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Eye Disease and Driving Performance: Correlates between Insight and Capability in Drivers with Glaucoma.

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ABSTRACT

The prevalence of visual impairment is higher in older populations. Due to the highly visual nature of the driving task, the impact of aging on visual function is of particular interest in the context of road safety. Although it has been suggested that older drivers compensate for the decline in their driving abilities, there has been little research which has related the compensatory driving behaviours to actual driving measures of elderly drivers who have visual impairment resulting from eye disease. In addition, current research on the driving performance of people with eye disease is limited. Importantly, it has been reported that people with eye disease often have limited insight into their condition and hence are unlikely to compensate for it. This study aims to address several issues: what impact does eye disease have on driving behaviour, is the impact of eye disease on driving mediated by awareness, and what compensatory behaviours do drivers with eye disease display compared to age-matched controls? Participants were elderly people with glaucoma who were currently driving. Driving related information was collected with questionnaires included the Activities of Daily Vision Scale, Driver Behaviour Questionnaire and a Driving Exposure questionnaire. Visual function tests included visual acuity, contrast sensitivity, visual fields and tests of glare sensitivity. Driving performance was assessed on a closed road circuit. Data collected to date indicates little correlation between self-rated ability and actual performance. Drivers with visual impairment perform worse at driving tasks such as obstacle avoidance and sign detection. It is envisaged that this study will guide policy decisions concerning advice for drivers with eye disease.

RESEARCH PROBLEM

Driving has assumed a central role in daily life in the developed world, particularly for the elderly, as the car represents an independent form of transport that allows better mobility in comparison with public transportation, especially following the onset of physical impairment (Lister, 1999). Indeed, the current generation of older drivers have driven for most of their lives and are extremely reluctant to give up driving due to the lifestyle changes that are required (Bonnel, 1999). However, there are many physical, sensory, and cognitive functions which deteriorate as people age and this may impair the driving ability of the elderly and increase their crash risk. Due to the highly visual nature of the driving task, the impact of aging on visual function is of particular interest, as are the effects of eye diseases. This paper reports preliminary findings from a larger program of research examining the impact of eye disease on driving behaviour in the elderly. The wider study population includes drivers with normal vision, and drivers with the eye diseases cataracts, glaucoma, and age-related macular degeneration. Self-reported driving behaviour is compared with participant's perceptions of their own visual ability and their measured visual function along with their driving performance in closed and open road environments. A diary study is planned as a future component of the research and this will allow a longitudinal study of the driving behaviour of these populations. The purpose of this paper is to examine the relationship between vision and driving capability within a group of drivers with glaucoma and compare their actual performance with their perceived ability.

BACKGROUND

Glaucoma is an eye disease which involves damage to the optic nerve head, visual field loss and increased pressure within the eye (Kanski, 1999). Some forms of glaucoma, such as the angle closure glaucomas, have a rapid onset and are painful (Kanski, 1999), while primary open angle glaucoma and normal tension glaucoma have a gradual onset over an extended period of time with the patient often being completely symptomless (Coleman, 1999). Due to this, this study focuses on these latter, progressive open angle glaucomas.

The prevalence of primary open angle glaucoma (POAG) is higher in older people (Kanski, 1999), with reported prevalence rates of 4.5% in people aged 60-69 years rising to 11.8% in those aged 90 years and above (Wensor, McCarty, Stanislavsky, Livingston, & Taylor, 1998). Glaucomatous visual loss is manifested as sensitivity losses across the peripheral visual field, referred to as scotomas, while central visual acuity usually remains at normal levels until late in the disease. Glaucomatous visual field loss usually progresses more in one eye than the other. Hence visual field loss in one eye can be masked by the more intact visual field in the other, making it difficult for the patient to notice any loss in overall visual function. In a study that compared the prevalence of glaucoma amongst black and white populations in Baltimore, it was found that half of the patients diagnosed with glaucoma during the course of the study were previously unaware of the condition (Tielsch et al., 1991). Glaucoma is also associated with decreased contrast sensitivity and depth perception (Coleman, 1999). Importantly, because glaucoma involves damage to the optic nerve head and retinal ganglion cells, the loss of visual function is permanent and irreversible. Treatment of glaucoma involves management of the condition to prevent further loss rather than trying to restore vision. It may take the form of either surgery or eye drops with the primary goal of reducing intraocular pressure.

The impact of glaucoma on driving has not been as well documented as the effect of some other eye conditions, such as cataracts. Owsley and McGwin (1999) report that there have been several studies where crash risk has been examined in relation to glaucoma, but it was suggested that these have been limited by inadequate consideration of confounding factors or by not specifying the degree to which those involved in the study were impaired by glaucoma. However, the review suggested that these studies usually found some correlation between glaucoma and increased crash risk and that further investigation is warranted as the medication dispensed to glaucoma patients may also have an effect on crash risk (Owsley & McGwin, 1999).

In a driving simulator study, Szlyk, Taglia, Paliga, Edward, and Wilensky (2002) compared the driving performance of patients with mild to moderate glaucoma with that of age-matched control subjects. While there were no significant between-group differences in crash rate (simulator and official crash records), the glaucoma patients tended to have lower driving speeds and more lane crossings. As a group, the patients with glaucoma also had shorter braking response times indicating a cautious driving style, however, those with poor contrast sensitivity had longer braking response times. Szlyk, et al (2002) suggested that this supports the notion that drivers with glaucoma try to display more caution, as those with better contrast sensitivity were able to detect stop signs earlier, whereas those with poor contrast sensitivity were stopping later because of their inability to detect and respond to the sign in time.

Drivers with glaucoma are not subject to any special licensing requirements in Australia (Austroads, 2003). Australian health professionals are required to ensure that visual acuity meets a minimum standard of 6/12 binocularly for an unconditional car or motorcycle licence and that there is no significant field loss that would impair driving (Austroads, 2003). However, there are problems with this approach. For example in many jurisdictions, including Queensland, there is no vision test at licence renewal and any visual problems must be self-reported by the applicant on the license form. This approach assumes that the applicant is aware of visual problems which may not always be the case, particularly with a progressive condition such as glaucoma (Tielsch et al., 1991). In the United Kingdom there is a requirement to inform licensing authorities of glaucoma, but when surveyed, 77% of ophthalmologists said they did not ask glaucomatous patients if they drove unless they considered them unfit to drive (Potamitis et al., 1994). Patients were also not normally informed about their responsibilities to the licensing department until the doctor declared them unfit to drive (81%). This was despite 51% of ophthalmologists being aware of the law to declare glaucoma regardless of visual ability (Potamitis et al., 1994).

The purpose of this component of the research was to examine the impact of glaucoma on driving performance assessed within a closed road setting. Furthermore, we wished to collect data on the impact of glaucoma on the perceived driving skill of glaucomatous drivers and examine their driving exposure and behaviour.

METHODS

Participants:

Participants were drivers over the age of 50 who had been diagnosed with the eye disease glaucoma. Participants were recruited from local ophthalmologists, community groups, or the QUT Optometry clinic. Participants were excluded if they had a co-existing ocular pathology.

Design:

Data was collected relating to the participant’s vision, driving performance, and self-reported vision and driving exposure and behaviour.

Driving performance was assessed at the Mt Cotton Driver Training Centre on a closed road circuit (Wood & Troutbeck, 1994), which was clear of other vehicles and was representative of a rural road environment. A Ford Falcon station wagon with automatic transmission and power steering was used. Two experimenters were seated in the vehicle to give instructions and record results. Each participant drove around a practice circuit in order to familiarise themselves with the car, the road environment and the experimental tasks. This was followed by the recorded circuit. Participants were asked to wear the spectacle correction that they usually wore for driving and were not permitted to wear sunglasses or use any other form of glare protection. The driving assessment involved tasks of recognition, divided attention, perception, speed of completion and manoeuvring.

Road Sign Recognition. There were 42 standard road signs containing a total of 65 items of information located around the course. Participants were required to report any road signs that they saw as they drove around the circuit. A participant's score was given as the total number of correctly identified items of information.

Road Hazard Recognition and Avoidance. Large, low contrast road hazards were placed at nine locations along the circuit. These road hazards consisted of 2.2 m wide sheets of thick grey foam rubber. Colliding with these hazards did not affect the vehicle. Participants were asked to report when they saw a road hazard and to avoid it as they would a hazard on the road such as a pedestrian. Performance was measured as the number of road hazards reported as seen and the number hit.

Gap Perception. Nine pairs of traffic cones set at variable widths were positioned throughout the test course. Six of the cone gaps were wide enough for the vehicle to pass through and three were too narrow. Participants were instructed to indicate when they saw a pair of cones, estimate whether the gap was wide enough to permit them to drive between the cones and, if so, to attempt to do so. If the participant thought that the cone separation was too narrow, they were instructed to indicate this and drive around the cones, treating them as a road hazard. Participants were scored for their accuracy of perceptual judgments by recording the number of correct judgments of gap width, as well as for their ability to negotiate the gaps without hitting the cones. Participants were encouraged to maintain a normal driving speed while conducting this manoeuvre.

Total Driving Time. An experimenter in the rear of the vehicle recorded the total time taken to complete the main 5.1 km test circuit.

Manoeuvring. Following completion of the main test course, participants were required to manoeuvre in and out of a series of nine traffic cones. The cones were placed on a straight section of the main circuit that was on a slight gradient and were separated by approximately 1.5 car lengths and arranged using lateral off sets. To make this task more visually demanding, the contrast of the nine traffic cones was reduced by covering them with a black cloth to match the colour of the road surface. Two additional high contrast cones were placed at each end of the low contrast cones and marked the start and finish positions for the task. The course was performed in both the uphill and the downhill direction. The mean time to complete the course and the mean number of cones hit were recorded.

Visual function was assessed at QUT's School of Optometry using a battery of tests, which were undertaken binocularly (with the exception of static visual fields). The refractive correction used habitually for driving (and worn for all of the driving assessments described here) was used in conjunction with the appropriate distance correction for each test. The vision tests were selected to better represent the driving environment than standard acuity tests and included measures of contrast sensitivity, peripheral vision and glare sensitivity.

Static Acuity. Static high contrast visual acuity was measured using high contrast Bailey Lovie Charts at a working distance of 3.0 m.

Pelli-Robson Letter Contrast Sensitivity. Letter contrast sensitivity was determined using the Pelli-Robson chart (Pelli, 1988) at a working distance of 1.0 m.

Disability Glare. An index of disability glare was measured using the Berkeley Glare Test (Bailey & Bullimore, 1991). The glare score was derived as the difference in visual acuity for the no-glare and glare conditions. This test was conducted at 1.0 m.

Visual Fields. Static visual fields were measured using the Humphrey Field Analyser. The right and left monocular static fields were measured using the SITA-standard strategy for program 30-2. The static visual fields were used as a basis to grade the severity of glaucomatous loss against the Hodapp scale for glaucoma (Hodapp, Parrish, & Anderson, 1993).

Three questionnaires were administered to participants to assess driving exposure and beliefs about driving skill and visual ability.

Exposure Questionnaire. This questionnaire was developed and piloted for the purposes of this research. It was based on items used in previous driving research (Wood & Mallon, 2001). It contains items on participant's beliefs about driving proficiency, situational avoidance, family assistance, how participants became aware of their condition and changes in their driving patterns. It also includes items on medication and co-existing pathologies.

Driver Behaviour Questionnaire (DBQ). This questionnaire measures exposure to inherently risky traffic behaviour such as speeding, failure to yield and driving errors related to lapses in concentration. The first edition of this questionnaire was used as no normative data for older populations was available for the second edition at the commencement of the study (Parker, Manstead, Stradling, & Reason, 1992).

Activities of Daily Vision Scale (ADVS). This test measures subjective difficulty with a variety of tasks involving day vision, night vision, glare, distance vision and near vision. It features well-documented and well-established normal data (Mangione et al., 1992).

RESULTS

To date, 27 glaucomatous participants (18 male, *m* = 70.06 years, *sd* = 7.93, 9 female, *m* = 68.66 years, *sd* = 8.12) with varying degrees of field loss have been tested on the closed road circuit. Of the 27 glaucoma participants only five reported visual problems prior to diagnosis, with the remaining 22 being diagnosed in a routine examination. The visual fields of each participant were graded on the Hodapp scale by an experienced optometrist with results as follows:

- four participants with no glaucomatous field loss;
- three had mild loss in one eye only;
- ten had mild loss in both eyes;
- three had mild loss in one eye and moderate loss in the other;
- one with mild loss in one eye and severe loss in the other;

- two with moderate loss in one eye and severe loss in the other;
- three with severe binocular loss;
- one with mild loss in one eye with the other eye having been enucleated in early childhood.

Importantly the experimenters at the driving track were unaware of the Hodapp rating of each of the participants.

On a five-point scale the participants rated themselves as having relatively good vision (m = 4.19, sd = 0.48) and as being better than average drivers (m = 3.93, sd = 0.61).

Poorer driving performance was associated with by several visual factors. Low contrast hazard collisions were correlated with contrast sensitivity ($r = -0.424$, $p < 0.05$), and the level of right ($r = 0.463$, $p < 0.05$), and left visual field loss ($r = 0.432$, $p < 0.05$), where poorer driving ability was associated with decreased visual performance. Similarly, decreased ability to recognise road signs was associated with lower contrast sensitivity ($r = 0.438$, $p < 0.05$).

None of the visual function measures was significantly correlated with self-rated vision. In other words, self-rated vision did not reflect actual visual performance. Nonetheless, when participants were asked to rate their vision compared to what they considered to be typical for other drivers, participants with worse field loss rated themselves less favourably ($r = -0.462$, $p < 0.05$ right eye, $r = -0.473$, $p < 0.05$ left eye). However, this apparent awareness did not affect comparisons of self-rated driving to the perceived average.

Self-reported driving difficulty in different situations (e.g. roundabouts, heavy traffic) was tested. The only positive correlation to be found between any of these ratings and the various measures of driving performance was hazard collision correlating to self-reported difficulty with night driving ($r = -0.397$, $p < 0.05$). In addition, the ADVS glare scale was also correlated with hazard collision ($r = -0.398$, $p < 0.05$).

DISCUSSION

This paper examined the relationship between vision and driving ability for a group of drivers with glaucoma in order to compare their actual ability with their perceived capability in both the vision and driving domain. The most interesting finding is the apparent lack of a relationship between self-rated ability and actual vision and driving performance. Previous studies (Owsley & McGwin, 1999; Szlyk et al., 2002) have indicated that the visual impairment resulting from glaucoma can result in degraded driving performance. The implication is that not only do drivers with glaucoma have impaired driving performance but these drivers also lack insight into the impact of their disease. This means that they may expose themselves to greater danger on the road.

The drivers in this study rated themselves as having good vision despite the fact that 85% (23/27) had impaired peripheral vision with several having severe field loss and one participant even lacking one eye. As a group, participants also rated themselves as above average drivers despite the fact that driving performance decreased with worse vision. Although this mismatch between perceived and actual ability is typical for many aspects of performance (Kruger & Dunning, 1999) it is particularly worrying in this case where drivers may have degraded driving performance even when the person does not necessarily believe this to be the case. This lack of insight denies the driver the opportunity to adjust their behaviour to compensate for their changing visual performance by limiting their driving exposure or avoiding more hazardous driving environments (e.g. night, heavy traffic).

The apparent decline in driving performance in glaucoma patients, together with their apparent lack of insight of the impact of their condition on driving is of great concern to road safety practitioners. It should be noted that this study is of an exploratory nature, having only a relatively small sample size and insufficient data from age-matched controls to make valid comparisons. Data from a wider range of drivers with glaucoma and an age-matched control population is currently being collected together with data from drivers with other eye diseases, such as cataracts and age-related macular degeneration. This will allow comparison of performance across all of these groups and may also facilitate the identification of which aspects of eye disease mediate self-awareness. Participants will be tested on an open-road circuit used in previous studies (Mallon & Wood, 2004; Wood & Mallon, 2001) which will allow observation of behaviour under real traffic conditions. Data from these studies will be used to inform a model of driving behaviour in people with eye disease which will then be tested with a further study, possibly taking the form of a diary study in order to gain longitudinal data on exposure.

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BIOGRAPHY

Trent Carberry is currently conducting post-graduate studies with the Centre for Health Research at the Queensland University of Technology in Brisbane, Australia. He received a B.Psych from Queensland University of Technology in 2000. His thesis concerns the compensatory driving behaviour of older people with eye disease.

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