Transportation Research Part F 53 (2018) 61–73

Contents lists available at ScienceDirect

Transportation Research Part F

journal homepage: www.elsevier.com/locate/trf

Driving at night with a cataract: Risk homeostasis?

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A R T I C L E   I N F O

Article history:
Received 5 April 2017
Received in revised form 18 September 2017
Accepted 23 December 2017

Keywords:
Cataract
Driving
Glare
Night

A B S T R A C T

Driving with a cataract can be dangerous, especially at night when road lighting and automotive lighting produce glare. Disability glare alters visual performance, while discomfort glare contributes to restricted mobility, with drivers avoiding driving at night. The present study was focused on the visual effects of an early cataract, and aimed at comparing three driving performance indexes at night, under glare conditions, with and without a simulated cataract. Two indexes directly referred to road safety, while a measure could be related to behavioral adaptation.

Using a driving simulator, twenty-six participants were asked to drive in simulated night-time conditions, under controlled photometric conditions where the adaptation luminance and the glare level were consistent with a two-lane rural road at night with oncoming traffic. The visual effects of a bilateral cataract were simulated using goggles which were in the range of an early cataract in terms of light scattering, light transmission, visual acuity and contrast sensitivity loss. Participants were asked to avoid virtual pedestrians on the road, both with and without a simulated cataract. Three performance indexes were considered: the rate of pedestrian crashes, the distance to the pedestrian when the participant avoided the crash, and the mean speed, which allowed to control for a possible behavioral adaptation to the reduced visual performance. For a better understanding of the visual functions responsible for the degraded driving behavior, contrast sensitivity and time-to-collision performance were also measured in glare conditions.

While simulated cataract resulted in slightly slower speeds, poorer driving performance was observed with the goggles than without, with more pedestrians being hit and shorter stopping distances. Time-to-collision estimates at 90 km/h were found to be predictive of stopping distances with a simulated cataract, while contrast sensitivity in glare conditions at 13 cycles per degree was found to be associated with the occurrence of a crash with cataract.

The decrease in speed with a simulated cataract was real but ineffective in terms of driving safety, which suggests that the behavioral adaptation to the degraded visual performance was insufficient. The precise impact of a cataract on driving abilities remains to be further studied, to provide scientific knowledge to help practitioners determine the moment when the individuals should forego driving.

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https://doi.org/10.1016/j.trf.2017.12.009

1. Introduction

1.1. Cataract

According to the World Health Organization, 246 million people suffer from low vision worldwide, while 39 million are blind. Un-operated cataract is among the major causes of visual impairment, and concerns 82 million people (WHO, 2014), while the first cause of blindness (20 million people) is cataract (Mariotti & Pascolini, 2010). In the US, 31% of the population above 65 years old suffer from a cataract pathology (Klein & Klein, 2013).

The visual consequences of a cataract are multiple. The main changes are a decrease in contrast sensitivity and visual acuity, as well as an increased sensitivity to glare (Kline & Li, 2005; Superstein, Boyaner, & Overbury, 1999); these deficits increase under low illumination conditions. Other visual decrements can be mentioned, such as poorer color sensitivity, astigmatism, poorer light transmission and diplopia (Phelps Brown, 1980).

Cataract refers to a crystalline opacification, often age-related (Klein & Klein, 2013), leading to the scattering of the light entering the eye, which is spread over the retina. This accounts for a loss of contrast sensitivity, similar to the light scattering that normal sighted people may experience in dense fog. Light scattering also accounts for glare sensitivity: a stronger scattering through the lenses increases the veiling luminance (Vos, 2003; van den Berg & Ijspeert, 1995).

Cataract surgery is usually postponed until an improvement can be expected in terms of life quality after surgery (Superstein et al., 1999). This is why self-reported complaints are so important in order to understand the actual impact of cataract on one's life. One of the main reported complaint of patients with a cataract in everyday life tasks is related to glare. In a survey of 442 Australian patients waiting for cataract surgery, Keay et al. (2016) observed that half of them reported that their cataract had affected their driving; among them, 60% mentioned night driving specifically. The importance of night driving complaints in such patients may be illustrated by the glare scale that de Wit, Franssen, and Coppens (2006) used in their rating of cataract severity: the highest level of severity is labeled as "*subject likely to stop driving at night*". Glare during night driving is problematic for a large proportion of older drivers, not only for cataract patients: in a population older than 65, Rubin, Roche, Prasada-Rao, and Fried (1994) found that 38% of the driver sub-population reported difficulties driving at night, primarily due to oncoming headlights (36%).

1.2. Risk homeostasis

Shinar and Schieber (1991) suggested that drivers with reduced visual capacities "*may compensate by restricting their driving to time when there are favorable light conditions*", for instance by avoiding driving at night because of their high sensitivity to glare. Such a behavioral adaptation is consistent with the *risk homeostasis* theory proposed by Wilde (1982): people are expected to adapt their behavior in order to keep a subjective level of risk. But there are two ways of compensating the increased risk of driving with a cataract:

- the first one is to drive less, which may impact people's mobility, and quality of life.
- the second one is to drive more cautiously, and to adapt one's behavior to the subjective level of risk. For instance, drivers with a cataract may drive more slowly than other drivers, in order to keep their reaction capacities in front of road hazards. Such a behavioral compensation will be particularly investigated in the present study.

These adaptations have different implications in terms of mobility: restricted driving lowers one's mobility, while driving more slowly does not. Both kinds of behavioral compensation require that the driver is aware of its visual deficit. On-road compensation (by reducing speed) also needs some ability to estimate the risk (e.g. collision risk) associated to the deficit. Otherwise, the risk compensation may be illusory.

1.3. Visual tests and driving performance

According to Owsley, Wood, and McGwin (2015), despite intensive research conducted in the field, the way visual impairments impact driving performance and safety is poorly understood, especially at night. This is yet an important issue. An efficient diagnosis of the consequences of cataract on driving would allow providing adapted recommendations in terms of behavioral adjustments, treatment strategy, visual design of road environments and driving license policy.

Usual visual tests such as visual acuity and visual field appear to be poorly predictive of the deficits experienced by patients in daily life activities, including driving (Ball & Beard, 2011; Higgins & Wood, 2005; Owsley & McGwin, 2010; Phelps Brown, 1980; Superstein et al., 1999). Indeed, visual acuity is measured in nearly optimal conditions, while it strongly depends on the illumination conditions; it may thus underestimate the visual performance in more demanding situations (glare, mesopic vision, etc.). Rubin et al. (1994) showed that contrast sensitivity—but not visual acuity—is associated with difficulties in tasks requiring distance judgments, as well as in night driving and mobility tasks. Moreover, Owsley, Stalvey, Wells, Sloane, and McGwin (2001) showed that contrast sensitivity is associated with crash involvement in cataract patients over 55 years old, whereas visual acuity is not. Drivers involved in a crash are 8 times more likely to have a serious contrast sensitivity deficit, compared with patients not involved in a crash. When driving at night, the rationale for these