Effects of Age-Related Macular Degeneration on Driving Performance

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PURPOSE. To explore differences in driving performance of older adults with age-related macular degeneration (AMD) and age-matched controls, and to identify the visual determinants of driving performance in this population.

METHODS. Participants included 33 older drivers with AMD (mean age [M] = 76.6 ± 6.1 years; better eye Age-Related Eye Disease Study grades: early [61%] and intermediate [39%]) and 50 age-matched controls (M = 74.6 ± 5.0 years). Visual tests included visual acuity, contrast sensitivity, visual fields, and motion sensitivity. On-road driving performance was assessed in a dual-brake vehicle by an occupational therapist (masked to drivers' visual status). Outcome measures included driving safety ratings (scale of 1–10, where higher values represented safer driving), types of driving behavior errors, locations at which errors were made, and number of critical errors (CE) requiring an instructor intervention.

RESULTS. Drivers with AMD were rated as less safe than controls (4.8 vs. 6.2; P = 0.012); safety ratings were associated with AMD severity (early: 5.5 versus intermediate: 3.7), even after adjusting for age. Drivers with AMD had higher CE rates than controls (1.42 vs. 0.36, respectively; rate ratio 3.05, 95% confidence interval 1.47–6.36, P = 0.003) and exhibited more observation, lane keeping, and gap selection errors and made more errors at traffic light–controlled intersections (P < 0.05). Only motion sensitivity was significantly associated with driving safety in the AMD drivers (P = 0.005).

CONCLUSIONS. Drivers with early and intermediate AMD can exhibit impairments in their driving performance, particularly during complex driving situations; motion sensitivity was most strongly associated with driving performance. These findings have important implications for assessing the driving ability of older drivers with visual impairment.

Keywords: age-related macular degeneration, driving performance, motion sensitivity

AMD is a leading cause of moderate to severe bilateral visual impairment in older adults aged 70 years and above[1]; with increasing prevalence rates predicted in the future as the population ages.[2] This increase in the number of older adults with AMD has significant health, social, and economic ramifications, given there are numerous functional difficulties associated with AMD, including reduced reading ability, face recognition,[3,4] postural stability,[5] and increased falls risk and injury rates.[6] Importantly, there are also implications for driving ability and safety, although there has been relatively limited research in this area.[7]

Drivers with AMD self-report more difficulties with driving, particularly night driving, even in the early stages of the disease.[8] Self-reported difficulties in night driving in AMD have been linked to reductions in scotopic (rod-mediated) sensitivity.[9] Drivers with AMD also self-regulate their driving habits, through avoiding challenging driving situations (night time, unfamiliar areas, rush hour),[10–12] and many older adults with AMD cease driving in the advanced stages of the condition.[12,13]

Few studies have assessed the crash risk and driving performance of older drivers with AMD with inconclusive findings. Studies have failed to find a link between AMD and increased crash risk,[14,15] indeed, drivers with intermediate levels of AMD had significantly lower crash rates than those with normal vision,[15] which was suggested to arise from driver self-regulation.[12,13] Simulator studies of small numbers of drivers with AMD suggest impairments in some aspects of driving ability, including delayed braking times, slower speeds, and more lane crossings, compared with age-matched controls.[16] Other studies of individuals with central field loss, many of whom had AMD, reported impaired pedestrian recognition rates in a driving simulator even when they appeared in the seeing field areas,[17,18] although vehicle control, including lane positioning and lead car following were not significantly different from controls.[19]

In this study, we investigated the impact of AMD on driving ability using a standardized on-road driving assessment, which was conducted under in-traffic conditions to represent typical driving conditions. The route included a wide range of tasks involved in day to day driving, with the design and location of the route chosen to represent the normal range of driving demands for most drivers. We hypothesized that drivers with AMD would have greater difficulty in visually demanding driving situations and exhibit more errors relating to observa-

tion and lane keeping compared with their normally-sighted counterparts. We also wished to explore which measures of visual function would be most strongly associated with driving ability and safety in drivers with AMD, as this has not been previously investigated. We hypothesized that central contrast sensitivity would have the strongest association with driving ability, given that reduced contrast sensitivity has been identified as the strongest correlate with other measures of functional performance, including impaired balance, gait, and increased falls risk in older adults with AMD.[5,6] Contrast sensitivity has also been shown to be predictive of crash risk and driving performance in older adults with cataracts.[20,21]

METHODS

Participants with AMD were recruited from the clinical records of the Queensland University of Technology (QUT) Optometry Clinic and private ophthalmology practices in South-East Queensland, and had been diagnosed as having AMD by their treating ophthalmologist. The age-matched control participants were recruited as a convenience sample from our existing database of healthy volunteers, as well as from the QUT Optometry clinic and newspaper advertisements.

All participants were aged 65 years and older, were regular drivers, and currently licensed in Australia, where the visual requirements for licensing include visual acuity equal to or better than 20/40 with one or both eyes and no significant binocular visual field defects within a horizontal extent of at least 110° within 10° above and below the horizontal midline. Participants were excluded if they had any significant ocular or visual pathway disease leading to visual field loss, other than AMD; had Parkinson's disease; a history of dizziness or vestibular disease; used a walking aid; or had cognitive impairment (Mini-Mental State Examination score <24 of 30).[22]

The study followed the tenets of the Declaration of Helsinki and was approved by the Queensland University of Technology Human Research Ethics Committee. All participants were given a full explanation of the nature of the study, experimental procedures, and possible consequences of the study, and written informed consent was obtained. Participants attended two testing sessions including an assessment of visual function and an assessment of on-road driving performance.

Visual Assessment and Driving Characteristics

All participants underwent a comprehensive eye examination that included ophthalmoscopy, slit-lamp biomicroscopy, and fundus photography, to confirm eligibility for the study. Nonmydriatic, 45° digital photography of the posterior pole using a Canon CR6-45NM fundus camera (Tokyo, Japan) was used to confirm the presence of retinal changes consistent with AMD. The severity of AMD in both eyes was independently graded by an experienced optometrist from the digital retinal images, according to the AREDS classification scheme (1) maximum drusen size and drusen area, (2) the frequency of retinal pigment depigmentation and/or geographic atrophy, and (3) the presence or absence of large drusen (>125 μm) in both eyes.[23] Participants completed a battery of visual tests each of which were conducted binocularly while wearing their habitual distance correction.

Visual Acuity. Distance high contrast visual acuity was measured with the Early Treatment for Diabetic Retinopathy Study (ETDRS) chart at 5 m, at a luminance of 100 cd/m², using the letter-by-letter scoring method.[24]

Contrast Sensitivity. Letter contrast sensitivity was measured with the Pelli-Robson Contrast Sensitivity chart at 1 m at a luminance of 110 cd/m², using the letter-by-letter

scoring method.[25] A +1.00 DS lens was used to compensate for the working distance.

Visual Fields. Monocular visual fields were assessed in each eye using the SITA-Standard 24-2 threshold strategy on a Humphrey Field Analyzer (model 750; Carl Zeiss-Meditec, Dublin, CA, USA). A binocular integrated visual field (IVF) was constructed by combining the monocular visual fields based on the more sensitive of the two eyes at each visual field location.[26] The mean total deviation value of all the corresponding points was taken as the mean deviation (MD) value for the IVF and considered only for locations in the central 10° given that AMD affects more central areas of the visual field. Binocular visual fields were also measured using the Binocular Esterman test with participants wearing their habitual driving spectacles, if any, as is the recommended procedure. The Esterman Efficiency Score (percentage of points seen) was recorded.

Motion Sensitivity. Central motion sensitivity was measured using a computer-based random dot kinematogram.[27,28] Participants viewed (at a distance of 3.0 m) a field of dots (subtending 5.1° × 5.1°), within which a smaller central panel of dots (4.1° × 4.1°) moved coherently in one of four directions (up, down, left, or right) over four discrete steps. Participants were instructed to indicate the predominant direction of motion of the central dots. Across trials, the extent of the movement (in terms of the displacement of each pixel between frames) was varied in a two-down one-up staircase, with eight reversals. The threshold (D_{min}) was defined as the average of the displacement for the last six reversals in the staircase.

Participants also completed the Driving Habits Questionnaire (DHQ), an instrument used to characterize driving habits, exposure, frequency, driving difficulties, and provide a self-rating of driving quality.[29] The degree of visual driving difficulty experienced in nine specific driving situations (when raining, driving alone, parallel parking, turning across oncoming traffic, highways, busy traffic, rush hour, night-time, and unfamiliar areas), and a composite difficulty score scaled on a 100-point scale was generated,[30] where a higher score reflected less overall driving difficulty.

Driving Performance

Driving performance was assessed under in-traffic conditions in an automatic, dual-brake vehicle using a previously published protocol.[28,31–33] Driving was scored by a highly experienced driver-trained occupational therapist seated in the back seat of the vehicle, while an accredited professional driving instructor in the front passenger seat was responsible for route directions and monitoring safety, and also scored driving safety independently. Interrater reliability of test scores between the driving instructor and occupational therapist (using the same scale) was high ($r = 0.94$; $P < 0.001$). The driving instructor and occupational therapist were both masked regarding whether the participants had AMD or not, and participants' functional performance in the laboratory testing. Participants drove along a 19.4-km route on the open road, which involved a wide range of tasks involved in day to day driving under in-traffic conditions, including reading signs, obeying traffic signals, responding to other road users (drivers, pedestrians, and cyclists), maintaining vehicle control, and lane position and signaling. The driving route was chosen as representative of the normal range of driving demands for most drivers, not commercial or professional drivers, or commuters. The driving route was located in a busy urban area and started with a short familiarization period and then progressed to driving along city and suburban streets, and involved simple and complex intersections for a range of moderate to high

traffic densities. The driving assessment was approximately 50 minutes in duration, except when the drive was terminated early if the driver was considered too unsafe to proceed. All assessments were conducted just outside of peak hour traffic times to avoid long periods of stopping (gridlock), and hence less driving. The occupational therapist scored driving performance at a series of locations along the driving route in terms of driving behaviors (at an average of 149 locations) and scored overall driving safety on a 10-point scale based on driving standards criteria described elsewhere.[28]

At each of the locations, several aspects of driving behavior were scored: general observation (scanning and attention), braking/acceleration (appropriate speed and braking), lane positioning, gap selection (gap selected when entering traffic or the gap between the driver and other vehicles), and approach to hazards (appropriate planning and preparation).[34] Observation of blind-spots (correct checking of blind-spot and shoulder checks) and indication/signaling (appropriate use of directional indicator) were also assessed where appropriate (average of 15 and 56 locations, respectively). For each behavior type, the total number of errors as a proportion of the total number of times the behavior was assessed was calculated for each participant.

Each of the locations was further allocated into one of six situation categories: traffic light–controlled intersections, one-way traffic (straight and curved driving), two-way traffic (straight and curved driving), give-way (stop/give-way intersections, nontraffic light–controlled intersections, pedestrian crossings, and roundabouts), maneuvering (reversing, parking, turnaround maneuver, and negotiation through traffic slowing devices), and merging (lane changing, merging, and entering/exiting traffic flow). For each situation, the total number of errors as a proportion of the total number of times that performance was assessed at that location was calculated for each participant. Driving errors that were considered by the occupational therapist to pose a significant risk to driving safety and required an instructor intervention to avoid an imminent safety issue (either through applying the brakes, accelerator or taking control/correction of the steering wheel) were classified as critical errors (CE). Where drives were terminated early because of unsafe performance, driving behaviors and situation errors were scored as a proportion of the number of locations that were assessed, and overall driving performance was scored as unsafe.

Statistical Analysis

Group differences for the vision and self-reported driving characteristics (as determined using the DHQ) were examined using independent *t*-tests and χ^2 tests, where appropriate. Linear regression models controlled for age were used to compare group differences in on-road driving performance, including driving safety ratings, driving behaviors, and driving situations where errors were made. For count outcome variables (CE), negative binomial regressions were used to assess group differences. Linear regression models controlled for age were also used to separately explore the associations between the vision measures and overall driving safety ratings for the drivers with AMD. Data were analyzed with SPSS (ver. 23; IBM Corp., Armonk, NY, USA) and $P < 0.05$ was considered statistically significant.

RESULTS

The sample consisted of 33 drivers with AMD (mean age = 76.6 ± 6.1 years) and 50 visually normal drivers without ocular disease (mean age = 74.6 ± 5.0 years). The participants'

TABLE 1. Demographic and Visual Characteristics of the Participants With AMD and the Age-Matched Visually Normal Controls

	AMD (*n* = 33)	Controls (*n* = 50)	*P* Value
Demographics			
Age, y	76.6 (6.1)	74.6 (5.0)	0.11
Sex, female *n* (%)	12 (36)	18 (36)	0.97*
Vision			
Binocular visual acuity (logMAR)	0.05 (0.12)	−0.10 (0.08)	<0.001†
Binocular contrast sensitivity (log units)	1.78 (0.23)	1.95 (0.27)	<0.001†
Visual field MD, better eye (dB)	−0.40 (1.65)	1.08 (1.29)	<0.001†
Visual field MD, worse eye (dB)	−2.59 (6.16)	0.37 (1.39)	<0.002†
Integrated visual fields (central 10°) (MD) (dB)	−0.09 (1.86)	1.55 (1.34)	<0.001†
Esterman, efficiency score (% points seen)	97.15 (3.24)	95.68 (4.03)	0.08
Motion sensitivity (log arc degrees)	−1.37 (0.33)	−1.80 (0.16)	<0.001†

* χ_1.
† $P < 0.01$.

demographic and visual characteristics are presented in Table 1. There were no significant group differences in age or sex distribution. The AMD drivers had a range of disease severity, both in terms of visual function and their Age-Related Eye Disease Study (AREDS) grades in the better eye, either having an AREDS grade of early (*n* = 20) or intermediate (*n* = 13). None of the participants with AMD were categorized as severe, given that they would not meet the visual acuity requirements for driving in Australia. With the exception of the binocular Esterman visual field test, all aspects of visual function were significantly worse in the AMD group compared with the controls including visual acuity, contrast sensitivity, visual field MD in the better and worse eye, IVF, and motion sensitivity.

The self-reported driving characteristics of the participants are presented in Table 2. There were few group differences, with the exception of self-reported driving difficulty, where the AMD drivers reported more difficulty than did the control drivers ($P = 0.002$). No drivers rated themselves as poor drivers, with the majority rating themselves as good drivers. Only one driver out of the whole sample reported that they had been advised to stop driving and that was from the control group. While a number of the participants from both groups self-reported being involved in a crash in the previous year or 5 years, there was no significant differences between the groups.

The on-road driving characteristics of the AMD and control participants are presented in Table 3. There was a wide range of driving performance across both AMD and control participants ranging from 2 (very poor performance) to 9.5 (excellent performance). The AMD drivers as a group were rated as significantly less safe than the controls when adjusted for age (4.80 vs. 6.21, respectively; $P = 0.012$), with a 1.41 point difference between the groups. Greater AMD severity was also significantly associated with impaired driving performance, adjusted for age (early: 5.50 versus intermediate: 3.73; $P = 0.002$), pairwise comparisons demonstrated that those with intermediate AMD had driving safety ratings that were significantly worse than either drivers with early AMD or controls ($P < 0.024$), but there was no significant difference between those with early AMD and controls ($P = 0.24$).

TABLE 2. Self-Reported Driving Characteristics

Characteristic	AMD (*n* = 33)	Controls (*n* = 50)	*P* Value
Years of driving experience, mean (SD)	56.15 (8.19)	54.53 (8.43)	0.39
Distance travelled in the past year, *n* (%)			
<5000 km	11 (36)	16 (32)	0.87*
5001–10,000 km	12 (39)	16 (32)	
10,001–15,000 km	6 (19)	12 (24)	
15,001–20,000 km	1 (3)	4 (8)	
>20,000 km	1 (3)	2 (4)	
Number of days driven in a typical week, mean (SD)	4.97 (1.78)	5.35 (1.49)	0.30
Composite driving difficulty score, mean (SD)†	0.91 (0.08)	0.96 (0.06)	0.002‡
Someone has suggested stopping driving, *n* (%)	0 (0)	1 (2)	0.61*
Driver dependency score, mean (SD)§	1.77 (0.79)	1.58 (0.65)	0.25
Quality of driving, *n* (%)			
Excellent	2 (6)	6 (12)	0.48*
Good	21 (64)	33 (66)	
Average	9 (27)	11 (22)	
Fair	1 (3)	0 (0)	
Poor	0 (0)	0 (0)	
Number of drivers with a history of 1 or more crashes, *n* (%)			
In previous 12 mo	3 (9)	1 (2)	0.28*
In previous 5 y	10 (30)	8 (16)	0.23*

* χ_1.
† Out of 100; lower scores indicate greater difficulty.
‡ *P* < 0.01.
§ Ranges from 1–3 with higher scores reflecting greater dependency on others to drive.

Negative binomial regression, with adjustment for age, indicated that the average rate of CE errors per drive was almost 4× higher for the drivers with AMD than the control drivers (1.42 vs. 0.36, respectively; rate ratio [RR] 3.05, 95% confidence interval [CI] 1.47–6.36, *P* = 0.003). When the AMD group was stratified by disease severity, those with intermediate AMD had significantly higher rates of CEs compared with controls (RR 4.39, 95% CI 1.80–10.71, *P* = 0.001), while the differences did not reach significance when those with early AMD were compared with controls (RR 2.11, 95% CI 0.87–5.11, *P* = 0.10). The driving assessment was terminated early due to safety concerns in nine drivers; the proportion was 3× higher in the drivers with AMD than controls but this difference was not significant (AMD: *n* = 6 (18%) versus controls: *n* = 3 (6%), Fisher's Exact Test, *P* = 0.146).

The most common type of driving behavior errors in both groups were those involving observations in the blindspot, however, there were no significant between group differences. Drivers with AMD made significantly more errors involving observation (*P* = 0.015), lane keeping (*P* = 0.044), and gap selection (*P* = 0.036). In both groups, most driving errors were made in situations where drivers had to merge, however there were no between group differences. Drivers with AMD made significantly more driving errors at traffic light-controlled intersections (*P* = 0.001).

In the separate linear regression models with adjustment for age, motion sensitivity was significantly associated with the driver safety ratings of the AMD drivers (standardized beta =

TABLE 3. On-Road Driving Characteristics of the Drivers With AMD and Age-Matched **Controls**

	AMD (*n* = 33)	Controls (*n* = 50)	*P* Value*
Overall driver safety rating (1–10)	4.80 (2.05)	6.21 (2.03)	0.012†
Critical errors (CE) (#)‡	1.42 (1.79)	0.36 (0.80)	0.003§
Driving behaviors (% errors to locations assessed)			
Observation errors	3.96 (3.06)	2.20 (2.28)	0.015†
Brake/accelerator errors	4.80 (3.15)	3.47 (3.74)	0.23
Indicator	11.32 (6.10)	9.02 (4.73)	0.13
Lane position	6.03 (4.85)	3.85 (2.83)	0.044†
Gap selection	1.77 (1.18)	1.12 (1.20)	0.036†
Approach	5.04 (3.58)	3.41 (3.57)	0.14
Blindspot	65.39 (23.85)	59.86 (22.66)	0.59
Driving situations (% errors to locations assessed)			
Traffic light situations	12.13 (7.47)	6.70 (5.66)	0.001§
One-way driving	16.69 (18.46)	12.63 (14.49)	0.55
Two-way driving	12.59 (10.79)	8.57 (7.51)	0.14
Give-way	22.11 (10.92)	19.75 (9.24)	0.60
Maneuvering	34.66 (20.44)	35.92 (20.43)	0.56
Merging	59.85 (20.64)	58.33 (19.75)	0.82

* Adjusted for age.
† *P* < 0.05.
‡ Negative binomial.
§ *P* < 0.01.

−0.460; *P* = 0.005; Fig.). None of the other visual measures, including contrast sensitivity (standardized beta = 0.204; *P* = 0.202), visual acuity (standardized beta = −0.233; *P* = 0.152), worse eye MD (standardized beta = −0.088; *P* = 0.585), better eye MD (standardized beta = 0.084; *P* = 0.606), or IVF central 10° (standardized beta = 0.138; *P* = 0.394) were significantly associated with driver safety ratings.

DISCUSSION

In this cross-sectional study, we demonstrated that older drivers with AMD as a group have impaired driving performance compared with age-matched controls without AMD. It is important to note, however, that there was a wide range of performance, with some drivers with AMD being rated as safe to drive. Collectively, the drivers with AMD had significantly higher rates of critical errors, with more errors made in more complex situations that involved traffic light–controlled intersections. Specific driving behavior errors exhibited by the AMD drivers involved observation of the driving environment, lane keeping, and appropriate gap selection. Importantly, of all of the visual function measures included in this study, a measure of central motion sensitivity was the only one that demonstrated a significant association with driving safety.

The drivers with AMD made more errors that involved observation, lane keeping, and selecting appropriate gaps in the traffic. Many of these errors suggest that the AMD drivers had difficulties in appropriately scanning and observing the environment, extracting relevant information regarding road signs, road markings, and other road users, and planning ahead regarding whether to progress or yield (give way), selection of appropriate gaps in traffic, changing lane, or pulling in and out of traffic. Our finding that lane keeping was challenging for the drivers with AMD supports that of a previous study of 10 AMD drivers, where maintaining correct lane position was a problem in both simulator and open-road driving situations.[16] Conversely, a recent simulator study of older drivers with binocular central scotomas failed to find problems with lane
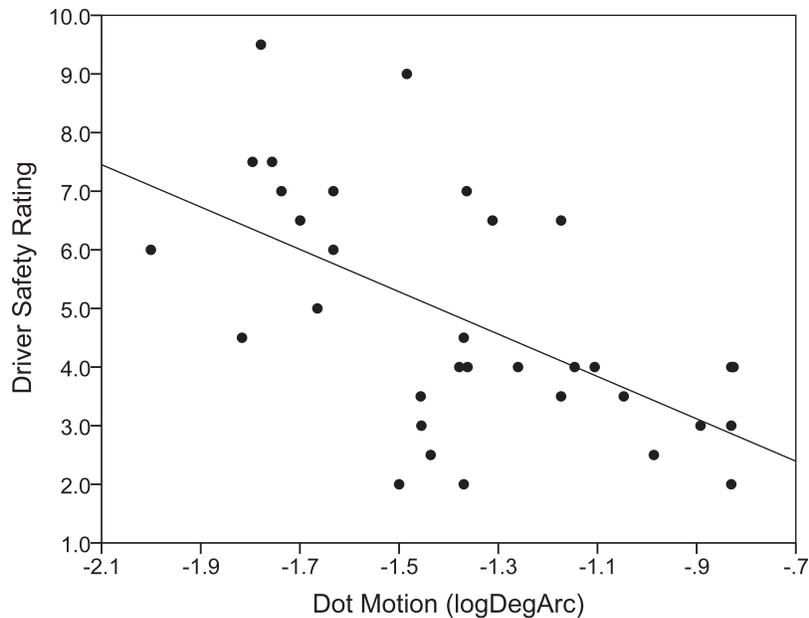
FIGURE. Scatterplot representing the association between motion sensitivity and driver safety ratings in the older drivers with AMD.

positioning.[19] Simulator studies have also reported that pedestrian hazard detection rates are significantly poorer among older drivers with binocular central scotomas, even when appearing in the seeing areas of their visual field compared with age-matched controls,[17,18] this supports our findings of observation problems for drivers with AMD.

Our findings also suggest that more complex driving situations, such as traffic light–controlled intersections, were the most challenging for drivers with AMD. This may be because it is more challenging for drivers with central visual impairment to effectively scan all of the relevant components of the driving scene in order to make appropriate strategic decisions regarding interactions with other traffic, as well as planning their own course through traffic. This is the first study to explore the impact of driving situations on driving performance in those with AMD; although, a previous study also reported that drivers with glaucomatous visual field loss had problems at traffic light–controlled intersections.[33] Interestingly, while drivers with AMD self-report avoiding challenging driving situations such as driving at night or in the rain and turns across traffic,[13] traffic light–controlled intersections have not been highlighted as a particular problem, even though our findings indicate otherwise.

While the drivers with AMD as a group were rated as less safe to drive and incurred higher rates of critical errors than did the controls, of interest was that these driving safety problems were related to disease severity. Drivers with early AMD were not rated as significantly different to controls and it was only drivers with intermediate AMD who were rated as significantly less safe to drive. These findings should be treated with caution, however, given the relatively small numbers of drivers with intermediate AMD in our sample.

An important finding was that neither central visual acuity nor contrast sensitivity were significantly associated with driving safety ratings. This is contrary to previous research that suggests that contrast sensitivity is significantly associated with a range of measures of everyday performance including balance, gait, and falls in older adults with AMD,[5,6] and of crash risk and driving ability in cataracts.[20,21] These differences may be explained by the fact that the participants with AMD in the current study were all current drivers, and thus had reasonably

good levels of contrast sensitivity. In this study, central motion sensitivity was the only visual function measure that was significantly associated with driving safety. This finding supports previous studies that have also found motion sensitivity to be a significant predictor of driver ability in older adults with and without visual impairment.[27,28] This may arise because the driving environment is a dynamic scene, due to the motion of the vehicle and other potential road hazards. Drivers need to be able to detect the speed and direction of motion of potential hazards; all of these are components of the central motion sensitivity task. These findings are supported by our previous studies in a general population of older adults,[28,35] and collectively suggest that visual acuity measured in a controlled environment, as assessed for driving in most countries, does not reflect the visual demands of driving in the real world, highlighting the need to reconsider the guidelines for the vision requirements for driving.

The findings of this study should be considered in terms of strengths and limitations. Strengths include assessment of driving performance under in-traffic conditions using a standardized route that was both extensive in duration and length, and included a variety of driving challenges. An important strength was that both the occupational therapist and driving instructor were masked to participants' visual characteristics and disease status. While our sample size was modest ($n = 33$), it is larger than previous studies that have explored the impact of AMD on driving, including simulator studies,[16–19] and unlike these studies, all of our participants were current drivers. It is, however, always challenging to recruit drivers with more advanced visual impairment to participate in on-road studies, which is why the number of drivers with intermediate AMD was relatively small. Drivers were also assessed in an unfamiliar vehicle rather than their own vehicle for the purposes of standardization and insurance, and drivers were assessed in an unfamiliar driving environment (given that the same route was used for every driver), so these factors may have impacted on any potential compensatory strategies of our drivers. As for any study conducted under in-traffic conditions, there may be minor variations in weather and traffic, although assessments were only conducted in dry conditions and outside of peak hour traffic. The occupational

therapist also took these situational variations into consideration when rating participants' driving performance, to ensure that the ratings were made in context of whether the driving situation during a particular assessment was more or less challenging than was typical.

In summary, this is the first in-traffic study that has assessed current drivers with AMD on a standardized route, compared with an age-matched control group without eye disease, in order to identify differences in specific driving error types and driving locations where errors were made. We demonstrated that while some older drivers with AMD were rated as having safe driving, as a group they were less safe and made more errors involving driving behaviors, such as observation, lane keeping, and gap selection, in complex situations including traffic light–controlled intersections. Importantly, in a growing ageing population and with developments in treatment for those with AMD, the number of drivers with AMD who have visual function that allows them to continue driving will increase in the future. A recent report highlights the use of anti-VEGF therapy as a major long-term treatment for neovascular AMD, with 50% of eyes having visual acuity 20/40 or better after 5 years of treatment; many would thus meet driving license requirements and could continue to drive.[36] The impact of these differences on road safety will thus become more critical in the future, particularly as problem areas include situations, such as traffic light–controlled intersections, where the consequences of errors can be fatal. These findings are important and should be explored in future larger scale studies. These would form the basis for advice to eye health practitioners and licensing authorities regarding the types of tests, such as motion sensitivity, that better identify drivers who are unsafe to drive and the types of driving situations that older adults with AMD find most challenging.

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