Literature Review Topic: Differences in Younger and Older Drivers' Visual Scanning Behavior While Driving

Reference	**West, S. K., Hahn, D. V., Baldwin, K. C., Duncan, D. D., Munoz, B. E., Turano, K. A., … Bandeen-Roche, K. (2010). Older drivers and failure to stop at red lights. *Journal of Gerontology*, *65A*(2), 179-183.**
Study Type	Field study: naturalistic instrumented vehicle study
Study Objective	To examine the rate of running red lights in an older cohort of drivers and to determine associated visual and cognitive risk factors
Independent Measures	<u>Demographics</u> • Age (per year increment) • Sex • Race (Blacks/whites) <u>Medical history</u> • History of arthritis • History of stroke • Pain (0 – 5 score; per unit increment) <u>Cognitive</u> • MMSE (per unit increment) • Brief Auditory Test of Attention (per unit increment better) • Trail Making Test Part B (per 10 s worse) <u>Visual function</u> • Visual acuity (per line loss) • Contrast sensitivity (per letter seen) • Visual Field (per point missed) <u>Visual attention</u> • Vertical extent (per degree increased) • Horizontal extent (per degree increased)
Dependent Measures	• Red light running failure rate: the number of failures per number of traffic lights encountered. • A failure was coded as traversing an intersection when the light was already red, or turned red within the first third of the intersection
Sample Characteristics	• 1,425 older licensed drivers in Maryland, recruited from the Salisbury Eye Evaluation Study. Age range 67 to 87, mean age = 75.2, SD=5.2
Methods/Procedures	• Measures of vision and cognition were measured at Round 1, as well as real-time driving video collected in drivers' own vehicles over a 5-day period. At Round 2 (1 year later) only driving video data were collected. • The Attentional Visual Field (AVF) test measured the extent of peripheral vision in which objects were detected while attention was also centrally fixated. The test assessed the AVF extent out to a 20° radius in a divided attention protocol. Participants fixated on a circular target in the center of the monitor and attended to two numbers simultaneously presented for 250 ms, one at the center of the circular target and the other located at fixed degrees out to 20° along one of four possible meridians (horizontal meridians: 0° and 180°, and vertical meridians: 90° and 270°) eccentric to the central number. At the same time the numbers were presented, 7 filled circles were presented at the same eccentricity and with the same size as the eccentric number. Participants had to report correctly the central and outer numbers and the location of the outer number. The widest angle out to 20° for which the participant had correct responses was recorded in the vertical and horizontal meridians. • Each participant's car was outfitted with a Driving Monitor System (DMS) for 5 days. Each DMS unit utilized 5 sensors, which were monitored by a custom-developed computer system, consisting of 2 cameras, a GPS receiver, a magnetic compass, and a two-axis accelerometer. The color camera was oriented to capture images of the road; the monochrome camera was positioned to capture images of the driver. The GPS receiver provided location and velocity data, the magnetic compass provided heading information, and the accelerometers provided lateral and axial accelerations. The GPS record of the participant's travels for the 5 days was compared against a database of traffic light locations. When the participant was within 30 m of a traffic light, the time was noted and the analysis software cued the recorded driver and road video to that time. If the accelerometer or GPS data indicated evidence of stopping, the instance was given an automatic "pass" by the program. Pass was defined as follows: if the speed at the light was less than 5 mph or if deceleration was greater than 10 mph. If a pass was not given, the

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	technician observed the road videos. If the technician observed in the road video a red light at any time the driver was going through the intersection, the encounter was graded as "fail." If a green or yellow light was observed, the encounter was graded as "pass." The camera was positioned in the vehicle such that the traffic light was only visible within the first third of the intersection, so a failure meant traversing the intersection when the light was already red or was turning red almost immediately upon entering the intersection. • Each traffic light encounter, and "pass" or "fail" for that encounter, was counted for each person. A failure rate was calculated as the number of failures per number of traffic lights encountered. Variables found to be associated with failure in Round 1 were used in predictive models of failure to stop at a red light in Round 2. Driving data were captured in Round 2 for 738 of the 1244 participants for whom driving data were captured in Round 1.
Results	• Of those who encountered a traffic light at Round 1, 3.8% failed to stop appropriately. 15% of offenders failed 10% or more of the traffic lights they encountered. • In Round 1, race, the brief auditory test of attention, Trails B, pain score, and AVF (both horizontal and vertical) were associated with running red lights The auditory test of attention was not included in the predictive model for Round 2 because of the strong correlation with the visual test of attention, and because the AVF was more relevant to detecting visual targets than the auditory test. Vertical AVF was included in the model (over Horizontal) based on the size of the association. • For Round 2, only loss of AVF was related to failure to stop at red lights. • The median AVF in those who failed to stop at least once at a red light was close to 7° compared with that in those who had no failures at 12°. Those who failed more than 10% of the traffic lights encountered had a median AVF of 6°. • Study authors state that they previously showed that AVF was associated with both cognition and the visual field. However, they did not find that, by itself, missing points in the visual field was related to stopping failure at red lights, which suggests that the cognitive component of the AVF is the component of interest. Furthermore, the test of auditory attention was also related to red light running, further supporting the role of attention in failure to stop. • Study authors hypothesized that, as older drivers approach an intersection and are paying attention to surrounding cars and traffic flow, the loss of vertical attentional field would hamper detection of the high-hanging traffic signal, which may have changed color. As the driver approaches the intersection, the traffic light moves to an increasingly more peripheral location in the vertical meridian, and if this location is part of the attentional field dropout, the older driver may not detect the change.
Study Strengths and Weaknesses	Weaknesses • Potential for self-selection bias: possible that only older drivers with good vision and good measures of cognition participated in the study. • DMS may have influenced more "good" driving as participants were aware their driving behavior would be observed. However, participants uniformly stated that they forgot about the system while driving. • Red light running may be related to the time allotted in the traffic signals to the amber color. Researchers had no data on the time allotted to the amber color. Strengths • Objective assessment of actual driving performance using road conditions and routes routinely encountered in our older population, without observer present.

Literature Review Topic: Training to Improve Older Drivers' Visual Scanning Ability

Reference	**Ball, K., Edwards, J., Ross, L., and McGwin, G. (2010). Cognitive training decreases motor vehicle collision involvement among older drivers. *Journal of the American Geriatricsl Society., 58*(11), 2107-2113.**
Training Type	Computer-Based Speed of Processing Training
Study Objective	To test the effect of speed of processing raining on subsequent at-fault motor vehicle collision involvement among older drivers
Independent Measures	Study Group: • Speed of Processing Training (SOPT) • Control (no training)
Dependent Measures	State-recorded, at-fault motor-vehicle crash involvement up to 6 years following study enrollment
Sample Characteristics	• The SOPT group: 179 drivers 65 and older (mean age = 72.8 years) • No contact control group: 409 drivers 65 and older (mean age = 73 years) Inclusion/exclusion criteria: > 65 years; no evidence of substantial functional (< 2 ADL disabilities) or cognitive decline (MMSE score > 23), and no self-reported diagnosis of Alzheimer's disease or any other health conditions with potential concomitant functional decline or increased mortality risk. Excluded those with severe losses in vision (acuity worse than 20/50) or hearing (self-report), or communicative difficulties (based on the interviewer's perception that participant could understand and be understood by others). None of the participants reported recently participating in any cognitive training studies.
Methods/Procedures	Trainer conducted SOPT in small groups of two to four participants at the study sites during approximately 70-minute sessions over a period of five to six weeks. Ten training sessions were administered (2 times/week for 5 weeks). SOPT involved practice of visual attention skills and the ability to identify and locate visual information quickly in increasingly demanding visual displays, using UFOV paradigm with the 3 subtests. Participants practiced speeded visual tasks on a computer, and difficulty was increased each time a participant achieved criterion performance on a particular task. For example, participants were asked to identify an object on a computer screen at increasingly brief exposures, followed by dividing attention between two tasks, then performing both tasks in the presence of distractions (with the primary modification being display speed). Involvement in motor vehicle crashes from study enrollment to 6 years following study enrollment was obtained from the Department of Motor Vehicles. Determination of fault was obtained from the crash report. Determinations of fault are made by the police officer completing the report based upon information received regarding the circumstances of the incident and the role of the driver(s).
Results	• the SOPT group experienced a significantly lower rate of at-fault crashes per year of driving exposure compared to the control group (RR= 0.55, 96% CI 0.33-0.92) and per person mile driven (RR = 0.58, 95% CI 0.35-0.97); • the associations were unchanged following adjustments for age at baseline, sex, race, education, study site, visual acuity, health, depression, and mental status. (RR= 0.52, 96% CI 0.31-0.87) and per person mile driven (RR = 0.57, 95% CI 0.34-0.96). • SOPT was associated with a cognitive training gain relative to controls of 1.46 standard deviations at immediate post-test (measured pre- and post-training on UFOV test), suggesting that cognitive improvement is a mediating factor in the crash reduction results.
Study Strengths and Weaknesses	• Strength: showed the improvements in cognitive function translated to improved driving safety (reduced crash involvement). • Weakness: no quantitative health rating scale or index of cumulative illness to compare groups at baseline; no driving exposure measures to compare groups for confounds of exposure in crash reduction

Literature Review Topic: Training to Improve Older Drivers' Visual Scanning Ability

Reference	**Classen, S., Cormack, N.L., Winter, S., Monahan, M., Yarney, A., Lutz, A.L., and Platek, K. (2014). Efficacy of an Occupational Therapy Driving Intervention for Returning Combat Veterans.** ***Occupational Therapy Journal of Research: Occupation, Participation, and Health, 34*(4), 176-182**.
Training Type	OT-Based Training
Study Objective	To determine whether an occupational therapy intervention (OT-DI) which included visual search training, reduced driving errors in a simulator.
Independent Measures	Case Study (no control group, no groupings by age)
Dependent Measures	Number of driving errors and type: • gap acceptance (determining safe time to cross in front of oncoming vehicle), • signaling (appropriate use of turn signals), • adjustment to stimuli (properly responding to road signs, other vehicles, pedestrians, or hazards) • vehicle positioning (space between vehicles), • speed regulation (too fast or too slow), • lane maintenance (lateral positioning of the vehicle), • visual scanning checking mirrors before lane changes and checking cross streets at intersections)
Sample Characteristics	NOTE: Sample did not include older drivers, however, this study is included in this annotated bibliography because returning combat veterans (CV) often have poly trauma that impairs visual, cognitive, perceptual and motor skills. PTSD mainly influences cognitive functions including attention, executive function, and processing speed, which may impair fitness to drive. Age-related diminished cognitive impairment is associated with similar impairments, but it is unknown whether the training would transfer to an older population. Sample included 8 combat veterans 30 to 55 (mean age = 39.8) who served in either Operations Enduring Freedom or Iraqi Freedom, a diagnosis of mild traumatic brain injury or PTSD, or an orthopedic injury, a valid driver's license, MMSE at least 24/30.

Methods/Procedures	• DriveSafety 250 simulator was used to administer baseline and post-training driving assessments. Occupational therapy driver rehabilitation specialists (OT-DRS) scored drivers on 7 driving errors using a standardized scoring sheet. Drives consisted of suburban setting with residential neighborhoods and rural roads (6 min) and city and highway settings lasting 10 minutes. Stimuli with potential to elicit hypervigilance were built into scenarios (trash bags, roadkill, helicopters flying overhead, loud backfire noise).
	• OT-DI consisted of three sessions 60 to 90 minutes each, occurring over a 6- to 8-week period.
	    • Session 1: OT-DRSs discussed baseline driving errors with the CV and explained strategies to diminish these errors.
	    • Session 2: OT-DRSs used a visual search CD that depicted roadways typical of those found in the United States (Visual Search Skills, developed by Miriam Monahan, Driver Research Institute, Richmond, VT). The CVs first identified distractions they were taught to attend to while in combat (i.e., scanning their environment instead of scanning the roadway) and then verbally called out the critical roadway information (e.g., a car pulling out of a driveway, a traffic light turning red as they are approaching) to manage safe driving in civilian life.
	    • Session 3: CVs performed a narrated drive applying and demonstrating the strategies taught previously. The OT-DRSs assessed driving errors and addressed those observed errors via feedback.

Results	• All errors decreased from pre to post-test, but only total errors and lane maintenance errors were significantly reduced (possibly due to small sample size and Type 2 error). Visual scanning mean errors decreased from 0.63 to 0.00 (p=.06)
Study Strengths and Weaknesses	<u>Limitations</u>: Small sample size, unknown whether training would transfer to reduction in errors on the road, no control group. <u>Strength</u>: The fact that lane maintenance errors decreased, even in the presence of triggers that would normally have diverted their attention from the roadway, indicates the OT-DI was effective in helping CVs adapt their driving behaviors (ignore triggers) for improving driving safety in a civilian environment.

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Reference	**Horswill, M. S., Kemala, C. N., Wetton, M., Scialfa, C. T., and Pachana, N. A. (2010). Improving Older Drivers' Hazard Perception Ability. *Psychology and Aging, 25*(2), 464-469.**
Training Type	Individualized Video-Based Training
Study Objective	To determine whether older drivers' hazard perception latencies could be improved by training with expert commentary on a video drive depicting hazardous conditions
Independent Measures	Study Group • Video presentation with expert commentary (Training Group) • Video presentation without expert commentary (Control Group)
Dependent Measures	• Latency to identify potential traffic conflicts on the Hazard Perception Test, presented on a touchscreen computer.
Sample Characteristics	• 24 drivers (14 males, 10 females) 65 to 94 (mean age = 7.83 years) randomly assigned to Training or Control Group. • Average mileage 4,805 miles/year • None had scores in the clinical range for depression, anxiety, or cognitive status • No significant difference between groups on acuity, contrast sensitivity, UFOV, Stroop test, Trails A or Trails B.
Methods/Procedures	Study was conducted in 1 session which took approximately 2 hours (which included cognitive and visual performance testing, as well as anxiety and depression scales, pre- and post HPT administration, and hazard perception training intervention). <u>Hazard Perception Test (HPT)</u>: • Video footage of a driver's eye view of unstaged hazardous traffic situations, presented on a 15-in. touch screen. Participants were instructed to touch any road user (e.g., cars, cyclists, pedestrians) who was likely to become involved in a traffic conflict with the camera car as early as possible. A traffic conflict was defined as a situation in which the camera car was required to brake or steer to avoid a collision. • 2 versions of the HPT were designed by splitting scenes from a validated test (Horswill et al, 2008; Wetton et al., 2009) into 2 sets (1 with 22 conflicts lasting 14 minutes and the other with 19 conflicts lasting 16 minutes). Reliability correlation = .72. • Response time to each traffic conflict was calculated as the time elapsed between the first possible moment the relevant road user was visible and the point at which the participant touched the road user. • Because this test was designed to be a latency rather than a hit rate measure, conflicts were chosen such that nearly all participants would be expected to respond eventually. • One HPT was given pre-training and the other post-training (order counterbalanced across both study groups). <u>Hazard Perception Training Video and Control Video</u> • A 17-min video of real driving, depicting a variety of hazardous situations was presented to participants. • Theo training group also heard an expert driving instructor giving a running commentary on the footage, indicating what he was paying attention to and giving general advice about anticipating hazards. For example: "Scanning ahead. Looking over the crest of the hill. Car turning left. Approaching traffic. More cars coming toward us. Cars on the right. Checking amongst the trees." Before hearing the commentary, those in the trained group were given written instructions, explaining the training and giving additional advice (e.g., "While you are watching the video consider: what can be seen; what cannot be seen; what may reasonably be expected to happen?"). • Those in the Control group viewed the video sequences but without hearing the commentary. They were given instructions beforehand, telling them to pay attention to the video "as if they were the driver of the vehicle depicted" but were not given any advice on hazard perception

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Results	• Latencies of Training group improved significantly between pre- and post-training test (4.93 s versus 4.40 s) • No significant difference in Control group latencies between pre- and post- training test (5.43 s versus 5.51 s) • No significant difference between groups on pre-intervention test (Training group = 4.93 versus Control group = 5.43 s) • Significant difference between groups on post-training test (Training Group = 4.40 s versus Control Group = 5.51 s) • Training group responded to traffic conflicts 513 ms earlier than they had prior to the training (latencies of Control group were unchanged following the intervention). • The time difference as a result of the training would equate to a distance of approximately 8.9 meters (29 ft) on the road if one was travelling at 60 kph (37 mph), which could plausibly be the difference between having and not having a crash.
Study Strengths and Weaknesses	• Whether training would transfer to shorter hazard identification latencies in actual driving was not tested in this study. • Longevity of training effect was not tested.

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Reference	**Horswill, M., Falconer, E., Pachana, N., Wetton, M., and Hill, A. (2015). The longer-term effects of a brief hazard perception training intervention in older drivers. *Psychology and Aging, 30*(1), 62-67.**
Training Type	Individualized Video-Based Training
Study Objective	To determine whether the reduction in response latencies shown on the HPT immediately following a hazard perception training intervention would be sustained at 1 month and 3 months post training, and whether a booster training 1 month post-training would reduce latencies at 3 months compared to no booster training.
Independent Measures	Study Group: • Hazard perception training (25 subjects; mean age 71.05 years; 36.4 % female; mean MMSE = 94.9) • Hazard perception training plus booster training (26 subjects; mean age 72.32 years; 45.5% female mean MMSE = 94.45) • Control – no training (24 subjects; mean age 73.46 years; 37.5% female; mean MMSE = 94.91)
Dependent Measures	• Latency to identify potential traffic conflicts on the Hazard Perception Test, presented on a touchscreen computer. Four unique tests were developed from a pool of 153 video clips, pre-intervention test had 39 clips, and each post-training test (immediate, 1-month, 3-month) had 38 clips. Internal consistency of each test = 0 .73.
Sample Characteristics	75 older drivers (ages 65 to 89) recruited from local newspapers, and randomly assigned to group. • None had ever taken a Hazard Perception Test (HPT) • Drove an average 6,258 miles per year • Scores > 75 on MMSE (all cognitively healthy) • No significant differences between groups on simple RT on touch screen or MMSE, age, miles driven, % female

Methods/Procedures	Study performed in 3 sessions:
	• Session 1 duration: 2 to 2.5 hours: demographics, driving history, simple RT, pre-intervention HPT, hazard perception training or control videos, immediate post-intervention HPT
	• Session 2 duration 1.5 to 2 hours: 1-month post-intervention HPT; booster training for booster training group
	• Session 3: 3-month post-intervention HPT
	Hazard-Perception Training:
	• Began with an instructional video defining traffic conflicts and how they could be anticipated by searching for relevant cues. Instructions for training exercises that would follow, but no mention of HPT or how to achieve a high score on the test.
	• Participants completed 4 trials each of the following 2 types of video-based training exercises.
	    • Participant-generated running commentary while viewing a traffic scene filmed from the driver's perspective. The traffic scene was replayed accompanied by a prerecorded expert driver commentary, for comparison with their own.
	    • Participants viewed a traffic scene that suddenly and without warning cut to a black screen. Participants were asked to describe all of the possibilities for what could happen next. The clip was replayed and frozen at the same moment, followed by a recording of the expert driver listing all possibilities. The clip was played past the cut point so that participants could see what actually happened.
	Control Group Placebo Intervention:
	Participants viewed video clips of a driving instructor discussing aspects of safe driving not directly related to hazard perception. Between these clips, participants viewed the same traffic clips that appeared in the training package, but without expert commentary or instruction.
	
	Hazard Perception Training Booster:
	Participated in the initial hazard perception training and saw 22 min of additional training video at the end of the 1-month follow-up session, which consisted of a shortened instructional video explaining the video exercises.

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	Hazard Perception Test (Outcome Measure): • Video footage of a driver's eye view of unstaged hazardous traffic situations, presented on a 15-in. touch screen. Participants were instructed to touch any road user (e.g., cars, cyclists, pedestrians) who was likely to become involved in a traffic conflict with the camera car as early as possible. A traffic conflict was defined as a situation in which the camera car was required to brake or steer to avoid a collision. • 4 unique versions were created using 105 clips from a previously validated HPT plus 48 new clips (correlation between response times to old and new clips = .77). Pre-intervention test had 39 clips, and all post-training tests had 38 clips.
Results	• Significant immediate effect of training on hazard perception response times: trained participants responded an average of 0.81 s faster than controls. • Effect of training on hazard perception response times remained significant at 1 month post-training: trained participants responded an average of 0.67 s faster than controls. • Effect of training on hazard perception response times remained significant at 3months post-training: trained participants responded an average of 0.45 s faster than controls. • No significant effect of training decay over time. • Booster session at 1 month post training did not improve latencies on 3-month HPT (no significant difference in response latencies at 3 months for training group versus training + booster group).
Study Strengths and Weaknesses	Weaknesses: • Booster training may not have been effective, because there was no significant training decay at the time it was administered. • No evaluation of whether training transferred to real-world driving situations • 3 participants dropped out due to simulator sickness (training in a simulator may not work for everyone). • Small sample (and 11 of the initial 75 had missing data for one or more post-training sessions). Report does not indicate counts of participants lost by group (not even the supplemental appendices). • Pre-intervention effects between Control and training groups had to be removed statistically (at baseline, Control group responded significantly faster than training groups at baseline, even though group assignment was randomized) • Participants may be more highly motivated to engage in training; study authors recommend more exercises in any real-world implementation of intervention. Strength • Showed the hazard perception training effects could be sustained for up to 3 months post training

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Reference	**Lavallière, M., Simoneau, M., Tremblay, M., Laurendeau, D., and Teasdale, N. (2012). Active training and driving-specific feedback improve older drivers; visual search prior to lane changes. *BMC Geriatrics, 12*(5).**
Training Type	Driving Simulator Training
Study Objective	To evaluate if simulator training sessions with video-based feedback can modify visual search behaviors of older drivers while changing lanes in urban driving
Independent Measures	Training Type: • Training with active practice and feedback (Feedback Group) • Training with active practice but no feedback (Control Group)
Dependent Measures	• Frequency of mirror and blind spot checks prior to changing lanes • Temporal inspection of blind spot checks (with respect to initiation of maneuver)
Sample Characteristics	22 older drivers ages 65 to 85: • Feedback group: 6 males and 4 females, mean age 72.1 years) • Control group: 9 males and 3 females, mean age 69.3 No significant difference between groups for years of driving experience, km driven per week, or on visual, cognitive, and physical screening measures.
Methods/Procedures	Driving Simulator: A fixed-based open-cab simulator powered by STISIM Drive 2.0 (System Technology Inc.) was used for training, with images projected on a flat wall (1.45 m high × 2.0 m wide) located 2.2 m from the steering wheel. Projector displayed a 40° horizontal by 30° vertical field of view with the center of the screen located at eye-level through the midline of the subject. Three video cameras were mounted on the cab facing the subject and zoomed to fully capture head and eye movements. A fourth camera captured the scenario displayed on the screen. A magnetic tracker secured on driver's head recorded head movements when driving. To simulate real driving conditions, the left-side mirror and a panel positioned in the left blind spot were instrumented with two white light emitting diodes (LED). The LEDs informed the driver about the traffic condition and the possibility of changing lanes (LEDs on represented traffic in target lane so no lane change should be attempted). The information displayed by the LEDs corresponded with the info displayed in the rear view mirror embedded into the simulator's scenario. This info was provided for training participants to gaze at these regions and to process the information before changing lanes. If a driver changed lanes while the LEDs were on, a crash would occur and be recorded in the simulator file. All subjects completed 5 study sessions as follows: Pre- and post-training on-road evaluation (Sessions 1 and 5). 7.5 mile (30 minute) on-road circuit in an urban area, with pre-determined directions during non-rush hour traffic, with a complete range of driving maneuvers. Each on-road evaluation included ten lane changes (8 towards the right and 2 towards the left). A qualified driving instructor sat in the passenger seat to provide instructions about upcoming maneuvers. No feedback was provided. The vehicle was instrumented with a GPS, 4 digital cameras (1 for driver's head and 3 for the driving environment: forward view and right and left blind spots). Synchronized videos were recorded at 25 hz on a pc with an external battery. The recording from the first drive was used in Session 2 feedback training; recordings from both drives were used for analyses of pre- and post-test training on blind spot and mirror checks prior to lane changing. Simulator Evaluation and Training: All subjects completed a 25-minute simulator evaluation on the same day they completed the on-road pre- and post-training evaluations. Recorded instructions informed participants about specific maneuvers (e.g., lane changes to pass a slower-moving vehicle). No feedback was given following the evaluations. The simulator drive was used to expose participants to the simulator, and to provide material for feedback for the first training session for the feedback group (Session 2). The simulator was used for all subjects in Sessions 2, 3, and 4, but only the feedback group received information about their performance on the road test (simulator training session 2) and on the prior simulator drives (for simulator training sessions 2, 3, and 4). Simulator drives were performed following individual driver refresher training courses in Sessions 2, 3, and 4 (given to all participants), based on AARP's 55-Alive program, lasting 40 minutes. The training focused on traffic regulations, and blind spot checks when changing lanes, and vehicle control. Driving-specific feedback was given to the feedback group, based on their prior simulator drives, by showing them video re-plays of their drives, including

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	simultaneous views of the roadway environment and their head and eye position at the time, and a plan view of the roadway. Feedback emphasized the role of preventive rather than reactive driving to increase mirror and blind spot inspections prior to lane changing. Their errors were pointed out, discussed, and proper reactions demonstrated. The feedback training was based on Risk Awareness and Perception Training Program (RAPT) described in Fisher, Pollatsek, and Pradhan (2006). Feedback participants then drove the scenario sections in the simulator where their errors occurred. Video data from the pre-and post-training on-road drive were used to compare frequency of visual inspections to the rearview mirror, side mirrors, and to the blind spot (head/shoulder checks) for each lane change. This was done for 15 seconds prior to the lane change and 5 seconds post lane change, to determine temporal inspection of blind spot areas. If a visual inspection was made to any of the three areas of interest a 1 was assigned; otherwise a 0, Mean frequency for each driver was calculated based on sum for each area, divided by the number of lane changes.
Results	• On the pre-test drive, both groups inspected their mirrors more frequently than making direct looks to the blind spot, prior to lane changing. On average, pre-training looks to the rearview mirror occurred for 91% of all lane changes and to the sideview mirrors on 85% (with no significant difference between groups). However, blind spot inspections made by direct looks were less frequent in both groups, with the feedback group making significantly more that the control group), even before training (32.3% of lane changes versus 12.5%). • There was no significant effect of training on looks to the rear-view and sideview mirrors (possibly due to a ceiling effect); however, the feedback group significantly increased their direct looks to the blind spot from pre- to post-road test (from 32.3% to 64.9%), whereas the control group did not (12.5% to 13.8%). • Feedback drivers increased the percent of their visual inspections toward the blind spot that occurred prior to the maneuver initiation, from pre- to post-training road test. The control group did not change the frequency or the timing of their looks toward the blind spot, from the first to the second on-road drive. • 2 of the 22 drivers (both controls) experienced simulator sickness (ratings of mild nausea), and therefore did not participate in the simulator training sessions (9% of the study sample)
Study Strengths and Weaknesses	<u>Strengths</u>: • Confirms that refresher training courses consisting of classroom training only do not transfer to improvements in safe driving habits behind the wheel • Simulator training combined with driving-specific feedback improved on-road driving skills, and could be an effective substitute for more costly on-road training. • Since both groups received the refresher training focusing on blind spot checks and active practice, and only the feedback group improved blind spot behavior, suggests that driving specific feedback is a necessary component for older driver training. <u>Weakness:</u> • Small sample size • Potential for simulator sickness may preclude the simulation training component for those prone to simulator sickness (2 of the 12 older control subjects reported feelings of mild nausea during practice and were excluded from further simulator training, although they attended the refresher course).

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Reference	**Roenker, D., Cissell, G., Ball, K., Wadley, V., and Edwards, J. (2003). Speed-of-processing and driver simulator training result in improved driving performance. *Human Factors, 45*(2), 218-233.**
Training Type	Computer-Based Speed of Processing Training
Study Objective	To determine whether speed of processing training (SOPT) for older drivers with deficits in UFOV can improve UFOV as well as driving performance immediately post-training and at 18-months post training
Independent Measures	Study Group: • Speed of Processing Training (SOPT) • Non-interactive simulator and classroom training (traditional driver training program) • Control group (no training)

Dependent Measures	• On-road test performance
	  ◦ Global driving score
	  ◦ Scores on 8 composite measures
	• UFOV Score

Sample Characteristics	• SOPT group: 48 drivers 59 to 86 (mean age = 72.1 years); UFOV reduction 30% or greater. • Non-interactive simulator training group: 22 drivers 63 to 81 (mean age = 72.4 years); UFOV reduction 30% or greater. • Reference control group: 25 drivers 55 to 80 (mean age = 69 years); intact UFOV (reduction < 30%).
Methods/Procedures	• UFOV and driving performance were assessed pre-training, immediately post-training, and 18 months post-training. SOPT: 4.5 hours and 1,040 training trials using UFOV-based protocol, but individually tailored. Training proceeded at individualized levels of complexity until the trainee could identify a single visual target at a display speed of 17 ms, could identify a visual target and simultaneously localize a peripheral target at a display speed of 40 ms with a peripheral target at 30°, and could perform this task when the peripheral target was embedded in distractors at a display speed of 120 ms and peripheral targets at 30°. Repeated practice of tasks of incrementally increasing complexity and decreasing display speed helped trainees to reach these goals. The overall goal of the training technique was to enhance cognitive processing speed by gradually increasing task difficulty while decreasing display speed until trainees achieved mastery through practice. Non-interactive simulator training: Two, 2-hour educational sessions conducted by CDRS in groups of 3-4 participants. Classroom style education consisting of an overview of rules of the road and safe driving practices, and practice with Doron simulator films demonstrating crash avoidance techniques, managing intersections, and scanning. Final hour consisted of in-vehicle demonstration by the driving instructor of safe driving skills. Driving evaluation: two loops of a 7-mile urban/suburban route with maneuvers deemed especially difficult for older drivers (e.g., left turns across traffic). At each potentially dangerous location, evaluators coded the extent the driver's maneuver was "dangerous" (either the driving instructor had to take control of the vehicle, or other traffic had to alter their course to avoid a collision). Two evaluators seated in the back seat rated 455 items, while a driving instructor sat in the passenger seat to provide instructions to the study participant. Raters provided a global rating after each drive ranging from 1 (drive aborted/very unsafe) to 6 (very competent driver). The 455 items were combined into 8 composites: (1) dangerous maneuvers; (2) proper and timely use of turn signals; (3) position in traffic relative to surrounding traffic while moving; (4) vehicle speed control relative to posted speed limits; (5) vehicle position when required to stop at a traffic control device; (6) tracking, or position of vehicle in proper lane; (7) changing lanes on multi-lane roads; and (8) position of vehicle when turning.

Results	• SOPT significantly reduced UFOV reduction, and training effect persisted at 18 month follow-up
	  ◦ At baseline, UFOV performance of controls (23.4) was significantly better than SOPT group (41.4) and simulator groups (37.95).
	  ◦ At immediate post-test, SOPT group's UFOV performance (16.93) equaled control group (22.88), while simulator trained group remained unchanged (33.41).

Literature Review Topic: Training to Improve Older Drivers' Visual Scanning Ability

Reference	**Roenker, D., Cissell, G., Ball, K., Wadley, V., and Edwards, J. (2003). Speed-of-processing and driver simulator training result in improved driving performance. *Human Factors, 45*(2), 218-233.**
	• At 18 months post-training, pattern at immediate post-training persisted: control = 25.10, SOPT = 27.11, similar = 34.23. • Both SOPT and simulator training improved global driving scores at immediate post-training assessment, but the effects were not sustained at 18 months. • SOPT significantly decreased the number of dangerous maneuvers, and this effect persisted at 18 months post training; Simulator training did not reduce number of dangerous maneuvers. • Simulator training improved use of turn signals and turning into the proper lane at immediate post-training assessment, but effects did not persist at 18 months. SOPT did not improve any other composite driving areas other than reduction of dangerous maneuvers.
Study Strengths and Weaknesses	Weaknesses: • 5 composite driving performance measures had to be dropped because of ceiling effects on the road test: smoothness in use of accelerator pedal, gap selection, smoothness in vehicle deceleration, and yielding right of way to traffic at 4-way stops. A fifth composite, search at intersections (head and eye movements) had to be eliminated due to difficulty making these assessments (e.g., drivers wore sun glasses). This may have minimized the ability to show treatment effects. • The reduction in dangerous maneuvers, although statistically significant, may not have much operational significance: the average number of dangerous maneuvers pre-training was 1.01 versus 0.65 at 18 months post-training. Strengths: • Study links speed of processing defects of poorer on-road driving performance, and shows that speed of processing training can improve UFOV as well as improve driving performance (i.e., reduce dangerous driving maneuvers that can lead to crash involvement), and that training effects persist at 18 months post-training. • Study contained control groups, and measured on-road performance.

Literature Review Topic: Training to Improve Older Drivers' Visual Scanning Ability

Reference	**Romoser, M., Fisher, D. L., Mourant, T., Wachtel, J., and Sizov, K. (2005). The use of a driving simulator to assess senior driver performance: increasing situational awareness through post-drive one-on-one advisement.** ***Proceedings of the Third International Driving Symposium on Human Factors in Driver Assessment*****, Training, and Vehicle Design. Pp. 456-463.**
Training Type	Driving Simulator Training
Study Objective	To investigate whether post-drive feedback following a simulated drive was effective in changing older drivers' attitudes about their own driving ability and could influence them to incorporate additional compensatory behaviors into their day-to-day driving.
Independent Measures	Driver age: older versus younger

Dependent Measures	• Pre- and Post-Feedback driving habits questionnaire assessing:
	  • Frequency of looking left and right at intersections (often, occasionally, rarely/never)
	  • Frequency of secondary looks toward oncoming traffic when initiating a turn
	  • Frequency with which they increased speed if they determined there was little time available to make a turn
	  • Frequency of looking left and right when approaching a crosswalk
	  • Frequency of glancing into target lane when changing lanes on an interstate
	• Number of "red flags" (errors) made during the simulator drive, consisting of:
	  • Failed to execute a primary look to the right or left to assess traffic in the intersection,
	  • Failed to execute a secondary look when proceeding into the intersection to assess oncoming traffic in areas where traffic may emerge while in the intersection,
	  • Took too long to turn given the time available,
	  • Failed to fixate and / or react to a critical target moving in the periphery,
	  • Merged an unsafe distance in front of another vehicle or,
	  • Had a collision of any kind or other unanticipated reckless action taken by the participant.

Sample Characteristics	Students, faculty, and staff recruited from the University of Massachusetts, Amherst, MA, all with at least 10 years of driving experience:
	  • 18 older drivers (age 70+)
	  • 18 younger drivers (25 to 55)

Methods/Procedures	• Driving simulator consisted of a full-body sedan surrounded by three projection screens subtending 135° of visual angle. A head-mounted eye tracker was used along with a magnetic head tracker. The information from both was used to determine the participant's point of gaze, which was then overlaid on the video output of the simulator and recorded for later replay. • Ten simulator scenarios represented situations where angle impact crashes were likely to occur if an error was made. Most of the scenarios involved turns at intersections. The scenarios could be grouped into (1) those that evaluated right turns, (2) those that evaluated left turns across traffic, (3) those that evaluated the driver's ability to detect peripheral cues, and (4) lane-change scenarios. • During the drive, the experiment administrator rated the driver's handling as "acceptable" or "unacceptable" (coded as a "red flag"). After the experimental drive, the participants sat down with the experimenter to receive post-drive feedback. The participant's drive was replayed on a large-screen television. All ten scenarios were replayed. After each scenario where a red flag was received, the video was paused and the administrator gave feedback regarding what the participant did wrong, why it could have led to a crash, and suggested compensatory strategies (such as taking secondary looks, or waiting for vehicles to move for a clear line of sight, etc.) to help avoid missing peripheral cues in similar situations to help avoid collisions. • Six months after their session, ten drivers were invited back to the lab to drive again, to determine how well older drivers were able to incorporate the feedback they received into their actual driving strategy (5 drivers with fewest red flags (low RF) and 5 drivers with the most red flags (high RF). Participants drove 10 new scenarios with the eye tracker. Red flags were determined the same as the first session.

Literature Review Topic: Training to Improve Older Drivers' Visual Scanning Ability

Reference	**Romoser, M., Fisher, D. L., Mourant, T., Wachtel, J., and Sizov, K. (2005). The use of a driving simulator to assess senior driver performance: increasing situational awareness through post-drive one-on-one advisement. *Proceedings of the Third International Driving Symposium on Human Factors in Driver Assessment*, Training, and Vehicle Design. Pp. 456-463.**
Results	• Older drivers were more than three times more likely to receive red flags as younger drivers (59 versus 18). • Older drivers received the most red flags (10 total) in the Left Turn with a 3-Second Reveal scenario; Younger drivers received 5 for this scenario. • The scenario with the second most red flags for older drivers was the Interstate Lane Change scenario (8 versus 2) followed by the Impatient Motorcyclist (7 versus 4) and Left Turn with Hidden Oncoming Traffic scenario (7 versus 5). • Reasons older drivers received red flags were: failed to look before or during a turn (32 flags), turned too slowly (10 flags), merged too close to an adjacent vehicle (5 flags), failed to glance into adjacent lane before merging into it (3 flags), and failed to fixate on the risk in the peripheral field of vision (2 flags). • Older adults who received red flags said they would be likely to very likely to change their driving behavior based upon the feedback they received. Both older and younger drivers who received feedback were generally receptive to the idea of incorporating the compensatory behaviors provided during the feedback sessions into their driving habits • Both the low and high RF participants who completed a second driving session experienced a reduction in red flags. Low RF drivers: 12.5% average reduction; high RF drivers 20.8% average reduction.
Study Strengths and Weaknesses	Weaknesses: • Simulator study showed improved scanning; unknown if the training would transfer to actual driving • Small sample size Strengths: • Post-drive feedback in virtual traffic setting was effective in improving older driver's scanning before turning and changing, and in detecting potential hazards in the periphery.

Literature Review Topic: Training to Improve Older Drivers' Visual Scanning Ability

Reference	**Romoser, M., and Fisher, D. L. (2009). The effect of active versus passive training strategies on improving older drivers' scanning in intersections.** ***Human Factors, 51*****(5), 652-668.** **STUDY 1:**
Training Type	Driving Simulator Training
Study Objective	• To determine whether older drivers looked less often for potential threats while turning than younger drivers (particularly secondary looks*). • To determine whether older drivers would be accepting of feedback regarding their looking behavior and would consider implementing the recommendations based on a review of their performance. ***Secondary looks** were defined as those that take place as or just after the driver begins a turn and are aimed in the direction from which other vehicles are most likely to come into conflict with the driver's vehicle. **Primary looks** were defined as the act of glancing from side to side as drivers are stopped at an intersection and are waiting for a break in traffic to execute a turn.
Independent Measures	Driver age group (older vs younger)
Dependent Measures	<u>Vehicle handling and scanning errors</u>: • failed to take a secondary look during a turn • took too long to complete the turn (3 s or longer) • merged too close to another vehicle (i.e., pulled out in front of a simulated vehicle, causing the simulated vehicle to brake or crash into the driver), • failed to glance into the target lane while changing lanes (this criterion applied only to the highway lane change scenario) • failed to fixate a peripheral risk (this criterion applied only to the bicycle-at-the-crosswalk scenario; drivers were flagged if they did not scan to the left or right and fixate the bicyclist approaching the crosswalk), and/or • other (risky maneuver, such as running a stop sign, leaving their lane or the road, or rear-ending the lead vehicle). <u>Likelihood of incorporating skills targeted in feedback (5-point scale, 1=much less often; 5=much more often)</u>: • When stopped, look both ways (primary look) • Take second look after starting turn (secondary look) • Increase speed if little time available to make turn • Scan to far left and right when approaching crosswalk • Turn head and glance into target lane before changing lanes
Sample Characteristics	• 18 older drivers 70 and older (range = 72 to 87; mean age = 77.7; SD = 4.62) • 18 younger drivers 25 to 55 (range = 25 to 55; mean age = 35.0; SD = 9.00), 10+ years of driving experience.
Methods/Procedures	Driving simulator consisted of a full-body sedan surrounded by three projection screens subtending 135° of visual angle. An ASL 5000 head-mounted eye tracker was used along with a magnetic head tracker. The information from both was used to determine the participant's point of gaze, which was then overlaid on the video output of the simulator and recorded for later replay. Participants encountered 10 scenarios representing a wide range of situations in which risky elements can appear from the side, outside of the driver's field of view, and therefore require a head movement (8 of 10 at intersections, and required a secondary look). They followed a lead vehicle to facilitate scenario timing. Following the drive, the participant's actual drive through each scenario was replayed during a review-and-feedback session. If the participant drove safely, this was pointed out at each instance to reinforce the behavior. If errors were recorded, three actions were taken: • Replay of the error portion of the drive, pausing to point out the driver's error and potential consequences (collision with oncoming car, hit bicyclist, near-collision, etc.). • Digital replay of an experimenter's drive through the intersection, showing experimenter making the same error, resulting in a crash.

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