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Older Drivers and Rapid Deceleration Events: Salisbury Eye Evaluation Driving Study

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Abstract

Drivers who rapidly change speed while driving may be more at risk for a crash. We sought to determine the relationship of demographic, vision, and cognitive variables with episodes of rapid decelerations during five days of normal driving in a cohort of older drivers. In the Salisbury Eye Evaluation Driving Study, 1425 older drivers ages 67 to 87 were recruited from the Maryland Motor Vehicle Administration's rolls for licensees in Salisbury, Maryland. Participants had several measures of vision tested: visual acuity, contrast sensitivity, visual fields, and the attentional visual field. Participants were also tested for various domains of cognitive function

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including executive function, attention, psychomotor speed, and visual search. A custom created Driving Monitor System (DMS) was used to capture rapid deceleration events (RDE), defined as at least 350 milli-g deceleration, during a five day period of monitoring. The rate of RDE per mile driven was modeled using a negative binomial regression model with an offset of the logarithm of the number of miles driven. We found that 30% of older drivers had one or more RDE during a five day period, and of those, about 1/3 had four or more. The rate of RDE per mile driven was highest for those drivers driving <59 miles during the 5-day period of monitoring. However, older drivers with RDE's were more likely to have better scores in cognitive tests of psychomotor speed and visual search, and have faster brake reaction time. Further, greater average speed and maximum speed per driving segment was protective against RDE events. In conclusion, contrary to our hypothesis, older drivers who perform rapid decelerations tend to be more "fit", with better measures of vision and cognition compared to those who do not have events of rapid deceleration.

Keywords

vision; cognition; driving; older people; epidemiology; naturalistic driving

1. Introduction

Drivers who make rapid decelerations during the course of driving may put strain on drivers behind them, and appear to be more at risk of crash involvement. Simulator studies have shown that sudden stops are particularly predictive of rear end collisions, especially if the leading car is a sport utility vehicle or other higher and wider passenger car (Harb et al., 2007). Driving simulator experiments in right turn lanes show that higher deceleration rates were associated with higher rear-end crash history (Yan et al., 2008).

There are few data on characteristics of drivers who make rapid decelerations. Younger subjects (ages 20–29 years) have been shown to have a shorter deceleration distance and time, compared to older drivers, and tend to drive faster (Porter and Whitton, 2002). Moreover, rear end crashes tend to occur more commonly in younger age groups and among males (Yan and Radwan, 2006).

Crashes which involve older drivers are more likely to involve multiple vehicles and occur at intersections than crashes involving younger drivers. (Mayhew et al., 2006) Deceleration patterns have been investigated as an indicator of a 'near crash' (Dingus et al., 2006) but also as a measure of appropriate speed management. (Baldwin et al., 2004) Age-related decline in physical, cognitive and sensory function, including vision, has been proposed as the reason for poor driving performance and increased crash involvement amongst older drivers. (Ball et al., 1993; Stutts et al., 1998; Staplin et al., 2003; Rubin et al., 2007; Horswill et al., 2010; Meuleners et al., 2011) In addition it has also been proposed that older drivers lose their driving skills when they start to drive less. (Langford et al., 2006) 'The low mileage bias' may explain part of the increased crash risk or compound the effects of decline in function. The larger number of older people who rely on driving for transport, the aging of the population in western countries and increased risk of crash involvement and vulnerability to injury (Lyman et al., 2002; Meuleners et al., 2006; Hanrahan et al., 2009) make older driver safety a growing public health concern. We had an opportunity to evaluate visual and cognitive risk factors among older drivers for the association with rapid deceleration driving events, using a unique Driving Monitor System that recorded real time driving behavior over a five-day period.

2. Materials and methods

2.1 Population

The Salisbury Eye Evaluation Driving Study participants were recruited by postal invitation through the Maryland Department of Motor Vehicle Administration. The licensees had to be resident in zip codes which encompass the greater Salisbury metropolitan area and aged 67 to 87 years as of March 1, 2006. The recruitment process has been described in detail elsewhere, (West et al., 2009) in brief of 8380 registered licensees, 4503 (54%) returned postcards. Of that group, 6.0% were no longer driving, 1.6% were deceased, and 2.3% were no longer living in the eligible area. Of the remainder, 42% agreed to participate and 83% of them completed the baseline clinic exam and driving assessment (n=1425).

2.2 Study Design

Participants had yearly visits, however this analysis is based on the cross sectional data from the baseline visit during which full clinical testing and driver monitoring was completed. A trained interviewer administered a questionnaire that collected data on medical conditions which may affect driving such as arthritis and stroke. We created a pain score that was the simple sum of positive answers to queries about pain in the feet, legs, knees, hips, or current medication use for arthritis; the score ranged from 0–5. The depression score was based on the Geriatric Depression Scale, (Yesavage et al., 1982) and ranged from 0 to 30 with higher scores indicating more symptoms of depression.

The time taken to brake in response to a visual stimulus was measured using an apparatus described previously (Zhang et al., 2007). The Brake Reaction Time (BRT) was the total time in milliseconds taken for the participant to remove their foot from the accelerator and depress the brake pedal using the average for five test sequences presented at random time intervals.

Each participant underwent a series of vision tests that included visual acuity, contrast sensitivity, and visual field. Presenting binocular visual acuity was tested, with the participant's usual distance vision spectacles, using ETDRS charts and forced choice protocols (Ferris et al., 1982). Results were coded as number of letters correctly identified and scored as LogMAR acuity. Contrast sensitivity was tested for each eye separately using the Pelli Robson contrast sensitivity chart. Results were coded as number of letters correctly identified (Elliott et al., 1990). The visual field was tested using the Humphrey Field Analyzer II, Full Field 81 Point test, with a Quantify-defects test strategy. Number of points missing on a 96 point bilateral visual field was recorded (Nelson-Quigg et al., 2000).

The participants also underwent a test of attentional visual fields. The attentional visual field was assessed using a custom-written program that comprised a computer, keyboard, touch-screen monitor, and mouse, and is described in detail elsewhere (Hassan et al., 2008). For a response to be correct, two numbers in the central and peripheral targets had to be correctly identified as well as the location of the peripheral target. The data are recorded as the widest angle out to 20° for which the participant had correct responses, in the vertical (0 and 180° meridians) and horizontal (90 and 270° meridians)

Each participant also underwent a series of tests that measure specific aspects of cognition. We specifically hypothesized a relationship with the cognitive domains of psychomotor speed and visual search, attention, and executive function; the specific test used was the Trail Making Test (TMT) Parts A and B. This test measures visuomotor and perceptual scanning skills, as well as flexibility to shift sets under time pressure. In TMT Part A, the time for participants to connect the smallest numbered circle, to the next higher number circles on a sheet with random distribution of numbered circles, 1 through 25. TMT Part B

requires a subject to consecutively connect circles while alternating between numbers (1–13) and letters (A–L), as quickly as possible. The number of seconds to complete Part A and Part B is scored, with a maximum of 300 seconds allowed for Part A and a maximum of 480 seconds allowed for Part B. We also measured auditory divided attention, using the Brief Test of Attention (BTA) (Schretlen et al., 1996). The participant listens to a number of series of letters and numbers and has to correctly count the number of letters heard. Visuomotor integration was assessed using the Beery-Buktenica Developmental test of visual motor integration (Kulp and Sortor, 2003). In this test, a series of 24 figures of increasing complexity was copied and scored for accuracy by trained observers. The Motor Free Vision Integration test is part of the AAA Road Wise assessment and assesses visuo-spatial integration independent of motor skills. The test requires participants to complete an image that is partially drawn by selecting which combination of lines successfully finishes the image. The participant does not have to draw the lines but select from multiple choices. The number of errors was recorded. Planning and problem solving aspects of executive function were assessed using the “Tower of Hanoi” test. The goal is to move successively larger discs from the first to third peg, making sure that at no time a larger disc was on top of a smaller disc. The number of moves required was recorded for this test.

2.3 Driving monitoring system (DMS)

To measure the driving outcomes of interest, each participant’s car was outfitted with a DMS created for this project. The system has been described in detail previously (Baldwin et al., 2004) and we summarize it here. Each DMS unit utilized five sensors, which were monitored and recorded by a custom-developed computer system. Data harvesting, time tagging, and storage were accomplished using a data acquisition software package specially created for the purpose. The sensor suite consisted of a high dynamic range color camera, a monochrome camera with infrared LED illuminators, a GPS receiver, a magnetic compass, and a two-axis accelerometer. The color camera was oriented such that it captured images of the road in front of the vehicle, while the monochrome camera was positioned so as to capture images of the driver. Both video streams were recorded at a resolution of 352×240 pixels and at a rate of 30 frames per second. The GPS receiver provided location and velocity data at a rate of 1 Hz and the magnetic compass provided heading information at a rate of approximately 8 Hz. Finally, the accelerometers provided lateral and axial accelerations at a rate of 10 Hz.

The GPS receiver, road camera, and driver camera were located in the upper portion of the windshield, on the passenger side of the vehicle. The DMS unit was located behind the passenger seat. After a DMS unit was installed in a participant’s vehicle, an installation procedure was observed for aligning both of the cameras and for nulling the effects of the vehicle on the magnetic compass heading. Average and maximum speed per driving segment were reviewed and the drivers who drove 55 miles per hour or faster during the 5 day period of observation were recorded.

A data analysis program was developed for the viewing and evaluation of the collected DMS data sets. Of particular interest to this aspect of the study, was the ability to use the accelerometer to evaluate each participant’s sudden deceleration of 350 milli-g’s or more (RDE). These included situations in which where the driver needed to rapidly decelerate to complete a turn safely, stop at a signal or avoid another vehicle, as these should have been anticipated. The cut-off of 350 milli-g was chosen based on pilot data collected on the local Salisbury roadways. (Baldwin et al., 2004) This criteria represents a level deceleration just beyond a comfortable amount of vehicular deceleration and is more conservative than criteria for near crashes. (Dingus et al., 2006)

2.4 Data Analyses

Each RDE, was counted and a rate estimated per mile driven. The relationship between RDEs and visual and cognitive function were modeled using a negative binomial regression approach with an offset of the logarithm of the number of miles driven. A negative binomial regression was chosen to be able to account for the over-dispersion of the data. We conducted stratified analyses for drivers with low mileage (<59 miles) and high mileage (59+ miles) in the 5 day period of monitoring. This category was used as 59 miles was the median weekly mileage in our study population. We adjusted for the average speed per segment and whether maximum average speed per segment was >55 mph was reached in all models to allow for differences in road type.

3. Results

We were able to code 1242 of the 1425 (87%) of persons who had driving data for rapid deceleration events. The remainder had either GPS failures or video card failures that did not permit us to code their driving segments. The drivers who were excluded from the analysis were similar in age, other demographic characteristics and general health to those whose data were used. The two groups also had similar performance on tests of vision and cognition, though the horizontal attentional visual field was slightly smaller in those who were excluded (14.0 versus 13.0 degrees, $p=0.05$) compared to persons with DMS data (Table 1).

3.1 Deceleration events

The number of deceleration events ranged from zero for 861 participants (69%) to one person who had 60 events (Figure 1) during the 5 day period of monitoring. Of those with rapid deceleration events, most (58%) had only one or two such events.

3.2 Predictors of Rapid Deceleration Events

We found that the rate of RDE per mile driven was higher for those driving fewer miles during the 5-day period of observation (Table 2). Those who drive less than 59 miles had a RDE mean rate of 2.1–2.4% per mile in comparison to 1.1–1.4% per mile with greater mileage.

Drivers with higher rate of RDEs were of younger age, and more often male compared to those who had none (Table 3). Those with RDE tended to perform better on cognitive tests, particularly tests of executive function; they also had better contrast sensitivity and better visual fields results than those without any RDEs. These data suggest that participants who were more “fit” tended to have rapid deceleration events.

Those with higher rates of rapid deceleration tended to have lower depression scores, and have faster initial brake reaction time than those with lower rates of RDEs. They also tended to have increasingly wider attentional visual fields. Thus, the trends in the predictors of RDEs continued in that those seemingly more “fit” were those with more RDEs. In analyses stratified by mileage (Table 4), similar trends were seen in the low mileage and high mileage groups. Compared to women, men were 53% more likely to have RDEs within the high mileage group.

In multivariate models, the demographic factors including older age and black race continued to be protective against RDEs. Those with a history of stroke or depressive symptoms were also less likely to exhibit RDEs. Of the functional tests, only the Tower of Hanoi and the number of errors in Motor Free Vision Integration remained associated with RDEs. Poorer performance on these tests was protective. Contrast sensitivity, visual field

loss and extent of attentional visual field were not independently predictive of RDEs. For every mile per hour increase in average speed, the drivers were 3% less likely to have RDEs.

4. Discussion

Our population of older drivers had a relatively high proportion of persons, almost 1/3 who executed a RDE in the five days of driving recorded. We had hypothesized that those with poor health, poorer vision and poorer cognition, would be more likely to have rapid deceleration events due to a decreased ability to plan and execute an orderly slowing or stop. However, the data suggested just the opposite. That is, persons with better health and better scores on cognition and tests of vision were more likely to have RDEs, and have more of them.

4.1 Determinants of rapid deceleration events

To our knowledge, this is the first time RDEs have been measured in a large cohort of older drivers using naturalistic driving assessment. Similar to younger cohorts, the rate of deceleration seems to be linked to “fit” drivers with high level of function. While our cohort generally had excellent sight – visual acuity close to 20/20 and complete visual fields, tests of cognition did reveal a range of functioning. It has been proposed that cognition is more predictive of driving performance than is vision.(Anstey et al., 2006) We speculate that the drivers with poorer cognitive function are self-regulating their driving exposure. While we could not directly measure these compensations, these may include being less likely to follow another vehicle closely.

A rapid deceleration event is a complex phenomenon that may consist of a combination of road conditions, following distance to a vehicle in front, incursions into the driving pathway, prevailing speed, reaction time, physical ability, impulsivity, planning ability, and car condition, to name some of the factors. In this analysis we found no evidence that poor vision or cognitive function increases these types of errors amongst older drivers. Knowing that brake reaction time is slower in older drivers(Martin et al., 2010) and that elements of brake reaction time were related to poor vision, cognition and physical complaints in lower limbs,(Zhang et al., 2007) this was a reasonable proposition. However, it seems that during everyday driving excursions, older drivers with worse cognitive function tend to show fewer RDEs, presumably as they are cautious and adapt their driving style to suit their capabilities.

The proposition that drivers who have worse cognitive or vision abilities compensate by not driving in such a way as to have to rapidly decelerate is supported by other research on self restriction. In a separate analysis of the same cohort,(Keay et al., 2009b) we found that those drivers, who had poor contrast sensitivity, poor visuo-spatial skills and reduced psychomotor speed, were more likely to restrict their driving space to their local neighbourhood or stop driving all together within the first year of the Salisbury Eye Evaluation and Driving Study. This and other studies have shown a consistent link between self restriction and reduced levels of physical, visual and cognitive function (Freeman et al., 2005; Anstey et al., 2006; Freeman et al., 2006; Vance et al., 2006; Sims et al., 2007). Drivers with vision deficits report avoiding driving at night,(Adler et al., 2005; Brabyn et al., 2005; Freeman et al., 2006) in unfamiliar areas(Adler et al., 2005) or on freeways (Adler et al., 2005). Problems with vision are commonly sighted reasons for both restricting driving and giving up driving all together (Keeffe et al., 2002). While previous studies have relied on self report of self regulation of driving, naturalistic driving has recently been used to characterize driving exposure in older drivers.(Blanchard and Myers, 2010)

4.2 Driving exposure and speed of travel

In our group of drivers, one quarter of the driving time was at speeds over 55 miles per hour though the average speed was 26 miles per hour, reflecting slower urban streets. Higher average speed was protective against a high RDE rate and this may be explained by a difference in the driving routes for drivers with high average speeds. Our study design allowed for drivers to drive their cars as usual during the week of recording. Drivers who had higher average speeds may have taken routes where there were fewer occasions to stop or less complex driving needs. Though we did not analyse the type of roadways, it is likely their route included more rural roads and freeways where there are long stretches of uninterrupted travel and therefore fewer opportunity for a rapid deceleration event.

4.3 Naturalistic driving research and older drivers

Several types of driving errors have now been explored using naturalistic driving assessment in the Salisbury Eye Evaluation and Driving Study with some instructive results. We examined stop sign errors and, similar to deceleration events found that drivers with functional loss, specifically those with visual field loss, were less likely to fail to stop (Keay et al., 2009a). The explanation proposed was that drivers with functional decline are taking added caution when driving through stop sign controlled intersections, leading to a reduction in these types of errors. In contrast, improper lane changes (Munro et al., 2010) and failure to stop at red traffic lights (West et al., 2009) were positively associated with poor cognition and restricted attentional visual field. It is likely that there is a difference in intent between these different types of driving errors. Confident, capable drivers may be inclined to drive through stop signs, particularly when in rural locations where risk might be perceived as low (Keay et al., 2009a). Similarly drivers with high level of executive function, with good health and less depressive symptoms, as identified here, drive in such a way as to have to occasionally rapidly decelerate.

4.4 Importance of rapid deceleration to crash risk

When a driver rapidly changes speed, this can impact the surrounding traffic flow and in the worst case scenario could result in a collision with another vehicle, most likely a rear end crash. Crashes involving older drivers tend to be intersection crashes rather than single vehicle crashes associated with high speeds, inattention and alcohol (McGwin and Brown, 1999; Mayhew et al., 2006). The characteristics that place older drivers at increased crash risk, namely poor low contrast vision, visual field loss, restricted attentional visual field, poor cognition, frail health and medications (Hu et al., 1998; Sims et al., 1998; Owsley et al., 1999; Rubin et al., 2007) have not been shown to be associated with likelihood of RDEs in this analysis. Older drivers who have the benefit of experience, may manage their speed conservatively and therefore, their speed and braking may be less likely to lead to a crash compared to younger drivers. This cannot be explored in the current study which involved only older drivers. RDEs are likely to be associated with inattention and driver distraction, as found in other analyses of near crashes in a large naturalistic driving study (Dingus et al., 2006).

4.5 Strengths and limitations

There are few other studies which have assessed driving performance in a naturalistic driving paradigm (Dingus et al., 2006) with some focused on older drivers exclusively, (Antin, 2010; Blanchard and Myers, 2010) though this field is expanding. Other studies involving older drivers have relied on simulators (Martin et al., 2010) or fixed route driving assessment (Porter and Whitton, 2002; Wood et al., 2008; Wood et al., 2009). Our approach is unique amongst studies exploring older driver behaviour as it uses an objective measure of driving performance which is used in the participants own vehicles, on their typical

driving routes during a 5 day period. Though the five day period of monitoring cannot be generalized to usual driving, others have reported that week-long periods of assessment were considered fairly representative by older drivers.(Blanchard and Myers, 2010)

Our choice of the definition of an RDE was 0.35g of braking. This is slightly lower, therefore more conservative than that used in a large naturalistic driving study to flag 'near crashes'(Dingus et al., 2006) wherein vehicle braking greater than 0.5g or steering input that results in a lateral acceleration greater than 0.4g were used. We would have had fewer events if a stricter criterion was used. We are unable to change our choice for comparison purposes.

5. Conclusions

These results provide further understanding of the way older drivers drive their cars. It appears that the older drivers in this population with functional impairment are less likely than those without functional impairment to execute rapid decelerations during their habitual driving routes. This is reassuring for those jurisdictions which rely on self-restriction and caution amongst older drivers who have some slowing of function. It appears that like other age groups, highly functioning drivers are those who drive in such a way that they need to rapidly decelerate.

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Highlights

- Rapid deceleration events were examined over a 5-day period of monitoring in a cohort of drivers aged 67 to 87 years
- Approximately 30% of drivers had events and a third of these had four or more events
- Older drivers with rapid deceleration events had slightly better performance on measures of vision and cognition

Figure 1.
Proportion of drivers with rapid deceleration events during five days of vehicle monitoring

Table 1

Baseline Characteristics by Inclusion in the Analysis

Characteristic	Included n=1242	Not included n=183	p-value
Age (mean(SD))	75.2 (5.2)	75.4 (5.1)	0.56
% Female	50.1	49.7	0.93
% Blacks	12.6	16.4	0.15
Medical History			
% History of arthritis	57.1	59.0	0.62
% History of stroke	9.7	6.0	0.11
Pain (0–5 score)	0.89 (1.09)	0.89 (1.04)	0.92
Depression score (mean(SD))	3.7 (3.6)	4.2 (4.1)	0.09
Initial brake reaction time(mean(SD))	0.369 (0.093)	0.383 (0.099)	0.11
Cognitive Function			
Brief test of attention (mean(SD))	6.5 (2.5)	6.3 (2.6)	0.44
TMT Part A(mean(SD))	50.1 (24.0)	54.0 (30.8)	0.10
TMT Part B(mean(SD))	129.5 (76.5)	134.6 (78.2)	0.41
Visual Motor Integration(mean(SD))	18.2 (3.5)	18.1 (3.6)	0.71
Tower of Hanoi moves (mean(SD))	11.1 (5.4)	10.9 (4.8)	0.68
Errors in motor free vision integration (mean(SD))	3.5 (2.5)	3.4 (2.5)	0.69
Visual Function			
Visual acuity (mean(SD))	−0.1 (0.11)	−0.01 (0.12)	0.92
Contrast sensitivity (mean(SD))	35.2 (2.3)	34.9 (2.7)	0.11
Visual Field (mean(SD))	2.1 (5.2)	2.8 (7.0)	0.18
Visual Attention			
Average extent (mean(SD))	12.5 (5.3)	11.7 (5.5)	0.09
Driving Characteristics			
Average speed per segment (mean(SD))	29.6 (9.7)	&&	
% Maximum average speed per segment>55m/h	26.4	&&	

&& DMS not done or unreliable data

Table 2

Rapid Deceleration Event (RDE) Rate by Number of Miles Driven

	Miles Driven			
	<30	30.0 – 58.9	59 – 110.9	111
# Participants	316	303	315	308
Mean RDE rate /mile	0.0242	0.0213	0.0144	0.0112
Standard deviation	0.0704	0.0554	0.0297	0.0300

* Categories were created according to quartiles of the distribution of miles driven

Table 3

Association of demographic, physical, visual and cognitive factors with the rate of rapid deceleration events per mile driven using bivariate regression models adjusted for age.*

Baseline Characteristic	Age adjusted Incident Rate Ratio (95% CI)	p-value
Demographics		
Age (per yr increment)	0.97 (0.94 – 0.99)	0.007
Male/Female	1.15 (0.86 – 1.52)	0.35
Blacks/Whites	0.47 (0.29 – 0.73)	0.001
Medical History		
History of arthritis	0.88 (0.66 – 1.18)	0.40
History of stroke	0.46 (0.27 – 0.77)	0.003
Pain (0–5 score) (per unit increase)	0.91 (0.80 – 1.04)	0.16
Depression score (per unit increase)	0.92 (0.88 – 0.95)	<0.0001
Initial brake reaction time (per unit increase)	0.22 (0.04–1.15)	0.07
Cognitive Function		
Brief test of attention (per unit decrease)	0.94 (0.88– 1.01)	0.08
TMT Part A (per 5 seconds increase)	0.95 (0.92 – 0.98)	0.003
TMT Part B (per 10 seconds increase)	0.96 (0.94 – 0.98)	0.0003
Visual Motor Integration (per unit decrease)	0.93 (0.90–0.97)	0.001
Tower of Hanoi moves (per additional move)	0.97 (0.94 – 1.00)	0.054
Errors in motor free vision integration (per error)	0.91 (0.87 – 0.96)	0.001
Visual Function		
Visual acuity (per line loss)	0.98 (0.87 – 1.12)	0.81
Contrast sensitivity (per letter loss)	0.91 (0.85–0.97)	0.008
Visual Field (per point missed)	0.96 (0.92 – 0.99)	0.02
Visual Attention		
Average extent (per degree loss)	0.95 (0.93–0.98)	0.0006
Driving Characteristics		
Average speed per segment (1 mile/hr increase)	0.97 (0.96 – 0.99)	0.0002
Maximum average speed per segment>55mph	0.63 (0.47 –0.86)	0.003

* Fitted using a negative binomial distribution with offset equal to the logarithm of number of miles driven

Table 4

Association of demographic, physical, visual and cognitive factors with the rate of rapid deceleration events per mile driven using bivariate regression models adjusted for age. *

Baseline Characteristic	Age adjusted Incident Rate Ratio (95% CI)	
	<59 miles	59 miles
Demographics		
Age (per yr increment)	0.96 (0.92 – 1.00)	0.95 (0.92 – 0.99)
Male/Female	1.23 (0.79 – 1.93)	1.53 (1.07– 2.19)
Blacks/Whites	0.31 (0.14 – 0.70)	0.66 (0.39 – 1.11)
Medical History		
History of arthritis	0.83 (0.53 – 1.31)	0.87 (0.62 – 1.23)
History of stroke	0.32 (0.14 – 0.75)	0.64 (0.34 – 1.21)
Pain (0–5 score) (per unit increase)	0.87 (0.71 – 1.06)	0.98 (0.83 – 1.15)
Depression score (per unit increase)	0.89 (0.84 – 0.95)	0.95 (0.90 – 1.00)
Initial brake reaction time (per unit increase)	0.12 (0.004–3.76)	0.21 (0.03–1.40)
Cognitive Function		
Brief test of attention (per unit decrease)	0.91 (0.83–1.00)	1.00 (0.93 – 1.09)
TMT Part A (per 5 seconds increase)	0.94 (0.89 – 0.99)	0.96 (0.92 – 1.00)
TMT Part B (per 10 seconds increase)	0.95 (0.92 – 0.98)	0.97 (0.95 – 1.00)
Visual Motor Integration (per unit increase)	0.94 (0.88–1.00)	0.93 (0.88–0.97)
Tower of Hanoi moves (per additional move)	0.96 (0.92 – 1.01)	0.99 (0.95 – 1.02)
Errors in motor free vision integration (per error)	0.91 (0.83 – 0.99)	0.93 (0.87 – 0.99)
Visual Function		
Visual acuity (per line loss)	0.97 (0.81 – 1.16)	0.95 (0.80 – 1.12)
Contrast sensitivity (per letter loss)	0.89 (0.81–0.99)	0.94 (0.86–1.04)
Visual Field (per point missed)	0.94 (0.89 – 0.99)	0.99 (0.95 – 1.05)
Visual Attention		
Average extent (per degree loss)	0.95 (0.91–0.99)	0.94 (0.91–0.98)
Driving Characteristics		
Average speed per segment (1 mile/hr increase)	0.98 (0.95 – 1.01)	0.99 (0.97 – 1.01)
Maximum average speed per segment>55mph	0.55 (0.22 – 1.39)	0.95 (0.67 – 1.34)

* Fitted using a negative binomial distribution with offset equal to the logarithm of number of miles driven

Table 5

Multivariate model predicting the Rapid Deceleration Events per mile driven *

Baseline characteristic	Age adjusted Incident Rate Ratio (95% CI)	p-value
Age (per yr increment)	0.96 (0.94 – 0.99)	0.005
Blacks/Whites	0.58 (0.37 – 0.92)	0.02
History of stroke	0.54 (0.31 – 0.87)	0.01
Depression score (per unit increase)	0.92 (0.89 – 0.96)	0.0001
Tower of Hanoi (per additional move)	0.97 (0.94 – 1.00)	0.045
Errors in motor free vision integration (per error)	0.94 (0.89 – 0.99)	0.03
Average speed per segment (1 mile/hr increase)	0.97 (0.95 – 0.98)	<.0001

* Forcing age and using a backward elimination strategy