An Examination of Driving Exposure, Habits and Harsh Braking Events in Older Drivers with Bilateral Cataract Using Naturalistic Driving Data

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Key Findings

- Poorer contrast sensitivity associated with fewer kilometres travelled per week while waiting for first eye cataract surgery;
- Driving at night was avoided by those with poorer binocular contrast sensitivity;
- Binocular visual acuity and stereopsis were not associated with driving exposure.

Abstract

The aim of this study was to examine driving exposure, habits and harsh braking events in older drivers with bilateral cataract using naturalistic driving data. Ninety six older drivers aged 55+ years were assessed in the month prior to first eye cataract surgery. Data collection consisted of a researcher administered questionnaire, a cognitive test and visual measures including visual acuity, contrast sensitivity and stereopsis. Participants' driving exposure, driving habits and harsh braking events were measured using an objective in-vehicle driver monitoring device. A multiple linear regression model was undertaken to examine predictors of driving exposure in older drivers with bilateral cataract. After controlling for potential confounding factors, only binocular contrast sensitivity ($p<0.05$) and gender ($p<0.05$) were significantly associated with kilometres travelled in a seven day period. One log unit increase in contrast sensitivity score was associated with an increase of 163 kilometres driven during the study period. Males drove an average of 50 kilometres more per week than women. Only eleven participants experienced a harsh braking event during the driving monitoring period. The study provides a better understanding of the driving exposure, habits and harsh braking events of bilateral cataract patients while waiting for first eye cataract surgery. Contrast sensitivity is an important measure to consider when determining the impact of cataract on driving. Further longitudinal research is required to examine changes in visual measures, driving exposure, habits and harsh braking events after first eye surgery and whether second eye surgery provides additional benefits for driving.

Keywords

Bilateral Cataract, Contrast Sensitivity, Driver Self-Regulation, Naturalistic Data, Older Drivers

Introduction

Cataract is one of the leading causes of visual impairment worldwide. It is the main cause of blindness (51%) and accounts for 33 percent of visual impairment globally (Pascolini & Mariotti, 2012). Approximately 50% of older people will develop cataract by their seventies and this increases to around 90% by their eighties (McCarty, Keeffe, & Taylor, 1999). The incidence of cataract worldwide has increased rapidly over the past 20 years and this is expected to continue as the population ages (Rochtchina et al., 2003).

Cataract can affect multiple aspects of vision and a growing body of evidence suggests that older drivers with cataract are less safe to drive (Owsley, Stalvey, Wells, & Sloane, 1999; Owsley et al., 2001). However, unlike other conditions of ageing, cataract can be easily corrected by surgery, which has been shown to reduce crash risk by thirteen percent one year after first eye surgery (Meuleners, Hendrie, Lee, Ng, & Morlet, 2012). In Australia however, public hospital patients often wait long periods of up to 12 months before cataract surgery (Meuleners et al., 2012), generating concern among road safety and licensing authorities about the impact of un-operated cataract on driving exposure and ability.

Previous research examining the effect of cataract surgery on driving outcomes has focused on self-reported driving difficulty. A meta-analysis of five studies found that the risk of driving difficulty reduced by 88% after cataract surgery (OR 0.12, 95% CI 0.10 to 0.16; Subzwari et al., 2008). There has also been limited research investigating driving exposure and habits among cataract patients and the research to date has used self-report measures only (Fraser, Meuleners, Lee, Ng, & Morlet, 2013; Owsley et al., 1999). These studies found that older drivers with cataract self-reported that they reduced their driving exposure in terms of number of days, trips and distance travelled per week prior to surgery, compared to before they had cataract (Fraser et al., 2013; Owsley et al., 1999). However, driving exposure was assessed using a self-reported questionnaire which has inherent biases and limitations. Previous research has found self-reported measures of driving outcomes may be less reliable than naturalistic data collection methods (Blanchard, Myers, & Porter, 2010; Molnar et al., 2013a).

Naturalistic studies which collect detailed GPS information allow an accurate and objective examination of driving outcomes such as driving exposure as well as events including harsh braking. This rich source of information provides a means for assessing the safety impact of driving behaviours in an unobtrusive manner. Several studies to date have used in-vehicle devices to measure rapid deceleration events and have used them as a surrogate measure for near crashes (Af Wåhlberg, 2008; Chevalier et al., 2017) with positive correlations found between incidents, near crashes and actual crashes (Wu, Aguero-Valverde, & Jovanis, 2014). The deceleration and acceleration behaviour of drivers specifically has also been shown to predict at-fault crash involvement (Af Wåhlberg, 2008).

To date, no published study has used naturalistic data to explore driving exposure, habits and harsh braking events for older drivers with bilateral cataract. This information is of relevance to licensing authorities and clinicians in terms of understanding cataract patients' driving habits in the waiting period for cataract surgery and the frequency of harsh braking events experienced. This would allow older drivers with cataract to be appropriately advised on driving risks they could face while awaiting first eye surgery and assist them in making an informed decision on whether they continue to drive or not during this wait time. Furthermore, the identification of participants whose driving performance would most benefit from cataract surgery would be useful in the prioritisation for surgery. Therefore, the aim of this study was to describe the naturalistic driving exposure, habits and harsh braking events of older drivers with bilateral cataract who were awaiting surgery and to determine factors associated with driving exposure (kilometres travelled).

Methods

Participants

Participants awaiting first eye cataract surgery were recruited from three public hospital eye clinics in Western Australia either by an invitation letter or a direct approach made by clinicians at the hospitals. Inclusion criteria stipulated that participants were aged 55+ years, drove at least twice a week, had bilateral cataract and had no other significant eye conditions, such as glaucoma, macular degeneration or diabetic retinopathy. Participants were excluded from the study if they were wheelchair-bound, diagnosed with dementia, Alzheimer's disease, Parkinson's disease, were non-English speaking or had cataract surgery previously. A total of 645 cataract patients were reviewed for inclusion in the study with 381 being excluded (predominantly due to being non-drivers, already had one cataract surgery and severe health issues). Of the 264 eligible patients, 111 (42%) agreed to participate in the study.

Data Collection

Participants were recruited between December 2014 and February 2017. Data collection took place during the month before first eye cataract surgery. Data collection consisted of a researcher administered questionnaire, a cognitive test, the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975) and three objective visual assessments, which were administered at Curtin University. Participants were also provided with an in-vehicle monitoring device at the end of the assessment. Informed written consent was obtained from each participant before any information was collected, following the tenets of the Declaration of Helsinki. Ethics approval was obtained from the three participating hospitals (Fremantle Hospital, Royal Perth Hospital and Sir Charles Gairdner Hospital) and the Curtin University Human Research Ethics Committee.

Questionnaires

Socio-demographic data

Information on age, gender, marital status, country of birth, level of education, employment status, living arrangements, medications, comorbidities, driver's licence and years of driving experience were collected via a researcher administered questionnaire.

Driving Habits Questionnaire (DHQ)

All participants completed the Driving Habit Questionnaire (DHQ; Owsley et al., 1999). It includes questions about actual driving, driving exposure, dependence, avoidance, crashes and driving space. This questionnaire has been previously validated for use with a Western Australian population of older drivers with bilateral cataract (Fraser et al., 2013).

Mini-Mental State Examination (MMSE)

The MMSE (Folstein et al., 1975) was administered to all participants. It assesses general cognitive function and is used as a screening tool for cognitive impairment. Scores range from 0 to 30 with a higher score indicating better cognitive functioning. The inclusion criterion was a score $\geq$ 24 on the MMSE which indicates normal cognitive function.

Measures of Vision

Three objective visual measures were administered under the guidance of an ophthalmologist under standard conditions, constant luminance and without mydriasis. Participants wore their habitual correction for visual testing.

Visual acuity: Monocular and binocular visual acuity were assessed using an Early Treatment Diabetic Retinopathy Study acuity chart (ETDRS), calibrated for a 3 metre distance (Ferris, Kassoff, Bresnick, & Bailey, 1982). A letter by letter scoring method was used and scores were expressed as a logarithm of the minimum angle of resolution (logMAR). In WA, drivers must have visual acuity of 0.30 logMAR or better with their better eye or binocularly for unconditional licensing. For visual acuity, lower scores indicate better vision.

Contrast sensitivity: Monocular and binocular contrast sensitivity were measured using the Mars Letter Contrast Sensitivity Test, at a distance of 50 centimetres (Mars Perceptrix ©) and expressed as log units. Normal contrast sensitivity for adults aged over 60 ranges from 1.52 to 1.76 log units. For contrast sensitivity, higher scores indicate better vision.

Stereopsis: Stereopsis was assessed using the Titmus Fly Stereotest (Stereo Optical Co., Inc.) and scores were expressed as log seconds of arc. Average stereopsis for people aged over 60 is approximately 1.97 log seconds of arc. For stereopsis, lower scores indicate better vision.

In-Vehicle Monitoring Device

All participants were provided with an in-vehicle monitoring device and instructed to use it for a period of seven days. Participants were instructed to only use it when they were driving their motor vehicle. They were also provided with a travel diary that they were asked to complete each time they drove their motor vehicle. The diary recorded the model, make and year of their vehicle, number, age and position of passengers, time, date, start and end time of the trip and distance travelled. At the conclusion of the monitoring period, a researcher interviewed participants to identify any issues with the devices and to confirm no one else drove the vehicle while the device was connected. Instructions were provided to all participants regarding the use of the device in the participant information sheet. They had to plug the device into their car's On Board Diagnostic II (OBD II) port for vehicles manufactured after January 2006 or the cigarette lighter prior to 2006 (Figure 1). The in-vehicle monitoring GPS system transmitted time stamped second-by-second data of speed and location for all trips and collected information on real-time driving exposure, time, date of travel and harsh braking events. The GPS data was cleaned to exclude "false trips" of less than 200 meters or which lasted less than 10 seconds. Trips made from the University after the assessments were excluded, as they were not representative of the participants' habitual driving behaviour.


Figure 1. In-vehicle driver monitoring device

Operational Definitions

Harsh braking episodes were defined as G-force exertion more harsh than -0.61G (Geotab©).

Day time driving was defined as the period from sunrise to sunset and night time driving as the period from sunset to sunrise, for each day. Specific times of sunrise and sunset for each day of the year were obtained from the Australian Government's Bureau of Meteorology website (www.bom.gov.au).

Driving between the hours of 6 and 9 a.m. or from 4 to 7 p.m. on weekdays was defined as peak hour driving.

The mean excursion radius for a driver was calculated as the mean distance (km) of the vehicle from the home of the driver (Keay et al., 2013), scaled to the amount of time the vehicle was present at each location away from home while the vehicle was in motion (i.e. speed > 0), with the moments in time the vehicle was stationary (i.e. speed = 0) excluded from the calculations.

Statistical Analysis

Descriptive statistics were used to summarise the socio-demographic and visual characteristics of the cohort. Driving exposure, habits and harsh braking events were also described in detail. Since the number of participants experiencing harsh braking events was low, only descriptive statistics were calculated. The primary outcome of interest was driving exposure as measured by total number of kilometres travelled in a seven day period prior to first eye cataract surgery. A multiple linear regression model was undertaken to determine the association between three objective visual measures (binocular visual acuity, binocular contrast sensitivity and stereopsis) and driving exposure in a seven day period. Binocular visual measures were chosen since these take into account how better and worse eye vision interact when undertaking tasks in the real world. The three objective measures of vision were entered as explanatory variables in the models and potential confounding factors such as age, gender, the number of comorbidities, cognitive status, retirement status and whether the participant lived alone were controlled for. All variables were entered into the model simultaneously. All statistical analyses were performed using SPSS statistical software, version 22 (SPSS Inc., Chicago, IL, USA).

Results

One hundred and eleven participants with bilateral cataract who were waiting for first eye cataract surgery were recruited into the study. Fifteen participants were excluded from the analysis due to poor data integrity from the in-vehicle monitoring device which was caused by faulty cigarette lighters and/or the loss of the monitoring devices. The final sample consisted of 96 participants (including eight who did not drive during the monitoring period).

The ninety six participants ranged in age from 55 to 91 years old, with a mean age of 73.4 years (SD=8.6). The mean number of years driving was 51.4 years (SD=10.6). As illustrated in Table 1, 18.8% of the sample were aged between 55 and 64 years, 35.4% between 65 and 74, 36.5% between 75 and 84 and 9.4% were 85 or older. The majority of participants were male (52.1%), married or in a de facto relationship (57.3%), were retired (72.9%) and did not live alone (58.3%). Forty-five percent (44.8%) were born in Australia, 60.4% had completed a higher degree and 43.8% wore bifocal or multifocal glasses. Ninety-eight percent (97.9%) of the participants reported at least one comorbid medical condition in addition to cataract, with a mean of 5.4 comorbid medical conditions per participant (SD=2.8). These conditions included musculoskeletal, circulatory, respiratory and endocrine conditions. Eighty-nine percent of participants were also taking prescribed medications, with a mean of 3.4 (SD=3.0) medications taken per participant. All participants had normal cognitive function according to the MMSE, with an overall mean for the sample of 27.7 (SD=2.1).

Responses to the self-reported DHQ questionnaire found that approximately half of the sample (51.1%) reported that cataract did not affect their driving. However, 10.6% of participants (n=10) reported that someone suggested that they stop or limit their driving in the past year. Among the participants who were told that they should stop or limit their driving, four participants did not drive at all during the seven day period. Eighty-one percent of participants (80.9%) preferred to drive themselves rather than being driven by someone else and the majority of participants considered themselves to be good (46.8%), excellent (24.5%) or average drivers (25.5%). Only few participants considered themselves to be a fair (2.1%) or poor drivers (1.1%). All but two of the 96 study participants owned their own car and all but one used their seatbelt while driving. Participants self-reported that in a normal week they drove an average of 5.1 days (SD: 2.0), an average of 170.1 km (SD: 243.9) and made an average of 12.9 trips (SD: 16.1).

Table 1. Demographic characteristics of older drivers with bilateral cataract aged 55+ (n=96)

	Number	Percent
Gender		
Male	50	52.08
Female	46	47.92
Marital status		
De facto/ married	55	57.29
Single/Separated Divorced/ Widowed	41	42.71
Age group		
55-64	18	18.75
65-74	34	35.42
75-84	35	36.46
>=85	9	9.38
Highest educational level		
Primary or Secondary School	38	39.58
Higher Education (University/ TAFE)	58	60.42
Country of birth		
Australia	43	44.79
Other	53	55.51
Employment status		
Retired	70	72.92
Employed/self-employed	18	18.75
Unemployed	6	6.25
Medical disability pension	2	2.08
Living arrangements		
Lives alone	40	41.67
Lives with other people	56	58.33
Habitual correction		
No correction	41	42.71
Single vision spectacles	12	12.50
Bifocals or multifocals	42	43.75
Contact lenses	1	1.04
Presence of comorbidities		
No	2	2.08
Yes	94	97.92
Prescription medication		
No	11	11.46
Yes	85	88.54

The results of the visual measurements prior to first eye cataract surgery are shown in Table 2. Mean binocular visual acuity, as measured by the ETDRS chart, was 0.14 logMAR (SD=0.16). Mean binocular contrast sensitivity, as measured by the MARS contrast sensitivity chart was 1.65 log units

(SD=0.15) and mean stereopsis as measured by the Titmus Fly test was 2.32 log seconds of arc (SD=0.72). Average visual acuity was better than the minimum required for licensing in WA (0.30 logMAR). However, average contrast sensitivity and stereopsis was poorer than normal levels for older adults but not severely impaired.

Table 2. Visual characteristics of older drivers with bilateral cataract aged 55+ (n=96)

Visual tests	Mean	SD
Visual acuity (logMAR)		
Better eye	0.19	0.15
Worse eye	0.43	0.29
Both eyes	0.14	0.16
Log contrast sensitivity		
Better eye	1.57	0.15
Worse eye	1.37	0.34
Both eyes	1.65	0.15
Stereopsis (log seconds of arc)		
Both eyes	2.32	0.72

In-Vehicle Monitoring Devices

The final sample used for the analysis of the in-vehicle monitoring device was 96 participants. No significant difference was found between the 96 participants who undertook the in-vehicle monitoring and the 15 who were excluded from this analysis due to poor data integrity in terms of gender (p=0.77), age (p=0.45), visual acuity (p=0.65), contrast sensitivity (p=0.74), and stereopsis (p=0.62). A total of eight participants (8.3%) did not drive at all during the study period but they were still included in all results. Reasons for this included "difficulties driving at night", "in the rain", or participants were told by someone else that "they should stop or limit their driving".

Overall Driving Exposure and Naturalistic Driving Patterns

Ninety-two percent of participants (n=88) drove during the 7 day period. As illustrated in Table 3, participants, overall, undertook an average of 15.6 trips (SD=10.5), drove an average distance of 115.8 kilometers per week (SD=99.0), and drove an average of 4.40 days (SD=2.1) in a seven day period. The maximum distance that participants travelled from home was 14.1 (SD=11.9) kilometres. Compared to the self-reported DHQ, participants actually drove less days and kilometres per week but made more trips per week than they reported.

Table 3. Naturalistic driving patterns of older drivers with bilateral cataract aged 55+ over a seven day period (n=96)

	Mean	SD
Overall driving (n=88)		
Kilometres travelled	115.77	98.97
Number of trips	15.56	10.51
Driving duration per week (minutes)	186.51	149.03
Number of days driving	4.40	2.06
Maximum excursion radius from home (km)	14.08	11.87
Day time driving (n=88)		
Kilometres travelled	101.27	87.45
Number of trips	14.04	9.15
Driving duration during day time (minutes)	165.00	127.82
Number of days driving	4.32	2.02
Night time driving (n=43)		
Kilometres travelled	14.50	29.47
Number of trips	1.52	3.49
Driving duration during night time (minutes)	21.51	47.37
Number of days driving	0.93	1.41
Weekday driving (n=88)		
Kilometres travelled	86.10	72.56
Number of trips	12.00	8.38
Driving duration per weekday (minutes)	142.48	113.13
Number of days driving	3.23	1.50
Weekend driving (n=72)		
Kilometres travelled	29.67	42.67
Number of trips	3.56	3.64
Driving duration per weekend (minutes)	44.03	55.85
Number of days driving	1.17	0.80
Peak hour driving (n=75)		
Kilometres travelled	33.97	38.48
Number of trips	4.56	4.39
Driving duration during peak hours (minutes)	57.84	61.38
Number of days driving	2.19	1.59

Daytime driving

Ninety-two percent of participants (n=88) drove during the daytime. Participants undertook an average of 14.0 trips (SD=9.2), drove an average distance of 101.3 kilometres per week (SD=87.5), and drove an average of 4.3 days (SD=2.0) during daytime in a seven day period.

Night time driving

Slightly less than half of the sample (45%) drove at night-time (n=43). Participants undertook an average of 1.52 trips (SD=3.49), drove an average distance of 14.50 kilometers (SD=29.47), and drove an average of 0.93 days (SD=1.41) during the night in a seven day period.

Weekday driving

Ninety-two percent of participants (n=88) drove during the week (Monday to Friday). Participants undertook an average of 12.0 trips (SD=8.4), drove an average distance of 86.1 kilometers (SD=72.6), and drove an average of 3.2 days (SD=1.5) during the work week.

Weekend driving

Seventy-five percent of participants (n=72) drove during the weekend. Participants undertook an average of 3.6 trips (SD=3.6), drove an average distance of 29.7 kilometers (SD=42.7), and drove an average of 1.2 days (SD=0.8) during the weekend.

Peak hour driving

Seventy-eight percent of participants (n=75) drove during peak hour traffic. Participants undertook an average of 4.6 trips (SD=4.4), drove an average distance of 34.0 kilometers (SD= 38.5), and drove an average of 2.2 days (SD=1.6) during peak hour traffic.

Table 4. Frequency of harsh braking events

Harsh braking events	**n=12**	**%**
Time of the day:		
Day time	10	83.3
Night time	2	16.7
Traffic:		
Peak hour	5	41.7
Non-peak hour	7	58.3
Type of road:		
Highway/freeway	2	16.7
Local roads	10	83.3

Harsh braking events

Ten participants recorded one episode of harsh braking during the seven day period and one recorded two episodes of harsh braking.

Ten harsh braking events occurred during the day, two occurred during night time driving, while five occurred while driving during peak hour traffic (Table 4). Ten harsh braking events occurred while the participants were travelling on local roads and two events occurred while they were driving on a freeway or highway. There was no significant differences between the participants who did and did not record any harsh braking events in terms of age (p=0.15), gender (p=0.68), binocular contrast sensitivity (p=0.73), binocular visual acuity (p=0.80) or stereopsis (p=0.79).

Table 5. Factors associated with total kilometres travelled for bilateral cataract patients waiting for first eye surgery (n=96)

Predictor	**B**	**Standard Error**	**95% CI**		**p value**
Age	-2.60	1.65	-5.88	0.68	0.12
Gender: (male)	50.49	21.85	7.05	93.94	0.02*
Number of comorbidities	1.93	3.55	-5.13	9.00	0.59
Living situation: (not alone)	13.43	21.27	-28.86	55.72	0.53
Employment status: (retired)	-18.32	29.91	-77.78	41.14	0.54
Binocular visual acuity	10.15	72.17	-133.32	153.62	0.89
Binocular contrast sensitivity	163.41	74.83	14.66	312.16	0.03*
Stereopsis	-14.52	13.92	-42.19	13.15	0.30
Cognition (MMSE[a] score)	1.52	4.91	-8.23	11.28	0.76

[a] MMSE: Mini-Mental State Examination
*$p<0.05$

Association between visual mesaures and driving exposure

The results of the multiple linear regression model examining the association between visual measures and the total kilometres travelled in a seven day period are presented in Table 5. Binocular contrast sensitivity ($p<0.05$) and gender ($p<0.05$) were the only variables significantly associated with driving exposure (total kilometres travelled) after controlling for potential confounding factors. Neither binocular visual acuity ($p=0.89$) nor stereopsis ($p=0.30$) were significantly associated with driving exposure. Participants with better contrast sensitivity scores drove more kilometres than those who had poorer contrast sensitivity scores. More specifically, one log unit increase in contrast sensitivity score was associated with an increase of 163 kilometres per week driven during the seven day study period. Males drove an average of 50 kilometres more per week than females.

Discussion

This is one of the first studies to specifically examine the driving exposure, habits and harsh braking events of older drivers with bilateral cataract, using objective naturalistic driving data as they wait for first eye cataract surgery. Driving is a complex task and cataract can negatively affect aspects of vision such as visual acuity, contrast sensitivity and stereopsis which can have a serious impact on driving ability (Fraser et al., 2013; West et al., 2003). The results of the study found that older drivers with poorer binocular contrast sensitivity drove significantly fewer kilometres per week prior to first eye cataract surgery than those with better contrast sensitivity. This is consistent with findings from the general older driver population (Sandlin, McGwin, & Owsley, 2014); however, that research used self-reported driving exposure, which is subject to bias. Visual acuity was not significantly associated with driving exposure in this study and inconsistent findings have been reported on this relationship in the literature (Owsley & McGwin, 2010). However, this study confirms previous findings that contrast sensitivity may be a more important measure related to a range of driving outcomes than visual acuity among cataract patients (Fraser et al., 2013; Owsley et al., 2001; Wood & Carberry, 2006).

Gender was significantly associated with driving exposure with males driving more kilometers per week than females. Previous research also found that females report poorer driving confidence, greater driving difficulty and more negative attitudes to driving than males (Conlon, Rahaley, & Davis, 2017; Wong, Smith, & Sullivan, 2015). Females are also less likely than males to be the principal driver (Conlon et al., 2017) which may explain the results of our study as 57% of participants were married.

Previous research has consistently found that as drivers' age, they report driving fewer kilometres per week (Braitman & Williams, 2011; Sandlin et al., 2014). This may be due to a variety of reasons which include older drivers having poorer health, mobility issues and being more frail (Meuleners, Harding, Lee, & Legge, 2006). However, the cohort in our study travelled fewer kilometres in a typical week than reported in previous older driver studies (Blanchard & Myers, 2010; Molnar et al., 2013a). They also appeared to restrict their driving to their local neighbourhood with the mean distance travelled from home being fourteen kilometres. This restriction of driving to the local neighbourhood is consistent with other research among older drivers (Keay et al., 2009). Eight participants did not drive at all during the seven day monitoring period while waiting for cataract surgery, due to driving difficulties or suggestions from others to stop or limit their driving. Overall, these findings may be indicative of participants acknowledging their driving limitations due to cataract and reducing their driving exposure. This reduction in travel by cataract participants as they wait for first eye surgery can be viewed as a positive safety response as it reduces their exposure on the road and the possible risk of crash involvement. It is also acknowledged however, that older drivers may participate in fewer activities that require driving due to changes in lifestyle or retirement (Molnar et al., 2013b). Therefore it should be noted that approximately 80% of participants in this study were retired or unemployed, which may have limited the need for travel by this group and contributed to the results.

Despite the overall low driving exposure observed, 81% of participants in this study still preferred to drive themselves rather than being driven by someone else, almost half of the cohort (n=43) drove at night time and 75 participants drove during peak hour, both of which have been found to be challenging driving situations for older drivers with cataract (Owsley et al., 1999). This raises concerns about fitness to drive while waiting for cataract surgery. Previous research has found that older drivers with cataracts, despite limiting their driving exposure, have an increased risk for at-fault crashes compared to age-matched controls without cataract (Owsley et al., 1999). This has also been confirmed in previous research which examined the impact of simulated cataract on driving performance (Wood & Troutbeck, 1994, 1995). Therefore, ophthalmologists could play an important role in ensuring that cataract patients are provided with adequate information about driving difficulties and risks they may experience due to cataract and how to limit their exposure to these while waiting for cataract surgery. They could then make an informed decision on whether they continue to drive during this period.

Previous research has found that drivers who brake rapidly may be at a greater risk for a crash or a near miss (Chevalier et al., 2017). In particular, a sudden stop has been shown to be associated with rear end crashes (Harb, Radwan, Yan, & Abdel-Aty, 2007). While only eleven participants (11%) in this study recorded at least one episode of harsh braking, this is comparatively high considering driving was only monitored for one week. For example, a previous study found that 64% of participants were involved in at least one episode over a much longer 12 month period (Chevalier et al., 2017). Further research using a larger sample size over a longer period of time is required to explore this issue further and determine whether cataract patients are in fact, at higher risk of harsh braking events.

A major strength of this study is that naturalistic driving behaviour was measured using objective in-vehicle monitoring devices in the participants' own vehicle. However there are several limitations to this study. The strict inclusion criteria may have impacted on the generalisability of the results. Furthermore, participants' naturalistic driving behaviour was only measured over a period of seven days, which may have limited driving exposure and the number of harsh braking events that were recorded. However, the choice of a seven day timeframe is consistent with previous naturalistic studies which has found this time frame to be representative of older drivers' patterns and habits (Blanchard & Myers, 2010; Blanchard et al., 2010; Thompson, Baldock, Mathias, & Wundersitz, 2016). In addition, participants may have modified their driving behaviour while using the devices, due to the fact that their driving behaviour was monitored. A further limitation is that 14% of participants were excluded from the study, due to missing information related to the devices. It should be noted however there was no significant difference between the two groups in terms of gender and age and visual impairment. Other visual measures such as visual field and disability glare were also not collected in this study. We also did not collect video footage of driving which would provide more in depth information regarding driving events. Further monitoring of driving exposure over a longer period of time before first eye cataract surgery and a larger sample is warranted. In addition, future research should examine how driving exposure changes after first and second eye cataract surgery. Despite these limitations, this study controlled for a wide range of potential confounding factors when examining the driving patterns, harsh braking events and exposure of older drivers while waiting for first eye cataract surgery.

Conclusions

The results of this study provide a better understanding of driving exposure, habits and harsh braking events of bilateral cataract patients while waiting for first eye cataract surgery. It also substantiates previous research that contrast sensitivity is an important visual measure to consider when determining the impact of cataract on driving. Cataract patients with poor contrast sensitivity drive fewer kilometres while waiting for surgery, meaning their mobility in the community is negatively affected. Therefore, clinicians should consider contrast sensitivity scores in their assessment and prioritisation for surgery of cataract patients who drive. Further longitudinal research is required to determine the impact of first and second eye cataract surgery on the objective driving exposure, habits and harsh braking events of bilateral cataract patients, particularly as information on the impact of second eye cataract surgery on driving outcomes is lacking.

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