
Purpose: To measure the accuracy and reliability of normally-sighted, visually impaired and blind pedestrians at making street-crossing decisions using visual and/or auditory information. Methods: Using a 5 point rating scale, safety ratings for vehicular gaps of different durations were measured along an unsignalized, two-lane street of one-way traffic. Safety ratings were collected from twelve normally sighted, ten visually impaired and ten blind subjects for eight different gap times under three sensory conditions: (i) visual + auditory information; (ii) visual information only; and (iii) auditory information only. Accuracy and reliability in street-crossing decision making were calculated for each subject under each sensory condition. Results: We found that normally-sighted and visually impaired pedestrians were accurate and reliable in their street-crossing decision making ability when using either vision + hearing or vision only (p>0.05). Under the hearing only condition, all subjects were reliable (p>0.05) but inaccurate with their street-crossing decisions (p<0.05). Compared to either the normally-sighted (p=0.018) or visually impaired subjects (p=0.019), blind subjects were the least accurate with their street-crossing decisions under the hearing only condition. Conclusions: Our data suggests that visually impaired pedestrians can make accurate and reliable street-crossing decisions like those of normally sighted pedestrians. When using auditory information only, all subjects significantly over-estimated the vehicular gap time. Our finding that blind pedestrians performed significantly worse than either the normally-sighted or visually impaired subjects under the hearing only condition suggests that they may benefit from training to improve their detection ability and/or interpretation of vehicular gap times.


PURPOSE: To investigate evidence-based visual field size criteria for referral of low-vision (LV) patients for mobility rehabilitation.

METHODS: One hundred and nine participants with LV and 41 age-matched participants with normal sight (NS) were recruited. The LV group was heterogeneous with diverse causes of visual impairment. We measured binocular kinetic visual fields with the Humphrey Field Analyzer and mobility performance on an obstacle-rich, indoor course. Mobility was assessed as percent preferred walking speed (PPWS) and number of obstacle-contact errors. The weighted kappa coefficient of association (κr) was used to discriminate LV participants with both unsafe and inefficient mobility from those with adequate mobility on the basis of their visual field size for the full sample and for subgroups according to type of visual field loss and whether or not the participants had previously received orientation and mobility training.

RESULTS: LV participants with both PPWS <38% and errors >6 on our course were classified as having inadequate (inefficient and unsafe) mobility compared with NS participants. Mobility appeared to be first compromised when the visual field was less than about 1.2 steradians (sr; solid angle of a circular visual field of about 70° diameter). Visual fields <0.23 and 0.63 sr (31 to 52° diameter) discriminated patients with at-risk
mobility for the full sample and across the two subgroups. A visual field of 0.05 sr (15° diameter) discriminated those with critical mobility.

CONCLUSIONS: Our study suggests that: practitioners should be alert to potential mobility difficulties when the visual field is less than about 1.2 sr (70° diameter); assessment for mobility rehabilitation may be warranted when the visual field is constricted to about 0.23 to 0.63 sr (31 to 52° diameter) depending on the nature of their visual field loss and previous history (at risk); and mobility rehabilitation should be conducted before the visual field is constricted to 0.05 sr (15° diameter; critical).


BACKGROUND: Despite sensational news reports, few studies have quantified the rates of poor driving performance among older drivers and the predictors of poor performance. We determined the rate of running red traffic lights among older drivers and the relationship of failure to stop to measures of vision and cognition.

METHODS: Multiple measures of vision and cognition were collected at the baseline examination of a population of 1,425 drivers aged 67-87 years in greater Salisbury, Maryland. Each driver had real-time data collected on 5 days of driving performance at baseline and again at 1 year. Failure to stop at a red traffic light was the primary outcome.

RESULTS: Overall, 3.8% of older drivers failed to stop at red traffic lights, with 15% of those who ran the light having failed 10% or more of the traffic lights they encountered. A narrowing of the attentional visual field (AVF; the extent of peripheral vision in which objects are detected while attention is also centrally fixated) was associated with failure to stop at traffic lights at baseline and predictive 1 year later (incidence rate ratio = 1.09 per degree lost, 95% confidence interval = 1.01-1.16). Persons with smaller vertical AVF were more likely to fail to stop. No demographic or vision variable was related to failure to stop.

CONCLUSIONS: Failure to stop at red lights was a relatively uncommon event in older drivers and associated with reduced ability to pay attention to visual events in the vertical field of vision.


The aims of this study were to determine whether perceived sense of direction was associated with the driving space of older drivers and whether the association was different between genders. Participants (1,425 drivers aged 67-87 years) underwent a battery of visual and cognitive tests and completed various questionnaires. Sense of direction was assessed using the Santa Barbara Sense of Direction (SBSOD) scale. Driving space was assessed by both the driving space component of the Driving Habits Questionnaire and log maximum area driven. Analyses were performed using
generalized linear models. The SBSOD score was lower in women than in men and significantly associated with log driving area in women but not in men. The SBSOD score also showed a significant association with women's self-reported driving restriction. The findings emphasize the need to explore the role of psychological driving factors, and include gender, in driving studies and models.


PURPOSE: To determine the visual and other factors that predict stopping or restricting driving in older drivers.

METHODS: A group of 1425 licensed drivers aged 67 to 87 years, who were residents of greater Salisbury, participated. At 1 year after enrollment, this group was categorized into those who had stopped driving, drove only within their neighborhood, or continued to drive beyond their neighborhood. At baseline, a battery of structured questionnaires, vision, and cognitive tests were administered. Multivariate analysis determined the factors predictive of stopping or restricting driving 12 months later.

RESULTS: Of the 1425 enrolled, 1237 (87%) were followed up at 1 year. Excluding those who were already limiting their driving at baseline (n = 35), 1.5% (18/1202) had stopped and 3.4% (41/1202) had restricted their driving. The women (odds ratio [OR], 4.01; 95% confidence interval [CI], 2.05-8.20) and those who prefer to be driven (OR, 3.91; 95% CI, 1.91-8.00) were more likely to stop or restrict driving. Depressive symptoms increased likelihood of restricting or stopping driving (OR, 1.08; 95% CI, 1.009-1.16 per point Geriatric Depression Scale). Slow visual scanning and psychomotor speed (Trail Making Test, Part A: OR, 1.02; 95% CI, 1.01-1.03), poor visuoconstructional skills (Beery-Buktenica Test of Visual Motor Integration: OR, 1.14; 95% CI, 1.05-1.25), and reduced contrast sensitivity (OR, 1.15; 95% CI, 1.03-1.28) predicted stopping or reducing driving. Visual field loss and visual attention were not associated. The effect of vision on changing driving behavior was partially mediated by cognition, depression, and baseline driving preferences.

CONCLUSIONS: In this cohort, contrast sensitivity and cognitive function were independently associated with incident cessation or restriction of driving space. These data suggest drivers with functional deficits make difficult decisions to restrict or stop driving.


PURPOSE: The attentional visual field (AVF), which describes a person's ability to divide attention and extract visual information from the visual field (VF) within a glance, has been shown to be a good predictor of driving performance. Despite this, very little is known about the shape of the AVF and the factors that affect it. The purposes of this study were to describe the AVF in a large sample of older drivers and identify
demographic, cognitive, and vision factors associated with AVF performance and shape.

METHODS: Registered drivers between 67 and 87 years of age, residing in Greater Salisbury, Maryland, were recruited to participate in the study. Participants underwent a battery of visual and cognitive assessments and completed various questionnaires for demographics, medical history, and history of depression. The AVF was assessed using a divided-attention protocol within the central 20 degrees radius along the four principal meridians. The shape of the AVF was classified as either symmetric or one of two asymmetric shape profiles.

RESULTS: Symmetrically shaped AVFs were found in just 34% of participants. AVF performance was significantly better along the horizontal (15.3 degrees) than the vertical (11.3 degrees) meridian (P < 0.05). After adjusting for AVF area, we found that poorer cognitive and vision performance was associated with a symmetric AVF shape. Overall AVF extent was predicted by vision and cognitive measures as well as various demographic factors.

CONCLUSIONS: Good vision and cognitive ability appear to be associated with having an asymmetric as opposed to a symmetric AVF shape profile.


OBJECTIVES: Concern for driving safety has prompted research into understanding factors related to performance. Brake reaction speed (BRS), the speed with which persons react to a sudden change in driving conditions, is a measure of performance. Our aim is to determine the visual, cognitive, and physical factors predicting BRS in a population sample of 1425 older drivers.

METHODS: The Maryland Department of Motor Vehicles roster of persons aged 67-87 and residing in Salisbury, MD, was used for recruitment of the study population. Procedures included the following: habitual, binocular visual acuity using ETDRS charts, contrast sensitivity using a Pelli-Robson chart, visual fields assessed with a 81-point screening Humphrey field at a single intensity threshold, and a questionnaire to ascertain medical conditions. Cognitive status was assessed using a standard battery of tests for attention, memory, visuo-spatial, and scanning. BRS was assessed using a computer-driven device that measured separately the initial reaction speed (IRS) (from light change to red until removing foot from accelerator) and physical response speed (PRS) (removing foot from accelerator to full brake depression). Five trial times were averaged, and time was converted to speed.

RESULTS: The median brake reaction time varied from 384 to 5688 milliseconds. Age, gender, and cognition predicted total BRS, a non-informative result as there are two distinct parts to the task. Once separated, decrease in IRS was associated with low scores on cognitive factors and missing points on the visual field. A decrease in PRS was associated with having three or more physical complaints related to legs and feet, and poorer vision search. Vision was not related to PRS.
CONCLUSION: We have demonstrated the importance of segregating the speeds for the two tasks involved in brake reaction. Only the IRS depends on vision. Persons in good physical condition may perform poorly on brake reaction tests if their vision or cognition is compromised.


Critical points were computed to determine the minimum field of view (FOV) size required for efficient navigation. Navigation performance in 20 normally sighted subjects was assessed using an immersive virtual environment. Subjects were instructed to walk through a virtual forest to a target tree as quickly as possible without hitting any obstacles (trees, boulders, and holes). The navigation task was performed in three FOV and image contrast conditions under binocular, monocular, chromatic and achromatic viewing conditions. FOV was constricted to 10 degrees, 20 degrees and 40 degrees diameter and average image contrast was nominally high (11%), medium (6%) and low (3%). Navigation performance was scored as latency in walk initiation, walk time to reach goal and the number of obstacle contacts. The results revealed a linear relationship between log FOV and the two time measures, log latency and log walk time. The slopes of the linear regressions for log latency and log walk time ranged between -0.11 and -0.41. Critical points were computed from the non-linear relationships found between the number of obstacle contacts and FOV. The critical points for efficient navigation were FOVs of 32.1 degrees, 18.4 degrees and 10.9 degrees (diam.) for low, medium and high image contrast levels, respectively, highlighting the importance of contrast on the size of the FOV required for efficient navigation. Neither binocularity nor image chromaticity significantly affected navigation performance. The findings of this study have important implications in the design and prescription of head mounted displays intended to augment navigation performance.


PURPOSE: This study explored the gaze patterns of fully sighted and visually impaired subjects during the high-risk activity of crossing the street.
METHODS: Gaze behavior of 12 fully sighted subjects, nine with visual impairment resulting from age-related macular degeneration and 12 with impairment resulting from glaucoma, was monitored using a portable eye tracker as they crossed at two unfamiliar intersections.
RESULTS: All subject groups fixated primarily on vehicles and crossing elements but changed their fixation behavior as they moved from "walking to the curb" to "standing at the curb" and to "crossing the street." A comparison of where subjects fixated in the 4-second time period before crossing showed that the fully sighted who waited for the light to change fixated on the light, whereas the fully sighted who crossed early fixated primarily on vehicles. Visually impaired subjects crossing early or waiting for the light fixate primarily on vehicles.
CONCLUSIONS: Vision status affects fixation allocation while performing the high-risk activity of street crossing. Crossing decision-making strategy corresponds to fixation behavior only for the fully sighted subjects.


BACKGROUND: Crossing the street is an activity that requires gathering information over a large area. The challenge in safely crossing a street is to acquire the necessary information for a decision of when to cross within a limited window of time. The purpose of this study was to compare the head movement behavior of visually impaired pedestrians with fully sighted pedestrians at two types of complex intersections: a plus intersection and a roundabout.

METHOD: We measured the head movement behavior of 12 subjects with normal vision, 11 subjects with age-related macular degeneration (AMD), and 10 subjects with glaucoma as they approached and crossed at the two intersections. The primary measures were the percentage of time the head was directed to the left, center, or right and the frequency of head turns. We compared measures across groups and relative to three criteria of head movement behavior for maximizing street-crossing safety.

RESULTS: Crossing the street can be divided into three phases: walking to the curb, standing at the curb, and crossing the street. We found that while moving, the majority of subjects directed their head to the center. This was true at the plus intersection and roundabout. Group differences were found in the frequency of head turns at the plus intersection, with the AMD pedestrians having a lower frequency of head turns compared with the fully sighted pedestrians. However, the frequency of head turns increased for all the groups during the last 4 seconds before crossing, with the frequency being the greatest during the last second. Numerous subjects had head movements consistent with pedestrian safety, although there were subjects in each group who failed to demonstrate maximum safety. More of the visually impaired pedestrians exhibited less safe head movement behavior than the fully sighted pedestrians.

CONCLUSIONS: The effects of visual impairment on head movement behavior were associated with pedestrian safety at critical moments in the street-crossing process. Mobility training programs aimed at teaching safe head movement behavior for street crossing could help to increase the safety of visually impaired pedestrians.


BACKGROUND: Crossing the street is a complex task that involves gathering, processing, and acting on information that is time dependent. The gaze behavior of subjects has been previously studied on increasingly complex and dynamic tasks such as making tea, walking indoors, and driving. The purpose of this study was to assess how normally sighted people use their vision to cross a street safely. Specifically, we identified the environmental features people look at when crossing two types of intersections.
METHOD: We measured the eye movements and head directions of 12 normally sighted people as they approached, evaluated, and crossed a light-controlled "plus" intersection and a roundabout. The primary measures were percentage of fixations and head direction.

RESULTS: Crossing the street can be divided into three phases, walking to the curb, standing at the curb, and crossing the street. We found that while moving, subjects fixated primarily on crossing elements and when standing at the curb, they fixated primarily on vehicles. At the plus intersection, fixation behavior corresponded with crossing strategy; the subjects who crossed early fixated on cars, and the subjects who waited for the light to change fixated on traffic controls. At the roundabout, all subjects determined an appropriate time to cross from vehicular traffic flow by directing the majority of their fixations on cars. When moving, the head position of subjects was predominately centered. Subjects also made head turns in both directions before crossing and directed the head toward the danger zone while crossing.

CONCLUSION: Crossing the street is a complex task that can be described in three phases. Common head and eye behaviors were found near the critical moments of crossing the street. Fixation behavior was closely related to street crossing behavior.


PURPOSE: To investigate the effects of age-related macular degeneration (ARMD) on mobility performance and to identify the vision determinants of mobility in subjects with ARMD.

METHODS: Walking speed and the number of obstacle contacts made on a 79-m indoor mobility course were measured in 21 subjects with ARMD and 11 age-matched subjects with normal vision. The mobility measures were transformed to percentage preferred walking speed and contacts score. The vision functions assessed included binocular visual acuity, contrast sensitivity, and visual field.

RESULTS: In this study, subjects with ARMD did not walk significantly slower or make significantly more obstacle contacts on the mobility course than the normally sighted subjects of similar age. Between 29% and 35% of the variance in the ARMD mobility performance was accounted for by visual field and contrast sensitivity measures. The most significant predictor of mobility performance scored as percentage preferred walking speed was the size of a binocular central scotoma.

CONCLUSION: As the size of a binocular central scotoma increases, mobility performance decreases.