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Useful visual field training: A way to improve elderly car drivers' ability to detect vulnerable road users

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ABSTRACT

Our study examined the ability of two groups of elderly car drivers to detect vulnerable road users (pedestrians and two-wheeled motorized vehicles) in a simulated car-driving task. One group was given specific training, aimed at increasing their useful visual field, while driving. The second group's task was to follow another vehicle. Data analysis indicated that the training given led to a significant increase in drivers' useful visual field. In addition, comparison of performances of the two groups permitted us to conclude that training had a beneficial effect on driving, as elderly drivers who received training were better able to detect pedestrians in the road environment. This research could potentially be applied in cognitive intervention programs for older adults in order to preserve their ability to drive and improve the safety of vulnerable road users.

1. Introduction

1.1. Older driver crashes involving a vulnerable road user

Elderly drivers have fewer crashes than any other age group of drivers according to the ratio between percentages of drivers involved in crashes and their proportion within the entire population of licensed drivers in a given year. However, elderly drivers are over-involved in pedestrian related hits (Bromberg, Oron-Gilad, Ronen, Borowsky, & Parmet, 2012). These data raise the question of elderly drivers' perception of pedestrians.

Elderly drivers also appear to experience difficulty in perceiving two-wheeled motorized vehicles. The most typical automobile-motorcycle collision occurs when an automobile manoeuvres into the path of an approaching motorcycle by violating the motorcycle's right of way. Pai extracted three gap-acceptance crash types (i.e., the approach-turn crash, the angle crossing crash and the angle merging crash which occurs at T-intersections) from data on automobile-motorcycle accidents collected in Great Britain (Pai, Hwang, & Saleh, 2009). Elderly motorists (aged over 60) appeared to be overrepresented in the

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three types of gap-acceptance accidents. This result implies that when intending to make a turn, these motorists may experience greater difficulty in intersecting with oncoming motorcycles than when carrying out other traffic tasks.

According to Pai, collisions could be partially attributable to speed/distance judgment errors (Pai, 2011). Previous studies have indeed revealed that older motorists tend to have problems adequately detecting, perceiving, and accurately judging the safety of a gap in conflicting traffic movements (Oxley, Fildes, Corben, & Langford, 2006). In a study carried out using a simulator, Staplin observed that detection failure and decision errors may occur in older individuals who tend to have longer perception and reaction times when performing left-turns at intersections (Staplin, 1995). Finally, according to Hancock, elderly drivers probably overestimate the speed of vehicles travelling at low speeds, and underestimate the speed of those travelling much faster, thereby contributing to collisions involving gap-acceptance problems at intersections (Hancock & Caird, 1993).

The fact that a vulnerable road user is not seen by older drivers may be explained by dysfunction in the sequence in which the driver processes information. When a driver detects a vulnerable road user in his/her peripheral vision, an eye saccade allows him or her to perceive this user with the foveal part of his or her retina for more careful examination and identification. It is, therefore, possible that the ability to detect a vulnerable road user depends on motorists' attentional ability. Evaluation of motorists' useful visual field is one way of measuring this.

1.2. Car drivers' useful visual field

The useful visual field was first defined by Mackworth as the area around the fixation point, in which information is briefly stored and interpreted during a visual task (Mackworth, 1965). In other words, this field corresponds to the part of the peripheral visual field around the fixation point inside which sources of information can be processed at a single glance, i.e. without any movement of the eyes or the head (Ball, Beard, Roenker, Miller, & Griggs, 1988; Sanders, 1970; Scialfa, Kline, & Lyman, 1987; Scialfa, Kline, Lyman, & Kosnik, 1987). It is generally measured by instructing the participant to carry out a dual task, one involving signals in the central part of the visual field and the other involving signals in the peripheral part of the visual field. The useful visual field is assessed on the basis of performance in the peripheral task, in which the participant has to detect the presence of a signal located at different eccentricities in his or her visual field. Due to the attentional workload involved in the central task, the useful visual field is smaller than the peripheral visual field.

The useful visual field has been evaluated during the driving task using a specific protocol (Rogé, Pébayle, Kiehn, & Muzet, 2002). Assessment of this field during driving has led to the conclusion that its size is not constant (Rogé, Otmani, Pébayle, & Muzet, 2008; Rogé & Pébayle, 2009; Rogé, Pébayle, Hannachi, & Muzet, 2003; Rogé et al., 2002, 2004). The useful visual field deteriorates depending on factors specific to the driving task, such as duration of driving, and speed. The field can not only vary during the driving task, its size can also differ according to features specific to the driver, such as his or her state of alertness and age.

1.2.1. The effect of aging on drivers' useful visual field

The ability to detect peripheral signals in a dual task deteriorates with age. However, the extent of deterioration varies between studies. Some researchers have observed a general interference (i.e. older people do not perform as good as younger people, irrespective of the eccentricity of the peripheral signal to be detected) (Seiple, Szlyk, Yang, & Holopigian, 1996; Sekuler, Bennett, & Mamelak, 2000). Other researchers have concluded that the deterioration of the useful visual field with ageing leads to tunnel vision (i.e. older people always have a lower performance than younger people, and the difference in performance becomes more pronounced as the eccentricity of the signal to be detected increases) (Ball, Roenker, & Bruni, 1990; Ball et al., 1988; Scialfa, Kline, & Lyman, 1987; Scialfa, Kline, Lyman, & Kosnik, 1987; Sekuler & Ball, 1986). A similar impact of age on the ability to detect visual signals in tests carried out using a computer has been observed in experiments based on driving tasks. Performance comparisons between two age groups (young drivers and middle-aged drivers) have been used to study the effect of age on the ability to detect visual information in the road scene while driving (Rogé & Pébayle, 2009; Rogé et al., 2003, 2004). Older drivers detected fewer signals (in the road scene or in traffic) than younger ones, and this difference increased when the signal was further from the fixation point, revealing an age-induced tunnel vision phenomenon.

1.2.2. Deterioration of the useful visual field and road safety

Deterioration of the useful visual field with age has important consequences with regard to involvement in accidents. Several researchers have noted that the risk of accident is much higher for elderly motorists when their useful visual field is reduced by 40% or more. To date, experimental procedure has consisted of studying the relationship between useful visual field reduction (measured with the Useful Field of View test (UFoV), an on-screen test which measures attentional abilities outside the driving task) and the number of accidents in real situations, counted over a period of several years, either before the UFoV test was carried out (Ball & Owsley, 1993; Ball, Owsley, Sloane, Roenker, & Bruni, 1993; Owsley, 1994; Owsley et al., 1998; Sims, McGwin, Allman, Ball, & Owsley, 2000) or just after this test (Owsley, 1994; Owsley et al., 1998). Myers used a different method, asking elderly drivers to take a real-life driving test evaluated by two assessors (Myers, Ball, Kalina, Roth, & Goode, 2000). Poor UFoV test performances were correlated to a high number of driving errors (failure to stop at a Stop sign, failure to see important road signs, errors of judgement or incorrect road position). Recently, Henderson and colleagues observed that a score in a subtest of the UFoV test significantly predicted not only driving examiners' scores of older drivers'