

## There is more to driving than 20/20

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## Objectives

- To understand how “routine” vision tests and their results relate to driving.
- To appreciate how driving affects the lives of your patients and others.
- To appreciate that driving is an important public health issue.
- To appreciate that communication is as important as testing.
- To appreciate environmental and distraction variables that can affect driving.
- To appreciate that legal driving is not always safe driving and that those who are safe drivers may not always be legal.
- To appreciate that this is about risk assessment in a dynamic environment.

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Driving is the primary mode of transportation for most people and a symbol of independence and life style.

Driving limitation impacts:

- access to health care, housing location, and employment opportunity
- psychological well being (increased depression and feeling of isolation)
- family and friends

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## The Premise

“Driving is perhaps one of the most cognitively complex everyday activities, involving the ability to successfully negotiate one’s environment on the road by making quick decisions and attending and reacting to various stimuli.”

But driving is necessary because...

“everyone needs a way to get to where they need to go.”

Vance DE, Fazell PL, Ball DA, et al. Cognitive Functioning and Driving Simulator Performance in Middle-aged and Older Adults With HIV. Journal of the Association of Nurses in AIDS Care, 25, e11-e26  
Schwartz SI, No one at the wheel, Hachette Book Group, Inc 2018

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## Some sobering statistics on MVC

- One person in 50 will have an incident in an average year:
- 1% will die
- 10% will be hospitalized
- 25% will be temporarily disabled

Centers for Disease Control (CDC). Cost of injury: United States: a report to Congress, 1989. MMWR Morb Mortal Wkly Rep. 1989;38(43):743-746  
 Safety Research Office, Ministry of Transportation. Ontario Road Safety Annual Report 1994. Downsview, Ontario: Safety Research Office, Ministry of Transportation; 1994

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## Overall crashes in PA

YEAR	2012	2013	2014	2015	2016
NUMBER OF DRIVERS	8,840,824	8,889,318	8,930,174	8,957,031	8,984,672
CRASHES	124,092	124,077	121,309	127,127	129,395
FATALITIES	1,310	1,208	1,195	1,200	1,188

1.4%	1.40%	1.35%	1.42%	1.44%
1.06%	.9%	.98%	.94%	.92%

From PennDOT Motor Vehicle Advisory Board 2017

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## What should we do or what do we have to do?

To what extent should doctors be involved in a patient's driving privileges?



PennDOT  
 Physicians Guide to Assessing and Counseling Older Drivers, AMA, National Highway Traffic Safety Administration, 2003  
 Clinicians Guide to Assessing and Counseling Older Drivers, 3<sup>rd</sup> edition, NHTSA, 2016

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## What should we do or what do we have to do?

Language from the states on reporting: "self report," "encouraged," "permitted," "should report," "discretionary."  
 PA "mandatory..."but doctors also need to be aware of consequences from no immunity to full immunity.  
 In PA we are not identified.

PennDOT  
 Physicians Guide to Assessing and Counseling Older Drivers, AMA, National Highway Traffic Safety Administration, 2003  
 Clinicians Guide to Assessing and Counseling Older Drivers, 3<sup>rd</sup> edition, NHTSA, 2016

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## Licensure for driving from the patient's and doctor's perspective:

- Visual acuity assessment for licensure.
  - As long as the individual's visual acuity and visual field was good enough to allow them to get a license, they can continue to drive until that license expires (4-12 years), regardless of how poor their acuity or visual field becomes.
- Visual acuity assessment for driving.
  - Individuals whose visual acuity or visual field drops below their state's licensure standards are no longer legal to drive from that time forward, not just after they come up for renewal.

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## Legal vs safe

In PA (or any state), are the visual acuities and visual fields which are necessary for a license the same as the visual requirements necessary for (safe) driving?

Other than legal visual requirements (acuities and visual fields), the rest of what I/ we can do is counsel about legal vs safe.

Important to get across to the patient and others:  
Driving regulation does not define the person but the law!

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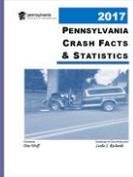
## Why are visual standards such a difficult problem

- “Human factors were cited by the in-depth team as probable causes in 92.6% of accidents investigated...”
- “Major human direct causes were... excessive speed, inattention,... and internal distraction.”

Treat JR, Tumbas NS, McDonald, et al, Tri-level study of the causes of traffic accidents: final report. Executive summary, Oct 1979

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## Crashes involving driver error



Contributing Factor	Crashes	Fatal Crashes
Speed-Related	31,051	441
Drinking Driver	9,143	160
Proceeded Without Clearance	8,967	64
Improper Turning-Related	14,004	60
Distracted Driver	15,614	58
Careless/Illegal Passing	4,793	54
Tailgating	6,800	19
Drowsy Drivers	2,591	10

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## Legal vs safe

- Low vision referral
- Chief complaint: wants to drive
- Seen 6 months prior for eye care, no Rx recommended, uses OTC readers
- Med hx: "optic nerve swollen" followed by neuro ophthalmologist, cataracts, diabetic (no ophthalmic issues), drug related encephalopathy, multiple medications
- Uncorrected VAs : 20/200 OU
- CSF testing: moderate loss
- Refraction: -2.00 with cyl: OD/OS 20/40, near +4.00 5 point continuous text at 10 "
- Slit lamp: angles almost closed so referred to glaucoma doctor who did PI
- OCT and Esterman

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## Some driving questions for patient and others

"Patients often overestimate their driving skills, believe that statistical data do not apply to them, and fail to take protective actions to reduce trauma from road crashes."

Redelmeier DA, Yarnell CJ, Thiruchelvam D, Tibshirani RJ. Physicians' Warnings for Unfit Drivers and the Risk of Trauma from Road Crashes. NEJM. Volume 367(13):1228-1236, 9/27/2012

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## Some driving questions for patient and others

### Patient's perspective

Are you comfortable driving?  
Do you restrict your driving?  
Any close calls/accidents/citations?  
Do you ever get lost when driving?  
Do cars or signs sometimes suddenly appear?

### Others' perspective

Drives too slowly  
Doesn't keep steady speed  
Follows too closely  
Drifts out of lane  
Makes turns from wrong lane  
Doesn't pay attention to signs  
Stops for no apparent reason  
Confuses gas/break pedal  
Would you let your xxx ride in the car?

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## The quandary...

- "Physicians' warnings to patients who are potentially unfit to drive may contribute to a decrease in subsequent trauma from road crashes, yet..."
- "...formal warnings may reduce the patient's quality of life, jeopardize doctor-patient relationships, burden family members, and generate bureaucratic hassles."

Redelmeier DA, Yarnell CJ, Thiruchelvam D, Tibshirani RJ. Physicians' Warnings for Unfit Drivers and the Risk of Trauma from Road Crashes. NEJM. Volume 367(13):1228-1236, 9/27/2012

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## What visual skills are needed for driving?

- Central eye sight
- Peripheral sight
- Contrast sensitivity
- Glare recovery
- Fixation, scanning, and eye coordination
- Eye head coordination
- Single simultaneous binocular vision
- Color vision
- Depth perception/stereo vision
- Figure ground
- Visual memory
- Eye hand coordination and reaction time
- Eye foot coordination and reaction time
- Useful field of view

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## Visual acuity

- Black stationary target on a very white background. No time limit to respond.
- Says nothing about cognition
- States' VA requirements vary



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## What the numbers mean for limited vs no driving

20/100 = the threshold to identify a stationary 1¾ inch target with maximum contrast under mesopic illumination at 20 feet without timing.

20/200 = the threshold to identify a stationary 3½ inch target with maximum contrast under mesopic illumination at 20 feet without timing.

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## Impact of central vision on driving

Acuity tests do not reflect the visual complexity of driving (there is a weak correlation)...however,

in a recent study between "normal" eyes and various levels of AMD, it was found that older drivers with intermediate AMD had a reduced risk of accidents than others including "normal."

*Compensate, avoid, caution, and self-regulate*

McGwin G, Mitchell B, Searcey K, et al, Examining the association between age-related macular degeneration and motor vehicle collision involvement: a retrospective cohort study, Br Journal Ophth, 2013 Sep;97(9):1173-6

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## Central vision reference for driving: Egocentric vs allocentric

Egocentric driving: the driver is the center of the organization of surrounding space. Decreases the need for a cognitive map for successful wayfinding.

Allocentric driving: external objects (environment) are important for the organization of surrounding space. Increases the need for a cognitive map for successful wayfinding.

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## Caveat...

Central field loss, which reduces visual acuity and possibly contrast sensitivity, can cause a decrease in response time for road hazard detection, most importantly pedestrians.

Approximately 65% of scotomas are lateral to the PRL, so scanning is critical to locate environmental obstacles.

Still want best corrected visual acuity!

Important phrase: response time

Bronstad PM, Bowers AR, Abu A, et al. Driving with a central field loss, JAMA ophthalmology 2013; 131 (3): 303-309

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## Bioptic Driving

Designed to enhance central vision for identification.  
Therefore typically used 5-10% of the time!



Correction through the use of telescopic lenses is not acceptable for purposes of meeting acuity requirements.

PennDOT has started to look into this type of driving for VI individuals

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## Visual fields Goldmann/Automated



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## Visual fields

Sixteen states have no required visual field testing unless the individual has been referred to an eye care practitioner after failing a visual acuity test or because the visual acuity test was passed using special telescopic lenses.

For the 34 states with a binocular horizontal visual field requirement, 15 stipulate 140°; for the other 19 states, the range is from 105° to 130°; Maine requires 150°.

In PA it is 120° binocularly.

Peripheral vision is important for awareness of environmental obstacles such as pedestrians, vehicles, signs, etc.

Steinkuller PG. Legal Vision Requirements for Drivers in the United States. *Virtual Mentor* 2010;12:938–40. <http://journalofethics.ama-assn.org/2010/12/hiaw1-1012.html>. Accessed Feb. 1, 2019

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## Visual field and eye glass temples

The State of California (Vehicle code 23120):  
 “No person shall operate a motor vehicle while wearing glasses having a temple width of one-half inch or more if any part of such temple extends below the horizontal center of the lens so as to interfere with lateral vision.”

Van Arnam R, Vitale MC. The regulation of sunglasses and reading glasses, The Vision Council [codes.findlaw.com/ca/vehicle-code/veh-sect-23120.html](http://codes.findlaw.com/ca/vehicle-code/veh-sect-23120.html)

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## Impact of peripheral loss and wayfinding

“Loss of peripheral vision may impede the ability to perform effective visual searches in the environment and attend to navigationally relevant objects.

... visual information acquired from successive fixations may not be coherent enough to allow an accurate representation of the location of objects in space relative to each other and the global environment structure.”

Therefore allocentric driving is more affected than egocentric driving.

Daga FB, Macagno E, Stevenson C, et al. Wayfinding and glaucoma: a virtual reality experiment. *Invest Ophthalmol Vis Sci*. 2017;58:3343–3349

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## “Survival vision vs cultural vision”

Crash rates were twice as high among those with binocular field loss than without.

A question that arises is the impact of sudden field restriction (stroke) vs. change over time (POAG).

Johnson CA, Keltner JL. Incidence of visual field loss in 20,000 eyes and its relationship to driving performance. *Arch Ophthalmol*. 1983; 101, 371-5

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## Hemianopia

- “The number of disabled stroke survivors in the U.S. is estimated to be more than 3 million annually.
- As many as one third of stroke survivors in rehabilitation have either homonymous hemianopia or hemi neglect.”

Peli E, Field Expansion for Homonymous Hemianopia by Optically Induced Peripheral Exotropia, *Optometry and Vision Science*, Vol. 77, No. 9, September 2000

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## Impact of a hemianopic visual field loss on driving

- A driver could have difficulty reacting to bikes, other vehicles, pedestrians, steering in a straight line, and incorrect lane positioning. <sup>1</sup>
- Add post TBI to visual field loss: increased difficulty maintaining a constant position in a lane. <sup>2</sup>

1. Bowers AR, Mandel AJ, Goldstein RB, Peli E, Driving with hemianopia: performance in a driving simulator, *Investigative Ophthalm and V Science*, 11/09

2. <http://www.msktc.org/tbi/factsheets/Driving-After-Traumatic-Brain-Injury>

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## Superior/inferior visual field loss from glaucoma and safe driving



Depends on which study you read

Kunimatsu-Sanuki, Iwase A, Araie M, The role of specific visual subfields in collisions with cars during simulated driving in patients with advanced glaucoma, doi:10.1136/bjophthalmol-2016-308754

Glen FC, Smith ND, Crabb DP. Impact of superior and inferior visual field loss on hazard detection in a computer-based driving test. *Bjophthalmol* 015;99:613–17.

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## Visual field loss

InWave Lens™



InWave Lens™



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## People at risk for what we are responsible to measure

"Little data exist suggesting a correlation between an accident and various levels of visual impairment."<sup>1</sup>

"Impaired near and distance visual acuity were not associated with any type of crash or near-crash event."

"Peripheral vision impairment in both eyes (unable to see a target at 70° or 85°) had rates of crash..., and at-fault crashes that were greater than those without this field loss."<sup>2</sup>

1. Keeny AH. The visually impaired driver and physician responsibility. *American Journal of Ophthalmology*. 1982;82(5):799-801
2. Huisingsh C, Levitan EB, Irvin MR, et al. Visual sensory and visual-cognitive function and rate of crash and near crash involvement among older drivers using naturalistic driving data. *Invest Ophthalm Vis Sci*. 2017;58:2959-2967

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## Saccades and pursuits

There is no age-related loss of ability to maintain accurate fixation when viewing a small, stationary stimulus. However...

there are age related inaccuracies for more eccentric locations. Fixation accuracy for pursuit eye movements for older observers breaks down when target velocity > 10 degrees/second. This is exacerbated when competing/distracting stimuli are present. Saccades have reduced peak velocity and increased onset latencies with age and with time on driving task.

Sharpe, JA, Sylvester, TO. Effects of age on horizontal smooth pursuit. *Investigative Ophthalmology and Visual Science*. 1978; 17, 465-468

Moralesa JM, Diaz-Piedraa C, Rieiroa H, et al. Monitoring driver fatigue using a single-channel electroencephalographic device: A validation study by gaze-based, driving performance, and subjective data. *Accident Analysis and Prevention*. 2017; 109, 62-69 63

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## Fixation, pursuits, and saccades

- Operator fixates on a target (stationary vs dynamic)
- Influences to modify fixation might be:
- Object or activity in peripheral visual field which can create random pursuits or saccades
- Goal: learn anticipatory rather than reflex eye movements by systematic scanning
- Can be impacted medically...

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## Some additional risk factors which can affect safe driving

- Age
- Traumatic brain injury (TBI)
- Distraction
- Environment

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## The aging process

“Aging has clear effects on fluid cognitive abilities, from processing speed and executive function to working memory and episodic retrieval, most of which decline systematically throughout the life span.”

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## The aging process

“the abilities to manipulate (i.e., processing speed) and retain (i.e., memory) acquired information exhibit steady decline over the life span, with a marked decline after about 60–70 years of age.”

By 2030, almost 20% of the US population will be 65+, and will constitute 1 out of 4 drivers by the mid 21<sup>st</sup> century.

Henninger DE, Madden DJ, Huettel SA. Processing Speed and Memory Mediate Age-Related Differences in Decision Making. Psychology and Aging.2010

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## Analysis of MD accidents in PA

### Mature Drivers

YEAR	2012	2013	2014	2015	2016
NUMBER OF DRIVERS 65+	1,735,337	1,816,186	1,865,494	1,901,546	1,934,397
CRASHES INVOLVING A 65+ DRIVER	18,219	18,727	18,805	19,948	21,125
FATALITIES IN CRASHES INVOLVING a 65+ DRIVER	276	277	300	279	267

1.05%	1.03%	1.01%	1.05%	1.09%
1.51%	1.48%	1.60%	1.40%	1.23%

From PennDOT Motor Vehicle Advisory Board 2017

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## OLDER DRIVERS are overly represented in certain types of accidents

- Yielding the right of way
- Improper turning (especially when crossing traffic)
- Failure to obey traffic directions
- Older drivers have accidents mostly at intersections.

McGwin G, Brown DB. Characteristics of traffic crashes among young, middle-aged, and older drivers. Accid Anal Prev 1999;31:181-98  
Preusser DF, Williams AF, Ferguson SA, et al. Fatal crash risk for older drivers at intersections. Accid Anal Prev 1998;30:151-9

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## Result of senior highway accidents

Older individuals are more likely to be disabled or die in an accident.

50% of all fatal accidents for drivers >80 years old are intersection collisions.

Drivers older than 65 are almost twice as likely to die in car crashes as those ages 55-64.

American Automobile Association

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## Aging visual pathologies that can impact driving

Macular degeneration

Diabetic retinopathy

Cataracts

Glaucoma

“Data suggest a possible association of advanced AMD and visual acuity with cognitive impairment in older persons.”

Age-related eye disease study research group, Cognitive impairment in the age-related eye disease study, AREDS Report No. 16, Arch Ophthalmology/Vol 124, April 2006

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## Diabetes

- “There is a link between type 2 diabetes and mental decline...”
- After 5 years, participants with diabetes at the start of the study experienced nearly three times the decline in functions like memory and the ability to think quickly compared with those without diabetes. (The decline was greater in people over age 60.)”

Diabetes Care, online 6/2/2010

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## Cataracts and contrast sensitivity

- Cataract causes decreased central visual acuity. Cataract, and the contrast sensitivity impairment it causes, elevates crash risk in older drivers.
- Those with cataracts experience reduction in driving and an increase in accidents as compared to those without cataracts (due to contrast sensitivity impairment).
- Those who underwent cataract surgery and IOL implant had half the crash rate of those who did not in the follow up period (4-6 years).

Owsley C, McGwin G, Sloane M, et al, Impact of cataract surgery on motor vehicle crash involvement by older adults. JAMA, 2002

Schlenker MB, Thiruchelvam D, Redelmeir DA, Association of Cataract Surgery with Traffic Crashes, JAMA Ophth, 2018

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## The other visual acuity

- Set of 3 near charts  
Each letter fades by 0.04 log units
- Norms for different levels of loss
- Profound (<0.48)
  - Severe (0.52-1.00)
  - Moderate (1.04-1.48)
  - Normal > age 60 (1.52-1.76)
  - Normal < age 60 (1.72-1.92)



1. Contrast sensitivity is more visually representative of the real world than standard visual acuity measurement.
2. However, contrast sensitivity testing may not be comparable to real life due to masking of the target by background elements.
3. Therefore, contrast sensitivity issues are based on the environment and a person's ability.

PennDOT did a pilot program with CSF testing

<http://www.precision-vision.com/index.cfm/product/303/mars-letter.cfm-contrast-sensitivity-test.cfm>

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## But...

“Crash rate 1 month post cataract surgery was one of the highest in the subsequent period...”

Why?

Overconfidence

Ongoing adaptation like depth awareness

Uncorrected refractive error

Anisometropia

Schlenker MB, Thiruchelvam D, Redelmeir DA. Association of Cataract Surgery with Traffic Crashes. JAMA Ophthalm. 2018

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## Glaucoma

Those with glaucoma report more difficulty with driving than those free of the disease.

Glaucoma impacts contrast sensitivity.

Motorists with glaucoma were 3.6 times more likely to be involved in crashes than those with normal vision.

Owsley C, McGwin G, Ball K. Vision impairment, eye disease, and injurious motor vehicle crashes in the elderly. Ophthalmic Epidemiol. June 1998; 5(2):101-13

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## Cataracts and glare

“The Impact of Cataracts on Mobility project demonstrated drivers with cataracts are 2.5 times more likely to be involved in motor vehicle accidents than age-matched drivers without cataracts.”

“one of the most common complaints from patients with cataracts is that glare impairs their night driving.”

Owsley C, McGwin G Jr, Sloane M, Wells J, et al. Impact of cataract surgery on motor vehicle crash involvement by older adults. JAMA. 2002;288:841-849

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## Brightness acuity tester



Glare test

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## Traumatic brain injury (TBI)

1.5 million people experience TBI yearly, of which 75% are felt to be mild.<sup>1</sup>  
 5.3 million Americans live with a long-term disability as a result of TBI.  
 Males are more likely than females to sustain a TBI at any age.  
 Children aged 0 to 4 years, older adolescents aged 15 to 19 years, and adults aged 65 years and older are most likely to sustain a TBI.  
 Falls are the leading cause of TBI. Rates are highest for children aged 0 to 4 years and for adults aged 75 years and older.<sup>2</sup>

1. Suter PS, Harvey LH, Vision Rehabilitation, CRC Press  
 2. Faul M, Xu L, Wald MM, Coronado VG. Traumatic Brain Injury in the United States: Emergency Department Visits, Hospitalizations and Deaths 2002–2006. Atlanta (GA): Centers for Disease Control and Prevention, National Center for Injury Prevention and Control; 2010.

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## Visual sequelae from TBI that can affect driving

- Visual field loss
- Unidentified traumatic myopia/hyperopia
- Uncorrectable decreased central vision
- Convergence/accommodative dysfunction
- Eye movement dysfunction
- Diplopia
- Photophobia

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## Describe driving as a sport

Driving is a non contact sport with the goal to go from one place to another without contact or incurring penalties (i.e., fines, injuries, or damage).

“Driving requires rapid response and the ability to carry out several activities at once, such as monitoring for hazards while steering and controlling the speed of the vehicle.”

Lana TM, Toxopeus R, Wilson D. The effects of visibility conditions, traffic density, and navigational challenge on speed compensation and driving performance in older adults, Accident Analysis and Prevention, 42, 2010

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## Rules of the sport

- No upper age limit
- No rule about prior injuries
- No coaching criteria
- No sexual/cultural discrimination
- Tryouts to get into the sport are inconsistent and no consistency to maintain play
- Officials: police, judges
- Penalties: warnings, ejections, jail, death
- Sometimes sent to farm team

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## Driving risk assessment

### TBI

Between 30 and 60% of people with severe brain injury return to driving after they are injured.

People with brain injury may place limitations on their driving habits; they may drive less frequently than they did before the injury or drive only at certain times (such as during daylight), on familiar routes, or when traffic is light.

However, a failure to recognize even mild cognitive difficulties on the part of the person with brain injury may lead to increased risk while driving.

### Seniors

By 2020, 40 million drivers will be over 65. By 2030, almost 20% of the US population will be 65+, and will constitute 1 out of 4 drivers by the mid 21<sup>st</sup> century.

Older drivers often times limit their driving to time of day, complexity of route, weather.

However, a group of older drivers with ocular pathologies, who were judged as being unsafe in driving during in-traffic conditions, reported that they drove regularly and didn't consider themselves unsafe.

I believe that we do not have good stats on mild TBI and Baby Boomers: no IMPACT or DEM/KD testing... just "shake it off."

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## The need for a coach...

- "...the remedial approach involves off-road skill-specific training, such as visual scanning practice."
- "...the functional approach involves the client practicing the full activity of driving a car, such as completing lessons with a driving instructor."

Unsworth CA, Baker A, Driver rehabilitation: A systematic review of the types and effectiveness of interventions used by occupational therapists to improve on-road fitness-to-drive, Accident Analysis and Prevention 71 (2014) 106–114

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## An important caveat

Drivers are not alone on the field of play.

Driver can only be responsible for self.

Other players (drivers) can have medical conditions, be tired, be on a prescriptive or non prescriptive medication, or be under the influence of alcohol, any of which can affect functioning on the field of play.

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## Medical conditions

Clinician's Guide to Assessing and Counseling Older Drivers 3<sup>rd</sup> edition

Cardiovascular disease, especially when associated with presyncope, syncope, or cognitive deficits	Unstable coronary syndrome Arrhythmias Palpitations Congestive heart failure Hypertrophic obstructive cardiomyopathy Valvular disease
Neurologic disease	Dementia Multiple sclerosis Parkinson disease Peripheral neuropathy Brain injury Spinal cord injury
Psychiatric disease	Mood disorders Depression Anxiety disorders Psychotic illness Personality disorders Alcohol or other substance abuse
Metabolic disease	Type 1 and type 2 diabetes mellitus (especially with hypoglycemic attacks or severe swings in blood glucose) Hypothyroidism
Musculoskeletal disabilities	Arthritis and foot abnormalities Contractures and decreased range of motion Inflammation Pain
Respiratory disease	Chronic obstructive pulmonary disease Obstructive sleep apnea

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## What about sleep?

- Obstructive sleep apnea: chronic condition characterized by frequent episodes of upper airway collapse during sleep.
- More than 50% of adults over the age of 65 years have some form of chronic sleep-related complaints.
- In one report 70% of men and 56% of women between 65 and 99 years of age had OSA.
- “the presence of both sleep apnea and increasing age overwhelmed the brain’s capacity to respond to cognitive challenges with compensatory recruitment and to maintain performance,” like creating an increased risk of accidents when response time is important.

Punjabi N, The Epidemiology of Adult Obstructive Sleep Apnea, Proc Am Thorac Soc Vol 5, pp 136–143, 2008  
Ayalon L, Ancoli-Israel S, Drummond SPA, Obstructive Sleep Apnea and Age, Am J Respir Crit Care Med Vol 182, pp 413–419, 2010

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## Selective attention impacted by fatigue

- Missing 2-3 hours of recommended sleep (at least 7 hours) in a 24 hour period, nearly quadruples the risk of an accident (same as driving under the influence of “over the limit” alcohol).
- 6-7 hours of sleep: 1.3 times the crash risk
- 5-6 hours of sleep: 1.9 times the crash risk
- 4-5 hours of sleep: 4.3 times the crash risk
- Less than 4 hours: 11.5 times the crash risk

Tefft BC, Acute sleep deprivation and risk of motor vehicle crash involvement, AAA Foundation for traffic safety, Dec 2016

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## Drowsy/Asleep Drivers

YEAR	2012	2013	2014	2015	2016
CRASHES	2,676	2,456	2,569	2,616	2,635
FATALITIES	29	10	23	22	26
	.03%	.03%	.03%	.03%	.03%
	1.1%	.4%	.9%	.8%	1%

Drowsy driving for 5 seconds of “micro sleep” at 50 mph = 121 yards traveled.

From PennDOT Motor Vehicle Advisory Board 2017

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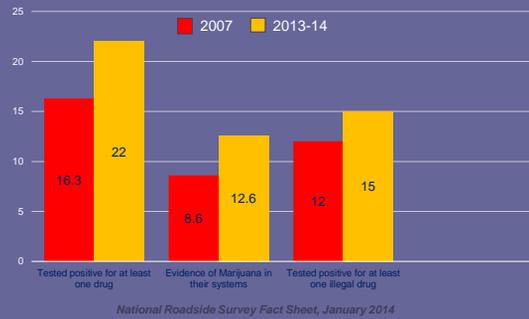
## Medications

Clinician's Guide to Assessing and Counseling Older Drivers 3<sup>rd</sup> edition

<b>Antidepressants</b>	
Tricyclics (tertiary more impairing than secondary)	Sedation, blurred vision, impaired cognition, tremor, heart palpitations
Selective serotonin reuptake inhibitors (SSRIs)	Impaired concentration, lightheadedness, tremor
<b>Others</b>	
Duloxetine	Sedation
Mirtazapine	Sedation
Bupropion	Insomnia (leading to next day somnolence)
Antihistamines (first generation and cetirizine)	Sedation, blurred vision, impaired cognition
<b>Antiparkinson agents</b>	
Dopamine agonists, levodopa, Anticholinergics	All classes may cause sedation. Medication-specific adverse events: sleep-attacks (most likely with dopamine agonists), dyskinesias (most likely with levodopa)
<b>Benzodiazepines/sedatives</b>	
	Sedation, clumsiness, dizziness, impaired vision, impaired cognition
<b>Muscle relaxants</b>	
	Sedation, blurred vision, impaired cognition
<b>Opioid analgesics</b>	
	Sedation, lightheadedness, impaired vision
<b>Other agents not discussed in text</b>	
Antihypertensives	Dizziness (low blood pressure) CNS effects (guanfacine, reserpine, methyldopa, clonidine)
Hypoglycemics	Symptoms of hypoglycemia (shakiness, impaired concentration, lightheadedness)
Indomethacin	CNS effects

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## 2013-2014 NATIONAL ROADSIDE SURVEY OF ALCOHOL AND DRUG USE BY DRIVERS



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## More questions than answers, but

Study by Highway Loss Data Institute: Collision claims in Colorado (2014), Washington (2014), and Oregon (2015) went up about 3% overall since legalization of recreational marijuana, compared to surrounding states.

Jackson Hole Daily 6/23/2017

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## Offensive and defensive thinking

- Not all drivers know or obey all the rules of the sport.
- Not all drivers have the same capability due to differences in physical ability, experience, familiarity with the environment, and reaction time.
- Young have speed but not experience, old have experience but not speed, and some have neither, but they can all suit up for the game.

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## Processing speed: Age and TBI

Aging has clear effects on fluid cognitive abilities, from processing speed and executive function to working memory and episodic retrieval, most of which decline systematically throughout the life span.

Post TBI can have difficulty with maintaining concentration over long periods of time, memory functioning, such as recalling directions, figuring out solutions to problems, reaction time, and safety awareness and judgment.

<http://www.msktc.org/tbi/factsheets/Driving-After-Traumatic-Brain-Injury>

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## Speed of play changes:15-80 mph

### Reaction depends on:

- **Sensation:** the time it takes to detect the sensory input from an object.
- **Perception/recognition:** the time needed to recognize the meaning of the sensation.
- **Situational awareness:** the time needed to recognize and interpret the scene, extract its meaning and possibly extrapolate into the future.
- **Response selection and programming:** the time necessary to decide which if any response to make and to mentally program the movement.

Marc Green: <http://www.visualexpert.com/Resources/reactiontime.html>

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## Response time also depends on

“**Automatic processes** occur without awareness of intent and they can be carried out concurrently with other processes without compromising performance,” as with experienced (middle aged) drivers.

“**Controlled processes** occur with awareness, and are deliberate and goal oriented. These processes are effortful and slow and it is difficult to carry out several controlled processes at once,” as with the novice and the elderly drivers.

Lana TM, Toxopeus R, Wilson D. The effects of visibility conditions, traffic density, and navigational challenge on speed compensation and driving performance in older adults, *Accident Analysis and Prevention*,42,2010

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## If it takes 1½ sec to decide...

- 15 mph = 22 ft/sec
- 20 mph = 29 ft/sec
- 30 mph = 44 ft/sec
- 40 mph = 59 ft/sec
- 50 mph = 73 ft/sec
- 60 mph = 88 ft/sec (132 ft)
- 65 mph = 95 ft/sec
- 70 mph = 103 ft/sec (155 ft)
- 80 mph = 117 ft/sec
- 90 mph = 132 ft/sec
- 100 mph =147 ft/sec

The 3-4second rule:

Choose a fixed point that is even with the car in front of you. For example, a road sign or a building. If you reach that same fixed point before you can count to three or four, then you are driving too close to the car in front of you and you need to fall back a bit.

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## Stopping also depends on

- “The quality of the vehicle's tires.
- The weight of the vehicle.
- The coefficient of friction of the roadway when its dry and when it is wet.”

Schwartz SI, No one at the wheel: driverless cars and the road of the future

73

## Distractors: selective attention

“Vehicles are now commonly instrumented with sophisticated navigation and entertainment systems which, like mobile phones, may add to the driver’s attentional burden, distracting them from the primary task of driving.”

Wood JM, Chaparro A, Philippe L, Hickson L, Useful field of view predicts driving in the presence of distractors. OVS 2012;89:373-81

74

## Selective attention

“Majority of motor vehicle collisions may be the result of inattention caused by increased distractibility, and evidence shows that older adults are particularly vulnerable to the effects of distraction.”

NHTSA. The impact of driver inattention on near-crash/crash risk: an analysis using the 100+ car naturalistic driving study data. Washington, DC: NHTSA, US Dept of Transportation; 2006

Hasher L, Zacks RT. Working memory, comprehension and aging : a review and a new view. Bower GH,ed. The psychology of learning and motivation. NY, NY: Academic Press, 1998: 193-225

Hasher L, Lustig C, Zacks RT. Inhibitory mechanisms and the control of attention. Conway A, Jarrold C, Kane M, Miyake A, Towse J, eds, Variation in working memory. NY, NY Oxford University Press; 2007: 227-49

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## General risk factors for driving

### Distractions



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## Distracted driving

YEAR	2012	2013	2014	2015	2016
CRASHES	14,640	14,376	13,974	14,810	16,050
FATALITIES IN DISTRACTED DRIVER CRASHES	57	64	55	66	69
	.17%	.16%	.16%	.17%	.18%
	.4%	.4%	.4%	.4%	.4%

Add seconds before being aware of need to react: feet traveled depends on speed

From PennDOT Motor Vehicle Advisory Board 2017

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## General risk factors for driving

Distractions that influence visual processing

NHTSA reports 30% of 3 million accidents are attributed to distractions while driving

- Hair
- Make-up
- Brushing teeth
- Tuning the radio
- Reading
- Reaching for something
- Rear seat activity
- Eating
- GPS
- Cell phones
- Animals
- Texting

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## Cell phone

"Cell phone conversations tend to artificially constrict the peripheral awareness as measured by a visual field. This suggests that cell phone use while driving can decrease the perceptual visual field, making the driver less aware of the surroundings and more susceptible to accident."



Maples WC, DeRosier W, Hoenes R, The effects of cell phone use on peripheral vision, Optometry/JAOA, 1/2008

NHTSA, U of Utah, The AAA Foundation for Traffic Safety, National Safety Council

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## Who do you trust?

- "AAA Foundation for Traffic Safety (2013) study conducted in the United States revealed that the majority of respondents believe that driving while using a cell phone is a very serious (57.7%) or serious (30.9%) threat to their personal safety."
- "...an average of 70% of respondents strongly or somewhat strongly support laws restricting hand-held cell phone use by drivers and approximately 45% strongly or some-what strongly support a total ban on cell phone use while driving."
- Interestingly "...the study found that the largest proportion of drivers use cell phones while supporting legislation to restrict the practice by others."...
- Conclusion: "Motorists are generally much more concerned about the risks presented by others' cell phone use than the risks presented by their own cell phone use."

Sanbonmatsua DM, Strayera DL, Behrends AA, Ward N, Watson JM, Why drivers use cell phones and support legislation to restrict this practice , Accident Analysis and Prevention 92 (2016) 22–33

80

## Dog day afternoons

"Among the potential driving-related distractions that have recently been receiving attention is driving with pets in the vehicle. This is partly based upon recent reports of MVCs caused by drivers who were distracted by pets in the vehicle.

It has been reported that roughly 70% of households own companion animals and that 56% of pet owners report riding with a pet in the vehicle at least once a month; 30% of those driving with pets in the vehicle admit to being distracted.

Additionally, while 83% of those surveyed agreed that an unrestrained dog was likely dangerous in a moving vehicle, only 16% have ever used any type of restraint on their own pet."

Bluncka H, Owsley C, MacLennan P, McGwin G, Driving with pets as a risk factor for motor vehicle collisions among older drivers Accident Analysis and Prevention, 58 (2013) 70–74

81

## And the one receiving lots of press: Texting

Sending a text causes a typical driver to look away from the road for 4.6 seconds in a 6 sec interval...at 55 MPH, a car will travel nearly 125 yards in that time...more than the length of a football field.



Driver distraction in commercial vehicle operations, US Dept of Transportation, Sept 2009

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## And...

### Both driver and pedestrian texting



In 2011, pedestrian deaths accounted for 14% of all traffic fatalities. Over two-thirds (70%) of pedestrian fatalities occurred at non-intersections versus at intersections. AARP

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## Playing in and on variable elements that can influence visual processing

- Rush-hour/heavy traffic
- Dawn and dusk
- Night
- Rain/Snow
- Fog/Contrast
- Glare
- Geography
- Intersections
- Interstate highways
- Driving alone
- Parallel parking
- Cue prompts
- Clutter

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## General variables that can impact visual processing

Changes in the field of play:

Light vs. heavy traffic

"In Washington county heavy truck accidents account for 7.7% of all accidents in 2013, compared to 5.9% in 2004."

"Associated Press did an analysis of traffic deaths and US census in 6 drilling states and found fatalities have quadrupled."

"Traffic fatalities in PA drilling counties rose 4% from 2009-2013 while the rest of the state fell 19%."

Kusic S, Heavy Metal, Pitt Business Times, Sept 12-18, 2014, pg 12-13

## Night driving

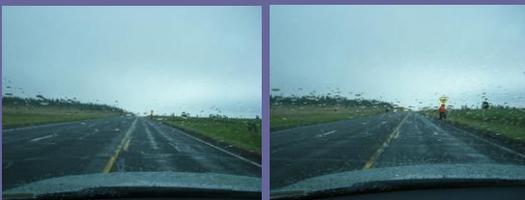
- Fatality rates are 3-4 X higher than daytime.
- Drivers 65 and older have greater fatalities at night than others, except younger than 25.
- Difficulty based on poor spatial and temporal processing
- Different luminance cause adaptation difficulties
- Pedestrian concerns
- Decrease in contrast, depth awareness, and visual reaction time...overdriving the headlights

NHTSA 2001  
Mortimer, R. G., & Fell, J. C. (1989). Older drivers: Their night fatal crash involvement and risk. *Accident Analysis and Prevention*, 21(3), 273-282

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## Rain



Rain lowers the contrast between objects and their background. Reduced visibility under rainy conditions is mainly due to the visual disturbance on the windshield.

A wet road is specular, and in some situations, can lead to disability glare and discomfort glare from other cars, road lights, etc....

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## Environmental contrast

- Distance perception: objects seem to be farther
- Perception of speed: cars seem to move slower



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## Glare

Distracting glare-Discomforting glare-Disabling glare-Veiling glare



Glare recovery times increase systematically with age and have been related to driving safety. Older adults who have retinal disease (BDR, AMD) have even longer recovery times.

Prolonged exposure to veiling glare can result in muscular fatigue and "attitudinal tenseness that degrades driving skills."

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## Putting this together Useful field of view

sight/processing/cognition

UFOV- an area from which one can extract visual information in a single glance without eye or head movement, measured binocularly, and involves detection, localization, and identification of targets against a complex background.

Test looks at higher order processing skills such as rapid visual processing, selective, and divided attention and speed of processing under increasingly complex visual scenes.

[www.visualawareness.com](http://www.visualawareness.com)

Roemaker DL, Cissell GM, Ball KK, Wadley VG, Edwards JD. Speed of processing and driving simulator training result in improved driving performance. Human Factors 2003

90

## Modifiers

- As we age, or with a TBI, it takes more time to visually process between 2 or more visual events under increasingly more complex task demands.
- Must react to and integrate visual information (scene sampling, peripheral vision, cluttered scenes, environmental challenges, etc.).

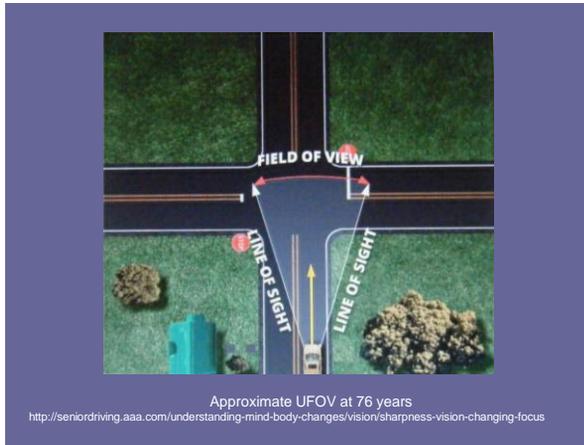
91



Approximate UFOV at 16 years

<http://seniordriving.aaa.com/understanding-mind-body-changes/vision/sharpness-vision-changing-focus>

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## Visual processing speed

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## Navigating while driving

Following a route (egocentric) vs way finding (allocentric)

Allocentric

- Can "compromise driving performance"
- Taxes memory and divides attention
- Hampers abilities to:
  - remember directions
  - respond to given direction (i.e., turn right)
  - locate landmarks (i.e., the blue house, 3rd stop sign)

Lana TM, Toxopeus R, Wilson D. The effects of visibility conditions, traffic density, and navigational challenge on speed compensation and driving performance in older adults, Accident analysis and prevention,42,2010

95

## And the solution: distractors

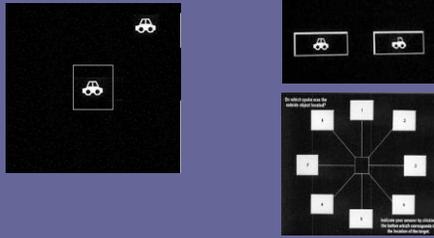
"Changes in the presentation of information to enable strategies that reduce processing or memory demands—may in turn ameliorate age-related declines in adaptive decision making."

GPS?  
Waze ?

Henninger DE, Madden DJ, Huettel SA, Processing Speed and Memory Mediate Age-Related Differences in Decision Making, Psychology and Aging,2010

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## Divided attention



## Figure ground

“Clutter increases demands on selective attention: the ability to select relevant items from irrelevant ones in the visual scene.”

“selective attention may be differentially more effective in predicting driving difficulties in situations of divided attention which are commonly associated with crashes.”

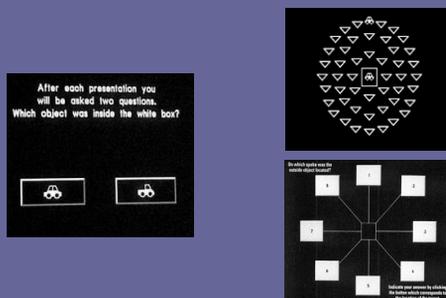
Lana TM, Toxopeus R, Wilson D. The effects of visibility conditions, traffic density, and navigational challenge on speed compensation and driving performance in older adults, *Accident Analysis and Prevention*, 42, 2010

Wood JM, Chaparro A, Lacherez P, Hickson L. Useful field of view predicts driving in the presence of distracters, *OVS*, 89, (4), 2012: 373-381

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## Selective attention



## Recommendations

- Comprehensive eye examination
- Assessment of contrast sensitivity
- Assessment of glare recovery
- Assessment of UFOV
- Assessment of out of instrument reaction time with eye hand, eye foot, scanning, etc
- Assessment of spatial/temporal awareness, i.e., where targets are, judgement of speed  
Address with vision therapy and "brain games"  
Behind the wheel driving instruction

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