and *interpersonal violations* (i.e. deliberate & aggressive) (Lawnton et al, 1997) may prove less clear.

The item-loading characteristics of the current study may also be influenced by a number of additional issues. First, although the findings are generally consistent with other surveys of professional drivers, the demographics of the current group may be different to other samples that have reported clear, distinctive factors. Second, and as highlighted above, it is possible that individuals who drive for work, especially fleet drivers, are a special population who may experience or exhibit different driving behaviours to the general motoring population. As the factor structure of the DBQ has been shown to vary considerably in different countries and different settings (e.g. three to six factors), situational and cultural factors need to also be taken into account when utilising the DBQ (Lajunen et al, 2003).

The relationship between the factors was explored with findings similar to previous research on general motorists (Dobson et al, 1999; Ozkan & Lajunen, 2005) and relatively strong correlations were evident between the speeding, aggression and error factors. This suggests that while the three factors can be considered distinct, to some extent they reflect similar driving behaviours. Additionally, those who engage (or report engaging) in one form of aberrant driving behaviour are also more likely to engage in other risky driving behaviours. However, determining whether an item is better understood as a *highway violation* or an *aggressive violation* may be dependent upon the driving purpose and associated environment. Further research that includes comparisons between professional versus general drivers on the DBQ will prove fruitful in establishing whether the relationship between the factors is affected by the purpose of the driving task, i.e. personal vs work. For example, it is also possible that speeding-related behaviours during personal driving time for general motorists may prove to be associated with intrinsic needs (i.e. sensation seeking and time management) where speeding for work purposes may directly reflect time and work pressure that in turn produces aggressive violations. Given that many work related tasks do take place in the vehicle while driving (i.e. taking phone calls, eating), multitasking and time pressures, alone or in combination, may directly affect driving outcomes. It may be that drivers in these circumstances are not dissimilar to younger drivers who are also known to speed, text or become distracted.

One of the central aims of the study was to examine whether the DBQ scores could predict those who reported a crash or demerit point loss within the sample. In contrast to previous research that contained small cell sizes which precluded the multivariate analysis of crashes and demerit point loss (Davey et al, 2007), 10.54% of the current sample reported being in a work crash in the last 12 months and 8.75% reported receiving a fine. While the cell sizes are still disproportionate, it did provide an opportunity to undertake regression analyses. In regards to the prediction of self-reported driving offences and crashes, some differences were observed in the bivariate relationships and those observed at a multivariate level. Both methods found kilometers per year to be a predictor of both crashes and offences. This is not surprising when considering that those who are more exposed to the road are at a greater risk. The findings in relation to driving exposure are generally consistent with similar studies (Sullman et al, 2002, Davey et al, 2007; Freeman et al, 2009). Additionally, this finding does have practical implications in

regards to identifying company drivers who spend more time on the roads. The bivariate modelling also found significant positive correlations between time spent driving, *errors*, *highway violations*, *aggressive violations*, crashes and offences at work.

At the multivariate level, exposure to the road, errors, self-reported offences and to a lesser extent *highway code violations* were predictive of crashes at work within the model, while gender, errors, highway violations and crashes predicted offences incurred while at work. In regards to the former, the research is supportive of previous research that has found errors can predict accidents (Blockey & Hartley, 1995; Freeman et al, 2009), and the strength of the association between errors and crashes was similar to that reported in the meta-analysis by de Winter and Dodou (2010). However, it is also noteworthy that other research has found an opposite relationship between errors and crashes (Stephens & Groeger, 2009). In contrast to previous research (Sullman et al, 2002; Stradling, Parker, Lajunen, Meadows & Xie, 1998), violations was not a predictor of crashes, which is in some part surprising given the well known role of excessive speed in increasing accident risk. Comparatively less research has focused on the DBQ and demerit point accumulation, and a corresponding analysis revealed that gender, errors, highway violations and crashes predicted such offences in the current sample. While gender and crash involvement may be an artefact of the current sample, engaging in more frequent *highway code violations* (e.g. speeding) would seem intuitively to result in more fines, particularly given that speeding fines are particularly common.

However, a central theme to emerge from this study is that the DBQ was not an efficient predictor of those who reported either being involved in a crash or incurring demerit point loss. For example, only 3% of the sample was correctly classified for crashes and .3% for demerit point loss. In fact and consistent with previous research (Davey et al, 2007; Freeman et al, 2009), exposure to the road was more effective at predicting crashes than the DBQ factors. There may be a number of reasons for this outcome. First, and similar to previous research (Davey et al, 2007), only a small proportion of the sample reported being in a crash, which likely contributed to difficulties identifying factors associated with the event. In light of this, it is possible that the use of principal components analysis to determine the factorial structure of the DBQ has some bearing on the subsequent validity of the obtained scales, as suggested by Mattsson (2012). In any event, given the issues discussed in this section, it is unclear whether DBQ subscales obtained using an alternate method would have a greater predictive capacity. Second, concerns remain regarding the reliability of the self-reported data, not least social desirability responding, memory recall bias, consistency motif and other forms of common method bias introduced when both the predictors and the predicted variables are gathered from the same source (af Wåhlberg, Dorn & Kline, 2010; Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). With this in mind, it is noted that the surveys were conducted in a work environment as often occurs in research involving professional drivers. While it is possible that conducting a survey in a public setting may affect responses, Sullman and Taylor (2010), in their study of professional drivers, found that the DBQ was not sensitive to location type. Third, a wide range of factors have the potential to affect any crash outcome. These include sleep deprivation, poor driving conditions, mobile phone usage and the issue of crash culpability, which all extend beyond the factors measured within the DBQ. In addition, as noted by Newnam and von Schuckmann (2012), the DBQ does not include items that specifically address behaviours understood to be prevalent within an occupational driving context, such as inattention resulting from work related distractions.

Taken together, the current findings add to the mixed body of evidence regarding which DBQ factors predict negative driving outcomes. While the psychometric properties of the scale proved robust in the current large sample of fleet drivers, questions remain regarding its efficacy to predict those involved in crashes. From a different perspective, social scientists have argued that individual studies often contain limited information and that effect sizes can be influenced through sampling error (Schmidt, 1992), as well as other methodological limitations associated with self-report data (af Wåhlberg, 2009). Perhaps at best we can hope that more fleet-based research is published that utilises the DBQ in order to provide appropriate data sources for corresponding meta-analyses such as the recent endeavour of de Winter and Dodou (2010).

As highlighted earlier, a number of limitations should be taken into account when interpreting the results of this study. Concerns have been expressed in regard to the reliability of the self-reported behaviour, such as the propensity of professional drivers to provide socially desirable responses. Similar concerns have been raised regarding methods to collect self-report data (af Wåhlberg, 2009), not least common method variance and the need to also examine official crash databases. Some minor treatment effect may also have been evident, as participants completed the questionnaire before they participated in a work-related safety workshop. In addition, while the sample represented a range of driving styles and vehicle types, the representativeness of the sample may not be easily transferable to other fleet driving populations. In fact, a sizeable proportion of the sample drove less than 10 hours per week while at work.

CONCLUSIONS

In summary, further research is required to not only establish the reliability and validity of the DBQ for fleet settings, but also to determine its efficacy to illuminate the origins of crashes. Future research would benefit from determining which complementary assessment tools (and data sources) should be utilised to increase the DBQ's usefulness as a tool to not only identify "at risk" drivers, but also as an evaluation instrument to measure the effectiveness of fleet safety interventions. Given that the predictive ability of the DBQ does not seem to increase with corresponding sample sizes (at least in the current case), future research is needed to determine what self-reported assessment tools are appropriate for use within samples that contain individuals with an increased crash risk, such as professional drivers. There is also a strong need to explore other factors that may contribute to the likelihood of driver crashes, particularly in regards to professional drivers. Further research in this area would, in turn, greatly assist in the development of targeted interventions and effective counter measures aimed at reducing the human, societal and economic costs resulting from work-related crashes. Similarly, it is important to establish the extent to which fleet drivers may differ in their driving behaviours from the general driving population, with obvious practical benefits in regards to the management of fleet settings. In addition, researchers need to start looking beyond self-report data, utilising elements such as GPS data or other independent data sources, to consider how best to measure the impact of aberrant driving behaviours on key road safety outcomes.

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