Published in final edited form as:
Curr Eye Res. 2011 March ; 36(3): 270–277. doi:10.3109/02713683.2010.548893.

Self-Reported Driving Difficulty by Persons with Hemianopia and Quadrantanopia

Walter T. Parker[1], **Gerald McGwin Jr.**[2], **Joanne M. Wood**[3], **Jennifer Elgin**[2], **Michael S. Vaphiades**[2,4], **Lanning B. Kline**[2], and **Cynthia Owsley**[2]

[1]School of Medicine, University of Alabama at Birmingham, Birmingham, Alabama, USA

[2]Department of Ophthalmology, School of Medicine, University of Alabama at Birmingham, Birmingham, Alabama, USA

[3]School of Optometry and Institute of Health and Biomedical Innovation, Queensland University of Technology, Brisbane, Australia

[4]Department of Neurology, School of Medicine, University of Alabama at Birmingham, Birmingham, Alabama, USA

Abstract

Purpose—To compare self-reported driving difficulty by persons with hemianopic or quadrantanopic field loss with that reported by age-matched drivers with normal visual fields; and to examine how their self-reported driving difficulty compares to ratings of driving performance provided by a certified driving rehabilitation specialist (CDRS).

Method—Participants were 17 persons with hemianopic field loss, 7 with quadrantanopic loss, and 24 age-matched controls with normal visual fields, all of whom had current drivers' licenses. Information was collected via questionnaire regarding driving difficulties experienced in 21 typical driving situations grouped into 3 categories (involvement of peripheral vision, low visibility conditions, and independent mobility). On-road driving performance was evaluated by a CDRS using a standard assessment scale.

Results—Drivers with hemianopic and quadrantanopic field loss expressed significantly more difficulty with driving maneuvers involving peripheral vision and independent mobility, compared to those with normal visual fields. Drivers with hemianopia and quadrantanopia who were rated as unsafe to drive based upon an on-road assessment by the CDRS were no more likely to report driving difficulty than those rated as safe.

Conclusion—This study highlights aspects of driving that hemianopic or quadrantanopic persons find particularly problematic, thus suggesting areas that could be focused on driving rehabilitation. Some drivers with hemianopia or quadrantanopia may inappropriately view themselves as good drivers when in fact their driving performance is unsafe as judged by a driving professional.

Keywords

hemianopia; quadrantopia; visual field defect; driving; self-report

---

Correspondence: Walter T. Parker, School of Medicine, University of Alabama at Birmingham, 700 S. 18th Street, Suite 609, Birmingham AL 35294-0009, USA. parkewt@uab.edu.

Declaration of Interest: The authors report no conflict of interest. The authors alone are responsible for the content and writing of the paper.

INTRODUCTION

Homonymous visual field defects occur when field loss is in the same relative position in visual space in each eye; hemianopia refers to loss in one half of the field while quadrantanopia refers to loss in one quadrant.[1] These conditions result from injury to the post-chiasmal visual pathways.[2] A recent survey of a community-dwelling population ≥ 49 years old estimated the prevalence of homonymous hemianopia to be 0.8%, with just over half of those affected reporting a history of stroke.[3] Other less common causes include traumatic brain injury and brain tumor.[2]

Driving difficulty is a mobility challenge facing hemianopic and quadrantanopic patients.[4–6] In fact, many jurisdictions automatically deny licensure to all persons with hemianopia or quadrantanopia.[7] Although some research has suggested that persons with these field defects are significantly worse drivers on average than drivers with normal visual fields,[8–11] other studies have demonstrated that some individuals with hemianopia and quadrantanopia exhibit effective driving performance and that their driving performance is indistinguishable from drivers of the same age who have normal visual fields.[12–14] These findings suggest the merits of individually assessing driving performance in persons with hemianopia or quadrantanopia as conducted by a driving rehabilitation specialist, rather than categorical denial of licensure. Further insight into the driving problems faced by persons with hemianopic and quadrantanopic field loss could be gained through the patient's own perspective, by asking them directly what sorts of situations present difficulty on the road. No previous study on hemianopia or quadrantanopia and driving has taken this approach.

Research conducted in patients with other types of neurological conditions has found that self-reported driving ability does not necessarily correlate with trained evaluator ratings of driving performance.[15–17] Yet, other research on older drivers has suggested the opposite, that those who reported avoiding certain difficult situations (e.g. driving at night, in the rain, or at night in the rain) were more likely to display more on-road performance errors[18] and receive driving assessment scores from driving instructors consistent with their the quality of their on-road performance.[19]

This study addresses two questions: To what extent do persons with hemianopia or quadrantanopia report driving difficulty in a variety of common driving situations, as compared to persons with normal visual fields? And, to what degree do their perceptions of driving difficulty relate to ratings of actual on-road driving performance by a certified driving rehabilitation specialist?

METHODS

The Institutional Review Board for Human Use at the University of Alabama at Birmingham approved the protocol. The nature and purpose of the study was explained to the participants, who were asked to sign a document of informed consent before enrolling. Participants with hemianopic or quadrantanopic field loss were identified through the Neuro-ophthalmology service at the University of Alabama at Birmingham Department of Ophthalmology clinic. To recruit these individuals, potential participants were sent a letter from their neuro-ophthalmologist describing the study, and those interested in the study were scheduled for participation. Participants in the same age range with normal visual fields were contacted from a volunteer research participant registry in the Department's Clinical Research Unit; they were matched within ± 2 years of the age of participants with hemianopic or quadrantanopic field loss.

Participants in the study were required to be ≥ 19 years of age, have a visual acuity of 20/60 or better in at least one eye (the visual requirement for licensure in Alabama), a current

Alabama driver's license, and be active drivers. (Alabama is not one of the jurisdictions that removes licensure from persons with hemianopia or quadrantanopia.) Exclusion criteria were Parkinson's disease, multiple sclerosis, Alzheimer's disease, hemiparesis and other types of paralysis, ophthalmic or neurological conditions characterized by visual field impairment (other than hemianopia or quadrantanopia for the visual field loss group), lateral spatial neglect as defined by the Stars test,[20] and requirement of adaptive equipment in a vehicle to drive.

Participants with field loss were required to have a diagnosis of homonymous hemianopic or quadrantanopic visual field defect, as indicated by the most recent neuro-ophthalmological examination from the medical record. They must have incurred the brain injury causing the visual field loss ≥ 6 months before enrollment in the study. For the age-matched reference group with normal visual fields, an additional inclusion criteria was no history of brain injury (e.g., stroke, trauma, tumor, or arteriovenous malformation).

The following information was obtained via interview-administered questionnaires or instruments. (1) demographics (age, sex, and race/ethnicity); (2) number of co-morbidities estimated by a general health questionnaire used extensively in previous studies;[21] (3) general cognitive status was estimated using the Mini-Mental State Examination (MMSE)[22] (4) driving habits and difficulty using a modified version of the Driving Habits Questionnaire (DHQ), which has been used extensively in previous research on vision and driving.[21,23,24] Driving exposure was estimated by asking about the extent of driving (days/ week, places/week, trips/week, and miles/week driven) in the recent past. Participants were also asked to rate their overall quality of driving on a 5-point scale. The rating scale was defined as follows: 1 = Poor; 2 = Fair; 3 = Average; 4 = Good; 5 = Excellent.

The DHQ asked about the extent to which participants experienced difficulty in 21 common driving situations (Table 1) that comprise three categories: driving situations that relied heavily on peripheral vision; those that involved low visibility; and those that require an attitude or propensity toward independent mobility behind the wheel. Each question began by asking if the participant performed a certain driving activity (e.g. driving at night) since the time of his/her brain injury. If the respondent performed that driving activity, then the participant rated on a scale from 2–5 to what extent they had difficulty with it (2 = extreme difficulty; 3 = moderate difficulty; 4 = a little difficulty; 5 = no difficulty at all). If the participant did not drive in that situation, they were asked if their not doing it was related to visual problems. If the reason was a visual problem, then they received a score of 1 for that item. However, if the reason for not performing the activity was for something other than a visual problem (e.g. does not parallel park because does not go to areas where there is parallel parking), then that particular question was not rated. To generate a driving difficulty score for each participant in each category (peripheral vision, low visibility, independent mobility), the item responses within that category were averaged.

Visual acuity was assessed binocularly using the standard protocol of the Early Treatment for Diabetic Retinopathy Study chart (ETDRS)[26] and expressed as log minimum angle of resolution (logMAR). Visual acuity was measured with the participant using the habitual vision correction they used while driving, if any. Binocular contrast sensitivity was measured with the Pelli-Robson chart using methods described previously.[12,13]

Visual fields were assessed by automated static perimetry, monocularly for each eye and also binocularly (Humphrey Field Analyzer Model 750i; Carl Zeiss Meditec, Dublin, CA). The right and left monocular fields were measured using the central threshold 24-2 test with the SITA standard testing strategy. Binocular fields were assessed using the Binocular Esterman test. The results of these tests were used to confirm the diagnoses of homonymous hemianopia or quadrantanopia, or normal visual fields, on the day of enrollment. For participants with hemianopia, the visual field loss was classified as right versus left hemianopia. Participants with quadrantanopia were classified by quadrant.

On-road driving performance was evaluated by a certified driving rehabilitation specialist (CDRS), who was also an occupational therapist with subspecialty training in vision impairment and rehabilitation. The vehicle used for the assessment (Chevrolet Impala 2007 with automatic transmission) had a dual-brake under the control of the CDRS who sat in the front seat. The same route was used for each participant. The route design was based on previous research on assessment of driving performance by visually impaired drivers[27–30] and covered about 6 miles of non-interstate driving in residential and commercial areas of a city. It was designed to cover a wide range of traffic conditions including simple and complex intersections, a broad range of traffic densities, and a variety of operational maneuvers. Before starting the on-road assessment, the CDRS directed the participant to perform a variety of basic driving maneuvers in a parking lot, without traffic, to confirm that they had acceptable vehicle control and to allow familiarization with the vehicle. Once the CDRS was satisfied with the participant's ability, the evaluation began on the road in low traffic conditions in a residential neighborhood. The course then proceeded to busier roads, and then to city driving in a commercial area. The driving evaluations took place between 9 AM and 3 PM to avoid rush hour traffic and were cancelled if there was rain or if there were wet road conditions.

The CDRS used a 5-point scale to rate overall driving performance according to whether in her clinical judgment the participant had the potential for safe driving. The rating scale was as follows: 1 = driving was so unsafe that the drive was terminated; 2 = exhibited a couple of unsafe maneuvers but did not reach the level of drive termination; 3 = driving was unsatisfactory but not unsafe at that time given traffic conditions; 4 = driver exhibited a few minor driving errors; 5 = there were no obvious driving errors. In this rating system scores of 1 or 2 signify a driver judged to be unsafe by the CDRS, and scores of 3, 4, or 5 signify a driver judged to be safe. A back-seat evaluator who was masked to the medical and functional characteristics of all participants also used the same 5-point scale rating as the CDRS to evaluate the overall driving performance of each participant after the drive was completed. The CDRS' and back-seat evaluator's ratings of safe versus unsafe were in 100% agreement, so only the CDRS ratings were used in analyses.

Statistical Analysis

T-tests and Fisher's exact tests were used to compare the participants with visual field loss and normal groups (as well as safe and unsafe visual field loss drivers), with respect to continuous and categorical variables, respectively. The hemianopic and quadrantanopic participants were combined into a single group for analysis because of the relatively small N. $P \leq 0.05$ (two-sided) was considered statistically significant.

RESULTS

Of the 24 participants with field loss who met eligibility criteria, 17 had homonymous hemianopia and 7 had homonymous quadrantanopia; an additional 24 participants with normal visual fields, age-matched to those with hemianopia or quadrantanopia, were also included in the analysis. Using a standard classification system for hemianopia,[1] 15 of the hemianopic participants had left hemianopia (7 complete, 8 incomplete) and 2 right hemianopia (both incomplete). Seven of 17 persons with hemianopia had macular sparing. Of those with quadrantanopia, 2 had right superior quadrantanopia, 1 right inferior, 2 left superior and 2 left inferior; all had incomplete quadrantanopia except for one participant who had complete. The etiology of hemianopia or quadrantanopia was as follows: 15 had cerebrovascular accident, 3 tumor, 2 arteriovenous malformation, 2 presumed congenital anomalies, 1 aneurysm, and 1 right temporal lobectomy. The time since brain injury causing the hemianopia or quadrantanopia was ≥ 1 year in all participants.

Demographic and general health characteristics are listed in Table 2. The field loss and normal groups were statistically similar in age, race and gender. The visual field loss group had a significantly higher number of chronic medical conditions. Although the distribution of MMSE scores was different between the field loss and normal groups, all participants had scores ≥ 24 (non-demented range). Those with field loss had visual acuity scores slightly worse than the normal field group, but both groups still averaged a visual acuity of 20/20 or better. Contrast sensitivity did not differ between the visual field loss and normal field groups.

Table 3 provides information on the quality of driving and driving exposure as self-reported by participants. Participants with hemianopia or quadrantanopia were more likely to indicate that during the past year someone had suggested they stop or limit their driving (29.2%), as compared to participants with normal visual fields (4.2%). The two groups were not different in how they rated the overall quality of their driving. Compared to those with normal visual fields, participants with hemianopia or quandrantanopia reported decreased driving exposure, indicating that they drove fewer places, made fewer trips, and drove fewer miles per week. There was no group differences in the number of days driven per week.

Drivers with hemianopic or quadrantanopic loss reported significantly greater difficulty for driving situations relying on peripheral vision and involving independent mobility, as compared to those with normal fields (Table 4). The difficulty ratings in the two groups were not significantly different for low visibility situations.

The CDRS rated all 24 drivers with normal visual fields to be safe on the road. For the visual field loss group, the CDRS rated 3 drivers as unsafe and 21 as safe; all 3 drivers rated as unsafe had hemianopia. Within the visual field loss group, self-reported difficulty was compared for those who were judged safe by the CDRS's versus those who were judged unsafe on the road (Table 5). There were no significant associations between the CDRS judgments of safe versus unsafe for the visual field loss drivers and these drivers' self-rated difficulty in the three driving situation categories. Although the self-reported difficulty levels were on average greater for those rated unsafe, there was wide variability within both the safe and unsafe groups.

DISCUSSION

This study identifies two types of driving situations where persons with hemianopia or quadrantanopia report more difficulty than drivers with normal visual fields. These are driving scenarios where peripheral vision is key for the safe execution of the driving task and situations involving independence in driving mobility. Previous work has established the relevance of peripheral vision for driver safety and performance.[31–33] Since extensive peripheral field loss is a hallmark of hemianopia and quadrantanopia, it is not surprising that those driving situations dependent on peripheral vision are those that hemianopic and quadrantanopic drivers report as problem areas. That hemianopic and quadrantanopic patients expressed more difficulty with driving situations that involve an independent attitude toward driving mobility might be a contributing factor to why they also drove significantly less (places/week, total trips/week, and total miles/week) and were more likely to have someone suggest they stop or limit their driving in the past year. In this study hemianopic and quadrantanopic drivers expressed similar levels of difficulty in low visibility situations as did drivers with normal fields; this may stem from poor visibility situations causing driving problems for drivers regardless of whether they have visual field loss or not. Also, contrast sensitivity of drivers in the visual field loss group was highly similar to that of drivers in the normal visual field group.

By identifying the nature of driving problems from the hemianopic or quadrantanopic driver's own perspective, we gain an improved understanding of potential foci for driving rehabilitation strategies. Measurements of on-road driving in those with hemianopic or quadrantanopic field loss indicate difficulties with lane keeping, steering steadiness, and gap judgement,[12–13] which have also been suggested as problematic by driving simulator studies.[8, 10–11] It is interesting that the self-report data from this study converge on these same types of problems, suggesting that some hemianopic and quadrantanopic drivers may be aware of the specific types of challenges they face on the road; hence this implies that they may be more accepting of or motivated to adopt compensatory strategies to maintain effective driving skills.

Although the research literature has repeatedly highlighted the driving problems stemming from peripheral field loss in hemianopic and quadrantanopic drivers, this same literature has emphasized that there is also wide individual variability in the driving skills exhibited by this population.[12–14] Some display good driving skills that are indistinguishable from those with no field loss, while others display obvious vehicle control problems (e.g., steering unsteadiness, lane-keeping problems).[12,13,36] Recent laboratory research on visual search by persons with hemianopia has confirmed individual differences in compensatory gaze behavior when performing visual tasks.[34] Whereas one group of hemianopic subjects exhibited eye and head movements that compensated for field loss when performing a comparative visual search task, another group did not show these compensations. The self-report data from the current study also reflect individual differences, with some reporting driving difficulty in maneuvers relying on peripheral vision, while others did not. This body of work is consistent with the notion that persons with hemianopic and quadrantanopic field loss who wish to drive should be allowed to have an individual driving evaluation by a rehabilitation specialist who can determine their actual on-road skill set, rather than being categorically denied licensure based on the type of functional impairment they have.[12–13, 35]

Those drivers with hemianopia or quadrantanopia who were judged to be unsafe on the road by the CDRS were not more likely to indicate driving difficulties than those who were deemed safe by the CDRS. This might imply that they did not have insight into the driving problems that they were in fact exhibiting. On the other hand, there were only three drivers rated as unsafe, making it difficult to address this question in the current study. Though there is no statistical significance, participants who were rated as unsafe by the CDRS had a lower average on the 5-point difficulty scale in all three categories tested (reliance on peripheral vision, low visibility, and independent mobility), as compared to those rated as safe. If further research with larger sample sizes does verify that self-reports of difficulty by some drivers with hemianopia or quadrantanopia and CDRS ratings are synchronous with each, this may indicate that at least some of these patients may have insight into their own driving problems that could be used to their advantage during the rehabilitation process. Previous research on driving by persons with Parkinson's disease[15,17] and dementia[16] indicate that many of them lack self-awareness of their diminished driving ability which may be due to cognitive impairment associated with these progressive neurological diseases. On the other hand, some drivers with hemianopia and quadrantanopia often have good mental status, and for those that do, this may improve their prognosis in reaping benefits from a driving rehabilitation program since they have the potential for self-recognition and awareness of problems they encounter on the road.

A strength of this study is that it is the first to our knowledge on hemianopic and quadrantanopic drivers to collect information about the types of driving situations where they experience difficulty from their own perspectives. The questionnaire and its item structure used to obtain this information from respondents is a well-studied and established instrument in the vision and driving research area.[21, 23–25] In addition, we were able to compare their self-reports to judgments about the quality of their driving performance by a professional specifically trained in driving assessment and rehabilitation. Limitations of this study must also be acknowledged. The sample size was small, which reduced the statistical power. In addition, we were unable to stratify the field loss group into separate hemianopic and quadrantanopic subgroups because it would have further reduced sample size.

In conclusion, when asked about the extent to which they have driving difficulty, drivers with hemianopia and quadrantanopia on average report more difficulty in driving scenarios that critically rely on peripheral vision and involve independent mobility, as compared to drivers who have intact visual fields. The specific driving situations where they report disproportionate difficulty are in agreement with those driving problems (e.g., lane-keeping, steering steadiness) identified as problematic in previous on-road driving performance research [12, 13, 36] and simulator research. [8, 10, 11] Thus these driving situations are logical focus points during the driving rehabilitation process. Our results also imply that some individuals with hemianopic and quadrantanopic field loss have insight into their on-road driving performance abilities, while others do not.

Acknowledgments

This research was funded by National Institutes of Health grants P30–AG22838 and R21–EY14071, EyeSight Foundation of Alabama, Research to Prevent Blindness Inc., the University of Alabama School of Medicine Dean's office, and a Queensland University of Technology Professional Development Leave grant.

References

1. Kline, LB. Visual fields. In: Kline, LB., editor. Neuro-Ophthalmology Review Manual. Thorofare, NJ: Slack Inc; 2008. p. 1-44.
2. Zhang X, Kedar S, Lynn MJ, Newman NJ, Biousse V. Homonymous hemianopia in stroke. J Neuro-Ophthalmol. 2006; 26:180–183.
3. Gilhotra JS, Mitchell P, Healey PR, Cumming RG, Currie J. Homonymous visual field defects and stroke in an older population. Stroke. 2002; 33:2417–2420. [PubMed: 12364731]
4. Warren M. Pilot study on activities of daily living limitations in adults with hemianopsia. Am J Occup Ther. 2009; 63:626–633. [PubMed: 19785262]
5. Papageorgiou E, Hardiess G, Schaeffel F, Wiethoelter H, Karnath HO, Mallot H, Schoenfisch B, Schiefer U. Assessment of vision-related quality of life in patients with homonymous visual field defects. Graefes Arch Clin Exp Ophthalmol. 2007; 245:1749–1758. [PubMed: 17653566]
6. Chen CS, Lee AW, Clarke G, Hayes A, George S, Vincent R, Thompson A, Centrella L, Johnson K, Daly A, Crotty M. Vision-related quality of life in patients with complete homonymous hemianopia post stroke. Top Stroke Rehabil. 2009; 16:445–453. [PubMed: 20139047]
7. International Council of Ophthalmology. Vision requirements for driving safety: Appendices 1 and 2. Sao Paulo, Brazil: International Council of Ophthalmology; 2006. p. 17-21.Available from www.icoph.org/pdf/visionfordriving.pdf
8. Szlyk JP, Brigell M, Seiple W. Effects of age and hemianopic visual field loss on driving. Optom Vis Sci. 1993; 70:1031–1037. [PubMed: 8115126]
9. Tant MLM, Brouwer WH, Cornelissen FW, Kooijiman AC. Driving and visuospatial performance in people with hemianopia. Neuropsychol Rehabil. 2002; 12:419–437.
10. Bowers AR, Mandel AJ, Goldstein RB, Peli E. Driving with hemianopia, 1: Detection performance in a driving simulator. Invest Ophthalmol Vis Sci. 2009; 50:5137–5147. [PubMed: 19608541]

11. Bowers AR, Mandel AJ, Goldstein RB, Peli E. Driving with hemianopia: 2. Lane position and steering in a driving simulator. Invest Ophthalmol Vis Sci. 2010; 51:6605–6613. [PubMed: 20671269]
12. Wood JM, McGwin G Jr, Elgin J, Vaphiades MS, Braswell RA, DeCarlo DK, Kline LB, Meek GC, Searcey K, Owsley C. On-road driving performance by persons with hemianopia and quadrantanopia. Invest Ophthalmol Vis Sci. 2009; 50:577–585. [PubMed: 18936138]
13. Elgin J, McGwin G, Wood JM, Vaphiades MS, Braswell RA, DeCarlo DK, Kline LB, Owsley C. Evaluation of on-road driving in people with hemianopia and quadrantanopia. Am J Occup Ther. 2010; 64:268–278. [PubMed: 20437914]
14. Racette L, Casson EJ. The impact of visual field loss on driving performance: evidence from on-road driving assessments. Optom Vis Sci. 2005; 82:668–674. [PubMed: 16127331]
15. Cordell R, Lee HC, Granger A, Vieira B, Lee AH. Driving assessment in Parkinson's disease--a novel predictor of performance? Mov Disord. 2008; 23:1217–1222. [PubMed: 18528878]
16. Iverson DJ, Gronseth GS, Reger MA, Classen S, Dubinsky RM, Rizzo M. Quality Standards Subcommittee of the American Academy of Neurology. Practice parameter update: evaluation and management of driving risk in dementia: report of the Quality Standards Subcommittee of the American Academy of Neurology. Neurology. 2010; 74:1316–1324. [PubMed: 20385882]
17. Wood JM, Worringham C, Kerr G, Mallon K, Silburn P. Quantitative assessment of driving performance in Parkinson's Disease. J Neurol Neurosurg Psychiatr. 2005; 76:176–180. [PubMed: 15654027]
18. Baldock MR, Mathias JL, McLean AJ, Berndt A. Self-regulation of driving and its relationship to driving ability among older adults. Accid Anal Prev. 2006; 38:1038–1045. [PubMed: 16725099]
19. Boccara V, Delhomme P, Vidal-Gomel C, Dommès A, Rogalski J. Seniors' perceived driving skill in a postlicense training program: comparison of instructors' assessments and self-assessments by seniors' age and sex. Percept Mot Skills. 2010; 110:117–128. [PubMed: 20391878]
20. Halligan PW, Marshall JC, Wade DT. Visuospatial neglect: underlying factors and test sensitivity. Lancet. 1989; 2:908–911. [PubMed: 2571823]
21. Owsley C, McGwin G Jr, Phillips JM, McNeal SF, Stalvey BT. Impact of an educational program on the safety of high-risk, visually impaired, older drivers. Am J Prev Med. 2004; 26:222–229. [PubMed: 15026102]
22. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state." A practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res. 1975; 12:189–198. [PubMed: 1202204]
23. Owsley C, Stalvey B, Wells J, Sloane ME. Older drivers and cataract: Driving habits and crash risk. J Gerontol. 1999; 54A:M203–M211.
24. Owsley C, McGwin G Jr, Sloane ME, Wells J, Stalvey BT, Gauthreaux S. Impact of cataract surgery on motor vehicle crash involvement by older adults. JAMA. 2002; 299:841–849. [PubMed: 12186601]
25. McGwin G, Mays A, Joiner W, DeCarlo DK, McNeal S, Owsley C. Is glaucoma associated with motor vehicle collision involvement and driving avoidance? Invest Ophthalmol Vis Sci. 2004; 45:3934–3939. [PubMed: 15505039]
26. Ferris FL 3rd, Kassoff A, Bresnick GH, Bailey I. New visual acuity charts for clinical research. Am J Ophthalmol. 1982; 94:91–96. [PubMed: 7091289]
27. Wood JM, Mallon K. Comparison of driving performance of young and old drivers (with and without visual impairment) measured during in-traffic conditions. Optom Vis Sci. 2001; 78:343–349. [PubMed: 11384012]
28. Wood JM, Anstey K, Kerr G, Lord S, Lacherez P. A multi-domain approach for predicting older driver safety under in-traffic road conditions. J Am Geriatr Soc. 2008; 5;6:986–993.
29. Bowers A, Peli E, Elgin J, McGwin G Jr, Owsley C. On-road driving with moderate visual field loss. Optom Vis Sci. 2005; 82:657–667. [PubMed: 16127330]
30. Wadley VG, Okonkwo O, Crowe M, Vance DE, Ball KK, Owsley C. Mild cognitive impairment and everyday function: Investigation of driving performance. J Geriatr Psychiatr Neurol. 2009; 22:87–94.

31. Johnson CA, Keltner JL. Incidence of visual field loss in 20,000 eyes and its relationship to driving performance. Arch Ophthalmol. 1983; 101:371–375. [PubMed: 6830485]
32.]McGwin G, Xie A, Mays A, Joiner W, DeCarlo DK, Hall TA, Owsley C. Visual field defects and the risk of motor vehicle collisions among patients with glaucoma. Invest Ophthalmol Vis Sci. 2005; 46:4437–4441. [PubMed: 16303931]
33. Wood JM, Troutbeck R. Effect of restriction of the binocular visual field on driving performance. Ophthalmic Physiol Optics. 1992; 12:291–298.
34. Hardiess G, Papageorgiou E, Schiefer U, Mallot HA. Functional compensation of visual field deficits in hemianopic patients under the influence of different task demands. Vision Res. 2010; 50:1158–1172. [PubMed: 20381514]
35. Casson EF, Racette L. Vision standards for driving in Canada and the United States. A review for the Canadian Ophthalmological Society. Can J Ophthalmol. 2000; 35:192–203. [PubMed: 10900516]
36. Wood JM, McGwin G Jr, Elgin J, Vaphiades MS, Braswell RA, DeCarlo DK, Kline LB, Owsley C. Hemianopic and quadrantanopic field loss, eye and head movements, and driving. Invest Ophthalmol Vis Sci. in press.

Table 1

Categories for Driving Difficulty Items on the DHQ and Items Included in Each Category

Reliance on Peripheral Vision	**Low Visibility**	**Independent Mobility**
Parallel parking	Driving while raining	Driving alone
Left-hand turns across traffic	Driving at night	Driving in unfamiliar areas
Driving on interstates or expressways	Driving into the sun	Driving long distances (more than 1 hour away)
Driving on high-traffic roads	Driving at dusk	Finding your way to places you want to go
Driving in rush-hour traffic		
Changing lanes while driving		
Merging with other traffic		
Driving in areas with traffic lights		
Passing other vehicles		
Driving through intersections without traffic lights		
Backing up		
Finding and reading street signs		
Seeing objects off to side while driving		

Table 2

Demographic and General Health Characteristics of Participants with Hemianopia and Quadrantanopia and Normal Visual Fields

	Hemianopia or Quadrantanopia *n* = 24	**Normal Fields *n* = 24**	***P*-value**
Age, years, mean (SD)	52.5 (19)	52.3 (18)	0.9342
Sex, n (%)			
Male	15 (62.5)	8 (33.3)	0.0820
Female	9 (37.5)	16 (66.7)	
Race, n (%)			
African American	2 (8.3)	4 (16.7)	
White, non-hispanic	21 (87.5)	20 (83.3)	0.6662
Other [a]	1 (4.2)	0 (0.0)	
Number of chronic medical conditions, mean (SD)	5.4 (3)	2.1 (1)	<0.0001
MMSE, mean (SD)	28.4 (1.5)	29.1 (1.2)	0.0456
Visual acuity, OU, logMAR (SD)	0.004 (0.27)	−0.154 (0.23)	0.0312
Contrast sensitivity, OU, log sensitivity	1.79 (0.13)	1.85 (0.11)	0.1079

NIH-PA Author Manuscript

NIH-PA Author Manuscript

Table 3

Self-reported driving quality and driving exposure by participants

	Hemianopia or Quadrantanopia *n* = 24	Normal Fields *n* = 24	*P*-value
Suggested to limit or stop driving in past year, n(%)	7(29.2)	1(4.2)	0.0479
Self-Rated Driving Quality			
Poor	0 (0)	0 (0)	0.2626
Fair	1 (4.2)	0 (0)	
Average	7 (29.2)	3 (12.5)	
Good	11 (45.8)	12 (50.0)	
Excellent	5 (20.8)	9 (37.5)	
Days per week normally drive, mean (standard deviation, SD)	5.4 (2.1)	6.4 (1.3)	0.0610
Places per week traveled, mean (SD)	4.2 (1.4)	5.4 (1.7)	0.0098
Total trips per week, mean (SD)	8.7 (4.5)	13.5 (5.8)	0.0029
Total miles driven per week, mean (SD)	173 (133)	281 (219)	0.0437

Table 4

Self-Reported Difficulty in Various Categories of Driving Maneuvers

	Hemianopia or Quadrantanopia n = 24	Normal Fields n = 24	*P*-value
Reliance on Peripheral Vision, *M* (SD)	4.42 (0.61)	4.95 (0.16)	<0.0001
Low Visibility, *M* (SD)	4.22 (0.85)	4.69 (0.36)	0.1042
Independent Mobility, *M* (SD)	4.35 (0.80)	4.92 (0.27)	0.0007

Table 5

Self-Reported Driving Difficulty in Various Driving Situation Categories and Their Relationship to the Certified Driving Rehabilitation Specialist's (CDRS) judgment as to whether the hemianopic or quandrantanopic driver was safe or unsafe. [1]

	CDRS's Rating		***P*-value**
	Unsafe n = 3	**Safe n = 21**	
Reliance on Peripheral Vision, *M* (SD)	3.91 (0.97)	4.49 (0.54)	0.4291
Low Visibility, *M* (SD)	3.33 (1.46)	4.35 (0.70)	0.2288
Independent Mobility, *M* (SD)	3.50 (1.30)	4.47 (0.66)	0.2037

[1] All drivers with normal visual fields were judged to be safe by the CDRS.