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Taxonomy of Older Driver Behaviors and Crash Risk

Appendix C

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Dr. Kathy Sifrit was the NHTSA Task Order Manager on this project.

16. Abstract

This project's objectives were to identify risky behaviors, driving habits, and exposure patterns that have been shown to increase the likelihood of crash involvement among older drivers; and to classify these crash-contributing factors according to a set of underlying functional deficits specific to, or more prevalent among, the older driver population. Such deficits may result from normal aging, age-related medical conditions, or medication use. A further goal was to identify and critically examine behavioral countermeasures with the potential to mitigate functional loss and/or diminish the occurrence of risky behaviors—and thus ameliorate crashes among older drivers.

The first task was an analysis of older driver injuries and fatalities using national databases (FARS, GES), to identify driving patterns, driving tasks, and contributing factors associated with crashes by older drivers; more details are available in a separate document, Report No. DOT HS 811 093, "Identifying Behaviors and Situations Associated With Increased Crash Risk for Older Drivers." Additional project tasks included a review of the literature describing age-related functional changes, and evaluations of existing behavioral countermeasures to reduce older drivers' crash risk; an expert panel meeting to supplement the information from the database analyses and literature review; and unstructured interviews with older drivers who have had crashes within the previous three years, and an age-matched group who have not had crashes within that period, to determine whether these groups differ in factors such as exposure or use of countermeasures.

The outcomes of these project activities were used to develop and refine a taxonomy table that captures critical relationships between topics and subtopics highlighted in the literature review and crash database analyses. This table identifies critical performance errors that underlie crash types where older drivers are most strongly overrepresented; the functional deficits that are implicated in causing such performance errors; and the countermeasure strategies that presently appear to hold the greatest promise to ameliorate or to accommodate those (age-related) deficits.

The taxonomy table is a resource that provides at-a-glance, state-of-the-knowledge information to assist researchers, health care practitioners, and others concerned about older driver safety to identify particular risk factors, and what can be done to reduce the risk. A hard copy version and an expanded, electronic version of this resource were developed.

17. Key Words	**18. Distribution Statement**
Safety, older drivers, functional abilities, crash analysis, countermeasure, driver performance, driving errors, rehabilitation, remediation, accommodation, compensation.	Document is available to the public from the National Technical Information Service www.ntis.gov

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APPENDIX C: TAXONOMY TABLE DETAIL

CRASH TYPE:
Click on a number below to link to the detail pages for each crash type.

	1	2	3	4	5
	CRASH TYPE 1 Left turn at intersection with stop-sign control for older driver's approach. Cross traffic does not stop	**CRASH TYPE 2** Left turn at intersection with signal control; permissive phase for older driver's approach	**CRASH TYPE 3** Right turn at yield sign in channelized right-turn lane, merging with trafic approaching from the left on principal arterial (40-45 mi/h)	**CRASH TYPE 4** Merge at yield sign onto limited access highway	**CRASH TYPE 5** Lane change on multilane (4+) roadways
DEFICITS					
1. Acuity	X X X X				
2. Contrast Sensitivity	X X X X X				
3. Visual Fields	X X X X X				
4. Depth & Motion Perception	X X X X X	X X X X X			
5. Dark Adaptation & Glare Recovery	X X X				
6. Speed of Processing	X X X X X	X X X X X	X X X X X	X X X X X	X X X X X
7. Selective Attention	X X X X X	X X X X X	X X X X X	X X X X X	X X X
8. Divided Attention	X X X X X	X X X X X	X X X X X	X X X X X	X X X
9. Working Memory	X X X X X	X X X X X			
10. Executive Function (Judgment/Decision- Making)	X X X X X	X X X X X	X X X X X	X X X X X	X X X
11. Spatial Abiliies	X X X X X	X X X X X		X X X X X	
12. Knowledge		X X X X X			X X X X X X X X X X
13. Head/Neck/Trunk Range of Motion	X X X X		X X X X		
14. Arm Strength/Range of Motion/Speed of Movement			X X X X X		
15. Leg Strength/Range of Motion/Speed of Movement			X X X X X		
COUNTERMEASURES					
A. Refractive Correction (inc. wavefront technology)	X X X X X				
B. Cataract Surgery	X X X X X				
C. Avoidance of Challenging Situations (License restrictions, DRS Initiated, or Self)	X X X X X	X X X X X	X X X X X	X X X X X	X X X
D. Conformal Vision Enhancement System	X X X X X	X X X X X	X X X X X	X X X X X	X X X
E. Central Vision Enhancement Systems (Bioptic Telescopic Lenses; Implantable Telescopes)	X X X X X				
F. Visual Field Expansion Systems (Prism, Bioptic Amorphic Lenses, Video Feeds)	X X X X X				
G. Training in Compensatory Head/Eye Movements, Scanning Strategies	X X X X X		X X X X		
H. Speed of Processing Training	X X X X X	X X X X X	X X X X X	X X X X X	X X X
I. Physical Aerobic Activity/Training	X X X X	X X X X X	X X X X X	X X X X X	X X X
J. Strength & Flexibiliy Exercises	X X X X X		X X X X X		
K. Visual Perceptual Therapy	X X X X X	X X X X X		X X X X X	X X X X X
L. Driver Safety Education - Theory/classroom only	X X X X X	X X X X X	X X X X X	X X X X X	X X X X X X X X X X X X X X X
M. Driver Safety Education - Theory + Behind the Wheel (BTW)	X X X X X	X X X X X	X X X X X	X X X X X	X X X X X X X X X X X X X X X
N. Driver Safety Education: Interactive/Computer-Based Technology	X X X X X	X X X X X	X X X X X	X X X X X	X X X X X X X X X X X X X X X
O. Education about Driving Aids (Car Fit, Features/Adaptive Equip, Shoes, etc.)	X X X X X	X X X X X	X X X X X		X X X X X X X X X X
P. Collision Warning Systems	X X X X X	X X X X X	X X X X X	X X X X X	X X X
Q. After-Market Non-Planar Driver-Side Mirror	X X X X		X X X X		
R. Medical Management (incl Pharmacy Review)	X X X X X	X X X X X	X X X X X	X X X X X	X X X X X X X X X X X X X X X
S. Cognitive Rehab (incl Memory Training) for Normally Aging	X X X X X	X X X X X	X X X X X	X X X X X	X X X
T. Compensatory Cognitive/Memory Training for Impaired/ MCI Pop	X X X X X	X X X X X	X X X X X	X X X X X	X X X
U. Pre-Trip Planning	X X X X X	X X X X X	X X X X X	X X X X X	X X X X X X X X X X

	CRITICAL DRIVER PERFORMANCE ERROR 1	CRITICAL DRIVER PERFORMANCE ERROR 2	CRITICAL DRIVER PERFORMANCE ERROR 3	CRITICAL DRIVER PERFORMANCE ERROR 4	CRITICAL DRIVER PERFORMANCE ERROR 5	CRITICAL DRIVER PERFORMANCE ERROR 6	CRITICAL DRIVER PERFORMANCE ERROR 7	CRITICAL DRIVER PERFORMANCE ERROR 8	CRITICAL DRIVER PERFORMANCE ERROR 9
	Failure to visually detect potential conflicts, hazards, or traffic control information (without regard to cognitive status)	(Assuming no sensory deficit) Gap judgment errors (Inability to accurately estimate closing speed and distance)	(Assuming no sensory deficit) Inability to predict the development of future conflicts from current traffic & contextual information	(Assuming appropriate response) Slowed vehicle control response	(Assuming no sensory deficits) Inadequate visual search/improper lookout (attentional failure, includes "looked but didn't see")	(Assuming no sensory deficit) Slowed decision making; traffic situation has changed by the time a maneuver is initiated, resulting in potential conflict	Lack of understanding of rules of the road	Lack of understanding (leading to failure to apply) safe driving practices (e.g., aiming mirrors, positioning within intersection to increase sight distance) (not willful or aggressive driving)	Inappropriate response selection (pedal errors)

CRASH TYPE 1: Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.

FUNCTIONAL DEFICITS THAT MAY INFLUENCE CRASH RISK

SENSORY/PERCEPTUAL (VISION)

- Acuity
- Contrast Sensitivity
- Visual Fields
- Depth and Motion Perception (Angular Motion Sensitivity)

ATTENTION/COGNITION

- Speed of Processing
- Selective Attention
- Divided Attention
- Working Memory
- Executive Function (Judgment and Decision Making)
- Spatial Abilities
- Knowledge (Rules of the Road and Safe Driving Strategies)

PHYSICAL/PSYCHOMOTOR

- Head/Neck/Trunk Range of Motion
- Arm Strength/Range of Motion/Speed of Movement
- Leg Strength/Range of Motion/Speed of Movement

CRASH TYPE 1: **Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION)

SPECIFIC DEFICIT: ACUITY

Associated Driver Performance Errors

- Could contribute to a failure to visually detect a potential threat.
- Acuity poorer than 20/40 independently associated with self-reported crashes, moving violations, being stopped by police in prior 5-year period (Marottoli et al., 1998).
- Acuity (score and response time) related to unsafe driving incidents; correlations higher for time to respond to acuity stimuli than acuity errors (McKnight & McKnight, 1999).
- Acuity response time rather than acuity score related to driving exam score (Staplin et al., 1998).
- Acuity slightly worse than 20/30 independently associated with self-reported difficulty driving on interstates, at night, in the rain, on high-traffic roads, during rush hour, alone, and making left turns (McGwin, Chapman, & Owsley, 2000).
- Poorer dynamic acuity related to crash involvement in prior 2-year period (Shinar, Mayer, & Treat, 1975).
- Dynamic acuity included in model predictive of closed course driving performance (Wood, 2002).
- Significant relationship between acuity and improper lookout (Shinar, McDonald, & Treat, 1978).
- Visual impairment worse than 20/30 in the better eye was independently associated with self-reported difficulty making left turns in sample of 384 drivers ages 55-85. Refractive error most frequent cause of impairment for the subsample with acuity worse than 20/40 but better than 20/60; cataract next most frequent cause. Both conditions are correctable. (McGwin, Chapman, & Owsley, 2000).
- Combined criterion using acuity, CS, and horizontal visual fields significantly related to prior crash involvement in drivers age 66+, but no visual measure alone was significantly associated (Decina & Staplin, 1993).

Included Behavioral Countermeasures

- Refractive correction (incl. Wavefront technology)
- Cataract surgery
- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Central vision enhancement systems (bioptic telescopic lenses, implantable telescopes)
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Collision warning systems
- Medical management (incl. pharmacy review).

CRASH TYPE 1: **Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: ACUITY		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Refractive correction (incl. Wavefront technology)	No before-after studies on refraction correction (updating prescription for corrective glasses) and driving safety uncovered. Panelist with expertise in the area stated that in the ophthalmology literature there is quite a bit of research on age and satisfaction for refractive errors corrective surgery. There is actually quite ample literature on people's feelings about their improved performance in everyday tasks there, clarity with which they can see things. It would seem reasonable that one would have asked the question about improved driving performance as a result of refractive error correction, but the panelist was not aware of anything done. Haddrill (2007): Ophthonix founder A. Dreher reports that iZon lenses (wavefront lenses) provide higher definition vision in the daytime and significantly improve night driving responses when compared with conventional lenses. Night vision improved a driver's ability to identify pedestrians by an average of 330 ms (30 ft sooner at 55 mi/h) when compared to conventional lenses. www.allaboutvision.com/lenses/wavefront-lenses.htm; http://ophthonix.izonlens.com/globals/faqs.asp; www.allaboutvision.com/whatsnew/lenses1.htm.	Even without research on effectiveness, panelists agreed that refractive correction should be advocated just on the prevalence of the problem and the inexpensiveness of the solution, particularly as there appears to be a decline in older people getting annual eye exams. Annual eye exams, refractive correction, and sooner diagnosis of treatable conditions (e.g., cataracts) are inexpensive solutions for reaching a substantial number of people for remediation. Vision specialist feedback to drivers regarding the driver licensing laws in their State in relation to their own level of impairment is important (and presently rare in practice); increasing awareness of impairments may lead to appropriate self-restriction. One of the early findings of the Salisbury Eye Study was that among the proportion of older individuals who had worse than 20/40 vision, more than half of them could be corrected just with glasses. A panel member (vision specialist) recommended inclusion of Wavefront technology as part of refractive correction. Wavefront technology diagnoses higher-order vision errors represented by the way the eye refracts or focuses light; such aberrations defocus images even with 20/40 acuity. Wavefront guided lenses can reduce certain higher-order aberrations, which potentially can improve low light image quality during activities such as driving at night. Panelist notes research on effectiveness for driving is currently limited to that conducted by lens manufacturer (see Haddrill, 2007, description of Ophthonix iZon wavefront guided lenses). Another caution noted by the panelist regarding the lens company research is that improvements in vision with the wavefront lenses were compared to patients' vision as they appeared for the study. But it is well known that many patients especially over age 60 haven't had regular eye check-ups or new prescriptions.
Cataract surgery	McGwin, Scilley, Brown, and Owsley (2003) found improvements in acuity with cataract surgery, and that improvement in visual acuity had a significant, independent association with the change in activities of daily vision scale (that includes daytime and nighttime driving). Wood and Carberry (2006) found that improvement in acuity that accompanied cataract surgery was related to improvement in overall driving score.	Panelists agree this is a relatively inexpensive treatment and improvements result in crash reduction. Cataracts are often the only medical condition affecting driving performance. Even if crash reduction benefit is small, cataract surgery may provide a large public health benefit because of the large number of people affected by cataracts.

CRASH TYPE 1: Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: ACUITY		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	Gallo, Rebok, and Lesikar (1999). Self-reported vision impairment was related to avoidance of challenging driving situations, but not to self-reported citations or crashes in prior 2 years. Authors conclude that vision impaired drivers who self restrict are less likely to crash. Vision impairment categories: no trouble seeing; a little trouble, a lot of trouble (i.e., may not be specific to acuity). Ball, Owsley, Stalvey, Roenker, Sloane, and Graves (1998): No relationship between avoidance score and crashes in subsequent 3 year period. De Raedt and Ponjaert-Kristoffersen (2000): poor performers on a road test but were free of (self-reported) at-fault crashes (prior 12 mo) used significantly more strategic compensation tactics (avoidance of challenging situations) than poor-performing drivers with a history of at-fault crashes.	Panelists indicate this may or may not be effective; "we don't know if this works." People try to self-regulate when there are alternative transportation options, but there are times when they "must" drive even if they'd rather not (e.g., winter when it gets dark earlier, or no other driver to take them). Making people aware of deficits is the first step in getting people to self restrict, if they will self restrict. Studies show that there are many unaware vision-impaired drivers. Ophthalmologists and optometrists need to be included as targets of outreach, similarly to the AMA guide, and other outreach efforts that NHTSA has done for specialized populations because, eyecare specialists are a group that does not know their red flags to tell patients that "these are the laws in our state and this is what you need to be concerned about."
Central vision enhancement systems (bioptic telescopic lenses, implantable telescopes)	Janke and Kazarian (1983): Crash rate in users is 1.5 times higher than population rate, but less than the crash rate of drivers licensed with other medical conditions. Clark (1996): Crash rates for BTL users 1.9 times higher than comparison group, but citation rates 0.7 of that for comparison group. Szlyk et al. (2000): Training in the use of BTL lenses (both lab and on-road) significantly increased performance in recognition, peripheral identification, and scanning compared to performance of non-trained BTL users.	Panelists in agreement with countermeasure if accompanied by training and assessment of driving safety after training. Recommend licensing with restrictions after low-driving program/rehab. Use lens only for spotting (5-10% of time). Training curriculum and design of lenses needs to be "nailed down." Training curriculum needs to be developed by Occupational Therapists. Countermeasure appropriate if no cognitive deficit.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for acuity deficit; raises awareness of deficit so they can self restrict. Also provide education to physicians and eyecare specialists so they can educate their patients. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. Panelist (a KEYS study author) noted that he has always questioned whether those self reported changes in driving habits were real; people may have been invested due to time spent in intervention and reported more avoidance than they really engaged in. Also, candidates for education intervention should not have advanced cognitive deficits (e.g., dementia). Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.

CRASH TYPE 1: **Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: ACUITY		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Collision warning systems	Oxley and Mitchell (1995): collision warning system tested in a simulator was effective in preventing older drivers from turning across traffic through gaps that were dangerously short.	Suggested by panelists as countermeasure that merits further research. Need forward as well as side-collision warning. Would be helpful if it caused the vehicle to brake, in addition to providing a warning. Concern is with complete reliance on the technology to detect hazards (especially for backing up) where older drivers back up without doing head/shoulder checks and have backed into (and killed) pedestrians. Also elderly people may be more distracted rather than assisted by some of the advanced technologies. And, most rehab center's adapted cars are not high-end/high tech, so it would be difficult for OTs to train people in the use of the technologies.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.

CRASH TYPE 1: **Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION)

SPECIFIC DEFICIT: CONTRAST SENSITIVITY

Associated Driver Performance Errors

- Could contribute to failure to visually detect potential threat.
- Poor contrast sensitivity has been correlated with poor driving performance (Wood, 2002; Baldock et al., 2007) and increased crash risk in prior 5-year period (Owsley, Stalvey, Wells, Sloane, & McGwin, 2001).
- Decreased CS in the better eye was independently associated with self-reported difficulty making left turns (McGwin, Chapman, & Owsley, 2000).
- CS along with visual spatial memory and 2 measures of visual attention RT explained 35% of the variance in driving ability demonstrated in on-road test (Baldock, Mathias, McLean, & Berndt, 2007).

Included Behavioral Countermeasures

- Refractive correction (incl. Wavefront technology)
- Cataract surgery
- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Conformal vision enhancement system (e.g., in-vehicle enhancement of Stop Sign)
- Central vision enhancement systems (bioptic telescopic lenses, implantable telescopes)
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Collision warning systems
- Medical management (incl. pharmacy review)

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GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: CONTRAST SENSITIVITY		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Refractive correction (incl. Wavefront technology)	Haddrill (2007): Ophthonix founder A. Dreher reports that iZon lenses (wavefront lenses) provide higher definition vision in the daytime and significantly improve night driving responses when compared with conventional lenses. Night vision improved a driver's ability to identify pedestrians by an average of 330 ms (30 ft sooner at 55 mi/h) when compared to conventional lenses. www.allaboutvision.com/lenses/wavefront-lenses.htm; http://ophthonix.izonlens.com/globals/faqs.asp; www.allaboutvision.com/whatsnew/lenses1.htm.	Wavefront technology diagnoses higher-order vision errors represented by the way the eye refracts or focuses light; such aberrations defocus images even with 20/40 acuity. Wavefront guided lenses can reduce certain higher-order aberrations, which potentially can improve low light image quality during activities such as driving at night. Panelist notes research on effectiveness for driving is limited to that conducted by lens manufacturer. Wavefront technology may address the contrast sensitivity issue without gizmos on the dashboard or other technology; there is a lot of promise there, but there needs to be some research in the area.
Cataract surgery	Monestam and Wachtmeister (1997): Self reported problems with distance judgment declined from 37% to 6% of sample following cataract surgery. McGwin et al. (2003): contrast sensitivity improved significantly in the sample that underwent surgery, and day and night driving scores on Activities of Daily Vision Scale significantly improved post-operatively in surgery group. Owsley et al. (2002): Patients with a cataract who underwent surgery and IOL implantation had half the crash rate of drivers with cataract who did not undergo surgery (4.74 crashes per million miles of travel vs. 8.95). Wood and Carberry (2006): Bilateral cataract surgery resulted in significant improvements in on-road performance, related to improvements in CS.	Panelists agree this is a relatively inexpensive treatment and improvements result in crash reduction. Cataracts are often the only medical condition affecting driving performance. Even if crash reduction benefit is small, cataract surgery may provide a large public health benefit because of the large number of people affected by cataracts.

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Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
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Conformal vision enhancement system (e.g., in-vehicle enhancement of Stop Sign)	Caird, Horey, and Edwards (2001). Simulator study with 24 younger and 24 older drivers. Conformal enhancement of a traffic light resulted in fewer drivers running the light. Drivers indicated conformal VES would be helpful when environmental conditions restrict visibility, but not under heavy traffic, cluttered environments, or in daytime. Less than 25% indicated they would use VES regularly if available. Oxley and Mitchell (1995) reported that in a sample of older 31 UVES and 15 IVES users, 100% found it easy to use, and 60-73% indicated it would encourage them to drive outside of their usual driving situations. Gish, Staplin and Perel (1999) found that 3 of 4 older drivers did not use VES to detect targets, but instead used it to detect curves in the road (controlled field study).	Panelists state older drivers in focus groups don't like anything in their cars that takes their focus away from the road (either on the windshield or on a heads-down display in the vehicle). They would choose not to drive in challenging situations rather than to use a device that may take their attention from the road, or that may be more difficult to operate. Another panelist indicated that following training in equipment use, older drivers are ok with such countermeasures; emphasizing that training is a critical component for new technologies to assist older drivers.

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• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for contrast sensitivity deficit; raises awareness of deficit so they can self restrict. Also provide education to physicians and eyecare specialists so they can educate their patients. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Collision warning systems	Oxley and Mitchell (1995): collision warning system tested in a simulator was effective in preventing older drivers from turning across traffic through gaps that were dangerously short.	Suggested by panelists as countermeasure that merits further research. Need forward as well as side-collision warning. Would be helpful if it caused the vehicle to brake, in addition to providing a warning.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.

CRASH TYPE 1: **Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION)

SPECIFIC DEFICIT: VISUAL FIELDS

Associated Driver Performance Errors

- Could contribute to a failure to visually detect a potential threat.
- Impaired detection capability for stimuli in the affected parts of the visual field (Lovsund, Hedin, & Tornros, 1991).
- Correlated with crashes (Ball et al., 1993; Johnson & Keltner, 1983; Ruben et al., 2007; Szlyk et al., 1991).
- Drivers with Glaucoma (McGwin, Owsley, & Ball, 1998; Hu et al., 1998) and macular degeneration (Owsley et al., 1998) have higher crash rate than those without, and these conditions can restrict visual field.

Included Behavioral Countermeasures

- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Central vision enhancement systems (bioptic telescopic lenses, implantable telescopes)
- Visual field expansion systems (prism, bioptic amorphic lenses, video feeds)
- Training in Compensatory Head/Eye Movements, Scanning Strategies
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Education about driving aids (Car Fit, features/adaptive equipment, shoes, etc.)
- Medical management (incl. pharmacy review)

CRASH TYPE 1: **Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: VISUAL FIELDS		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	Hennessy (1995): poorer visual field ability (modified Synemed perimeter) was significantly associated with greater avoidance of driving at night, rain, dusk, dawn, and making left turns, but the predictive value of visual fields performance on crash rate (prior 3 yrs) was mediated only for avoidance of left turns; But avoidance did not reduce risk, it increased it (inadequate compensation).	Panelists indicate this may or may not be effective; "we don't know if this works." People try to self-regulate when there are alternative transportation options, but there are times when they "must" drive even if they'd rather not (e.g., winter when it gets dark earlier, or no other driver to take them). Making people aware of deficits is the first step in getting people to self restrict, if they will self restrict.
Central vision enhancement systems (bioptic telescopic lenses, implantable telescopes)	Janke and Kazarian (1983): Crash rate in users is 1.5 times higher than population rate, but less than the crash rate of drivers licensed with other medical conditions. Clark (1996): Crash rates for BTL users 1.9 times higher than comparison group, but citation rates 0.7 of that for comparison group. Szlyk et al. (2000): Training in the use of BTL lenses (both lab and on-road) significantly increased performance in recognition, peripheral identification, and scanning compared to performance of non-trained BTL users.	Panelists in agreement with countermeasure if accompanied by training and assessment of driving safety after training. Recommend licensing with restrictions after low-vision driving program/rehab. Use lens only for spotting (5-10% of time). Training curriculum and design of lenses needs to be "nailed down." Training curriculum needs to be developed by Occupational Therapists. Countermeasure appropriate if no cognitive deficit.
Visual field expansion systems (prisms, bioptic amorphic lenses, video feeds)	Szlyk et al. (1998): Following training with the lenses (lab and on-road), patients showed improvements in all visual skill categories, including peripheral detection and selecting appropriate gaps. Authors note further research necessary to determine safety while driving.	Panelist states that 100 degree binocular field is a good minimum standard; if < 100 degrees and adamant about driving, a driver should be offered these systems to see if he/she can adapt to it (should be the standard of care). Target audience would be a driver with 50 degree binocular fields in a State with no visual field requirement, and prisms (ref Eli Peli) could be used to expand the field to 100 degrees to make driving safer. Video feed may be better than amorphic lenses.

CRASH TYPE 1: Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: VISUAL FIELDS		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Training in compensatory head and eye movements, scanning strategies	• Coeckelbergh et al. (2001): Training in compensatory viewing strategies, particularly on-road training, improved viewing behavior for persons with central or peripheral visual field constriction, and increased the number of subjects who passed a road test who previously failed. Ss had visual field defects due to ocular pathology; those with severe cognitive impairments were excluded from participation. • Dynavision apparatus has been used in office rehab settings to train compensatory scanning strategies for visual inattention and visual field deficit in persons with intact attentional mechanisms. Klavora et al. (1995) found that Dynavision training with 10 older (age 46-73) post-CVA individuals resulted in significantly improved behind-the-wheel driving performance when compared with expected outcomes. All failed their first BTW assessment pre-Dynavision training. Training involved three 40-minute Dynavision Training sessions per week for 6 weeks. On the second BTW assessment, 6 of the 10 subjects earned a "safe to resume driving and/or receive on-road driving lessons." • Laderman, Szlyk, Kelsch, and Seiple (2000): 4-week training on a task in a rehab center setting to teach peripheral detection, scanning, and tracking where the clients sat close to a screen and detected slide images in the periphery using amorphic lenses, then turning their heads toward the object to identify it more clearly through the carrier. 8-week training in-vehicle on closed course with driving instructor to practice skills. Before-after training results indicated 39% improvement in tasks involving peripheral detection, and 27% improvement in scanning tasks. Authors note further research is needed to define standards and evaluation methods for training curricula.	Panelists agreed that this is an appropriate countermeasure, but candidates must be cognitively intact. This type of training has been used for telescopic and amorphic-lens drivers ("search and destroy" method referred to by panelist, described by Laderman et al., 2000) and has been effective in improving peripheral visual detection. It was noted that Mary Warren has a compensatory training program for drivers with visual field defects, but none of the panelists thinks she has published anything. One panelist mentioned a book that may be useful in this training older adults to scan effectively by Ken Mills "Disciplined Attention: How to Improve Your Visual Attention When You Drive." The book (directed toward young driver training) is not a countermeasure that's ready to go, but it's one ready to be researched.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for visual field deficits; raises awareness of deficit so they can self restrict. Also provide education to physicians and eyecare specialists so they can educate their patients. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills education. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Education about driving aids (CarFit, features/adaptive equipment, shoes, etc.)		Panelists state that vehicles have safety features but many need to be adjusted, and older drivers don't know how to do this. Education about driving aids is a positive theme to staying on the road longer. Countermeasure merits further research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.

CRASH TYPE 1: **Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION)

SPECIFIC DEFICIT: DEPTH AND MOTION PERCEPTION

Associated Driver Performance Errors

- Could contribute to gap judgment error: driver turns left into too short a gap, and traffic approaching from right must slow to avoid a crash.
- Older drivers (especially females) rely on distance instead of integrating speed and distance, especially for higher-speed roads (Yan, Radwan, & Guo, 2007; Andersen & Enriquez, 2006; Scialfa et al., 1991; Dazentas, McDowell, & Cooper, 1980; Braitman et al., 2007; De Raedt & Ponjaert-Kristoffersen, 2000).
- Impairments in stereoacuity are related to retrospective crashes (Owsley, McGwin, & Ball, 1998; Ivers et al., 1999; Staplin et al., 1998).
- Poor structure from motion performance is related to simulator crashes (Rizzo et al., 1997 and at-fault safety errors on the road (Uc et al., 2005).
- Central motion sensitivity related to on road driving performance (Wood, 2002).
- In failure-to-yield crashes at stop signs, drivers ages 70-79 made more evaluation errors than drivers ages 35-54 and those age 80+; evaluation errors occurred when the driver saw the other vehicle but misjudged whether there was adequate time to proceed (Braitman et al., 2007).
- Panelists indicated that a deficit in depth and motion perception could be associated with inability to predict development of future conflicts (critical performance error #3), in addition to gap judgment errors (#2).

Included Behavioral Countermeasures

- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Education about driving aids (Car Fit, features/adaptive equipment, shoes, etc.)
- Medical management (incl. pharmacy review)

CRASH TYPE 1: **Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: DEPTH AND MOTION PERCEPTION		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	Ball, Owsley, Stalvey, Roenker, Sloane, and Graves (1998): No relationship between avoidance score and crashes in subsequent 3 year period. De Raedt and Ponjaert-Kristoffersen (2000): drivers who performed poorly on a road test but were free of (self-reported) at-fault crashes in the prior 12-mo period used significantly more strategic compensation tactics (avoidance of challenging situations) than poor-performing drivers with a history of at-fault crashes.	Panelists indicated that drivers could choose the route that has a protected turn.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for depth and motion perception deficits; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Education about driving aids (CarFit, features/adaptive equipment, shoes, etc.)		Panelists state that vehicles have safety features but many need to be adjusted, and older drivers don't know how to do this. Education about driving aids is a positive theme to staying on the road longer. Countermeasure merits further research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.

CRASH TYPE 1: **Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.**

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: SPEED OF PROCESSING

Associated Driver Performance Errors

- Effect of slowed SOP may be slowing of retrieval of knowledge of right-of-way rules, and slowed reasoning and decision-making about appropriate visual search and vehicle control.
- SOP deficits (UFOV subtest 1) accounted for 4.1% of the variance in crash involvement (prior 3-years) for drivers age 70+ (type not specified) adjusting for age, gender, and driving exposure (Hennessy, 1995).
- Slowed SOP was significantly related to avoidance of left turns (Hennessy, 1995).
- Older drivers who performed poorly on the Trails A test had significantly more retrospective crashes (Stutts, Stewart, & Martell, 1996, 1998; Goode, Ball, Sloane, Roenker, Roth, Myers, & Owsley, 1998) and prospective crashes (Lesikar, Gallo, Rebok, & Keyl, 2002) than drivers who performed well on this SOP measure. Crash type not specified in these studies.
- Older crash-involved drivers with licenses suspended for failure to yield the right of way performed significantly worse on Trails A than subjects w/o suspended licenses (Lundberg, Hakamies-Blomqvist, Almkvist, and Johannson, 1998).
- Panelists indicated that a speed of processing deficit could be associated with the following critical driver performance errors: #2 gap judgment errors; #3 inability to predict development of future conflicts; #4 slowed vehicle control response; #5 inadequate visual search/improper lookout; #6 slowed decision making; #9 pedal errors (inappropriate response selection).

Included Behavioral Countermeasures

- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Speed of processing training
- Physical aerobic activity/training
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Collision warning systems
- Medical management (incl. pharmacy review)

CRASH TYPE 1: **Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: SPEED OF PROCESSING		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	Hennessy (1995): poorer SOP ability was significantly associated with greater avoidance of driving at night, rain, dusk, dawn, alone, left turns, and heavy traffic, but the predictive value of the SOP subtask on crash rate (prior 3 yrs) was mediated only for avoidance of left turns; But avoidance did not reduce risk, it increased it (inadequate compensation).	Panelists indicate this may or may not be effective; "we don't know if this works." People try to self-regulate when there are alternative transportation options, but there are times when they "must" drive even if they'd rather not (e.g., winter when it gets dark earlier, or no other driver to take them). Making people aware of deficits is the first step in getting people to self restrict, if they will self restrict.
Speed of processing training	Roenker et al. (2003): Speed of processing training using all 3 subtests of UFOV compared to Doron simulator training and untrained reference group. Global ratings of on-road driving performance improved for both training groups, but only SOP group maintained performance at 18 mo. For "dangerous maneuvers" component, both training groups showed improvements, but only SOP training maintained improvement at 18 mo. Dangerous maneuvers included 6 opportunities for unprotected turns across traffic and 9 left-turn entrances to a high-traffic road.	Panelists agreed this may be a viable countermeasure, but there is a need to establish the link between training on task and transfer to driving.
Physical aerobic activity/training	Marmeleira, Godinho, and Fernandes (2008) found that a 12-week exercise program with 3, 60-min sessions per week improved visual attention in speed of processing and divided attention (using the UFOV protocol) at 12 weeks follow-up in adults ages 60 to 81. The intervention incorporated perceptual and cognitive tasks (problem solving and responding to challenging situations) with aerobic activity. Examples are: walking while listening for auditory cues to perform fast and specific psychomotor responses). At 12 weeks, speed of processing and divided attention were significantly improved compared to baseline for the exercise group; at baseline, there was no difference between groups. Actual driving performance was not studied, and there was no exercise-only group to determine the contribution of physical activity alone on speed of processing or divided attention.	Research article provided by panelist following meeting; panelists did not get to comment on countermeasure for deficit. Merits further research.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for speed of processing deficits; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Collision warning systems	Oxley and Mitchell (1995): collision warning system tested in a simulator was effective in preventing older drivers from turning across traffic through gaps that were dangerously short.	Suggested by panelists as countermeasure that merits further research. Need forward as well as side-collision warning. Would be helpful if it caused the vehicle to brake, in addition to providing a warning.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.

CRASH TYPE 1: **Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.**

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: SELECTIVE ATTENTION

Associated Driver Performance Errors

- Older drivers with selective attention deficits had shorter time to collision values, took longer to cross the road, and had shorter safety cushions (on-road study) than drivers with no impairment in selective attention ability (Pietras et al., 2006).
- Poor visual attention (number cancellation test) related to poor on-road driving performance, specifically scanning visual field for potentially dangerous objects, yielding the right of way, negotiating turns safely (Richardson & Marottoli, 2003).
- In lab study using change blindness technique to measure selective attn., older drivers more likely to miss detecting relevant vehicles when making safe-not safe to turn decisions (Caird et al., 2005).
- Selective attention with visual search correlated significantly with global road test score, accounting for 19% of the variance (De Raedt & Ponjaert-Kristoffersen, 2000). It also correlated significantly w/visual behavior and communication (r= -.43) and perception and reaction to signals (r=-.37).
- Poor scores on Brief Test of Attention and on Trails A were related to slower perception-reaction times and slower brake movement times during a computerized test of simple RT (Zhang et al., 2007).
- Panelists indicated that a selective attention deficit could be associated with the following critical driver performance errors: #2 gap judgment errors; #3 inability to predict development of future conflicts; #4 slowed vehicle control response; #5 inadequate visual search/improper lookout; #6 slowed decision making; #9 pedal errors (inappropriate response selection).

Included Behavioral Countermeasures

- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Conformal vision enhancement system
- Speed of processing training
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Collision warning systems
- Medical management (incl. pharmacy review)
- Cognitive rehab (incl. memory training) for normally aging population
- Compensatory cognitive/memory training for impaired/MCI population

CRASH TYPE 1: **Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: SELECTIVE ATTENTION		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	Ball, Owsley, Stalvey, Roenker, Sloane, and Graves (1998): No relationship between avoidance score and crashes in subsequent 3 year period. De Raedt and Ponjaert-Kristoffersen (2000): drivers who performed poorly on a road test but were free of (self-reported) at-fault crashes in the prior 12-mo period used significantly more strategic compensation tactics (avoidance of challenging situations) than poor-performing drivers with a history of at-fault crashes.	Panelists indicate this may or may not be effective; "we don't know if this works." People try to self-regulate when there are alternative transportation options, but there are times when they "must" drive even if they'd rather not (e.g., winter when it gets dark earlier, or no other driver to take them). Making people aware of deficits is the first step in getting people to self restrict, if they will self restrict.
Conformal vision enhancement system (e.g., in-vehicle enhancement of Stop Sign)	Caird, Horey, and Edwards (2001). Simulator study with 24 younger and 24 older drivers. Conformal enhancement of a traffic light resulted in fewer drivers running the light. Drivers indicated conformal VES would be helpful when environmental conditions restrict visibility, but not under heavy traffic, cluttered environments, or in daytime. Less than 25% indicated they would use VES regularly if available. Oxley and Mitchell (1995) reported that in a sample of older 31 UVES and 15 IVES users, 100% found it easy to use, and 60-73% indicated it would encourage them to drive outside of their usual driving situations. Gish, Staplin, &and Perel (1999) found that 3 of 4 older drivers did not use VES to detect targets, but instead used it to detect curves in the road (controlled field study).	Panelists state older drivers in focus groups don't like anything in their cars that takes their focus away from the road (either on the windshield or on a heads-down display in the vehicle). They would choose not to drive in challenging situations rather than to use a device that may take their attention from the road. Another panelist indicated that following training in equipment use, older drivers are ok with such countermeasures. Panelists stated this countermeasure needs further research for use in clients with selective attention deficits.
Speed of processing training	Roenker et al. (2003): Speed of processing training using all 3 subtests of UFOV compared to Doron simulator training and untrained reference group. Global ratings of on-road driving performance improved for both training groups, but only SOP group maintained performance at 18 mo. For "dangerous maneuvers" component, both training groups showed improvements, but only SOP training maintained improvement at 18 mo. Dangerous maneuvers included 6 opportunities for unprotected turns across traffic and 9 left-turn entrances to a high-traffic road.	Panelists agreed this may be a viable countermeasure, but there is a need to establish the link between training on task and transfer to driving.

CRASH TYPE 1: Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: SELECTIVE ATTENTION		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for selective attention deficits; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Collision warning systems	Oxley and Mitchell (1995): collision warning system tested in a simulator was effective in preventing older drivers from turning across traffic through gaps that were dangerously short.	Suggested by panelists as countermeasure that merits further research. Need forward as well as side-collision warning. Would be helpful if it caused the vehicle to brake, in addition to providing a warning.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.
Cognitive rehab (including memory training) for normally aging population	One panelist noted that reasoning training conducted as part of the ACTIVE trial described by Ball, Berch, Helmers, Jobe, Leveck, et al. (2002) showed an effect on decreased driving difficulty in the 6 years following enrollment in the study. These findings were presented at the 2008 GSA meeting, but not published as of the date of this report.	Panelists indicate this is building subskills for the driving task. An OT panelist noted that you cannot just do a lot of the cognitive retraining tasks and assume that it will generalize to driving. You need to make that part of the therapy program. Countermeasure has tremendous promise but it is just in its infancy for developing the training protocols, and making sure it is appropriate. There is a real need for good research to make sure that we use this appropriately.
Compensatory cognitive/memory training for impaired/MCI population		Panelists were cautious about recommending cognitive interventions for people with early stage dementia, and indicated that strategies must be compensatory rather than restorative for this group.

CRASH TYPE 1: **Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.**

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: DIVIDED ATTENTION

Associated Driver Performance Errors

- UFOV performance predicted on-road driving performance, and was significantly correlated with tactical anticipatory behavior in changing situation; visual behavior; and insight, sense of context, and practical implementation (De Raedt & Ponjaert-Kristoffersen, 2000).
- The greater the reduction in UFOV, the higher the likelihood of failing on-road test (Myers et al., 2000).
- Drivers with restrictions in UFOV (composite measure of all 3 tests, with a 40% or more deficit) had 15 times more intersection crashes (type not specified) in prior 5-year period than drivers with normal visual attention (Owsley et al., 1991).
- Drivers with UFOV divided attention deficit had a significantly higher odds of crashing (prospectively) than drivers with normal divided attn performance (crash type not specified) (Rubin et al., 2007; Staplin et al., 2003; Edwards et al., 2008).
- Divided attention deficit associated with prospective crashes, the majority of which were failure-to-yield the right of way (Owsley et al., 1998).
- Impairment in UFOV independently associated with difficulty driving in the rain (McGwin, Chapman, Owsley, 2000).
- In failure-to-yield crashes at intersections (e.g., proceeding after stopping at a stop sign, turning left at a green light, or right on a red light), the predominant error for drivers ages 80+ was search & detection errors; these occurred more frequently for drivers age 80+ (86%) than for drivers ages 35-54 (84%) and those age 70-79 (55%). Although drivers ages 35-54 made many search and detection errors, these were most often due to distraction, whereas drivers age 80+ most often "looked but did not see"/inadequate search ((Braitman et al., 2007).
- Panelists indicated that a divided attention deficit could be associated with the following critical driver performance errors: #2 gap judgment errors; #3 inability to predict development of future conflicts; #4 slowed vehicle control response; #5 inadequate visual search/improper lookout; #6 slowed decision making; #9 pedal errors (inappropriate response selection).

Included Behavioral Countermeasures

- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Speed of processing training
- Physical aerobic/activity training
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Collision warning systems
- Medical management (incl. pharmacy review)
- Cognitive rehab (incl. memory training) for normally aging population
- Compensatory cognitive/memory training for impaired/MCI population

CRASH TYPE 1: **Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: DIVIDED ATTENTION		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	Ball, Owsley, Stalvey, Roenker, Sloane, and Graves (1998): No relationship between avoidance score and crashes in subsequent 3 year period. De Raedt and Ponjaert-Kristoffersen (2000): drivers who performed poorly on a road test but were free of (self-reported) at-fault crashes in the prior 12-mo period used significantly more strategic compensation tactics (avoidance of challenging situations) than poor-performing drivers with a history of at-fault crashes. Hennessy (1995): poorer divided attention ability was significantly associated with greater avoidance of driving at night, rain, dusk, dawn, alone, left turns, and heavy traffic, but the predictive value of the divided attention subtask of UFOV on crash rate (prior 3 yrs) was not mediated by any of the forms of self restriction. Owsley et al. (1998) found that older drivers with UFOV reduction of 40% or more and who reported driving fewer than 7 days per week had a 45% decreased crash risk compared to older drivers with a 40% or more reduction in UFOV who reported driving 7 days/week.	Panelists indicate this may or may not be effective; "we don't know if this works." People try to self-regulate when there are alternative transportation options, but there are times when they "must" drive even if they'd rather not (e.g., winter when it gets dark earlier, or no other driver to take them). Making people aware of deficits is the first step in getting people to self restrict, if they will self restrict.
Speed of processing training	Roenker et al. (2003): Speed of processing training using all 3 subtests of UFOV compared to Doron simulator training and untrained reference group. Global ratings of on-road driving performance improved for both training groups, but only SOP group maintained performance at 18 mo. For "dangerous maneuvers" component, both training groups showed improvements, but only SOP training maintained improvement at 18 mo. Dangerous maneuvers included 6 opportunities for unprotected turns across traffic and 9 left-turn entrances to a high-traffic road.	Panelists agreed this may be a viable countermeasure, but there is a need to establish the link between training on task and transfer to driving.
Physical aerobic activity/training	Marmeleira, Godinho, and Fernandes (2008) found that a 12-week exercise program with 3, 60-min sessions per week improved visual attention in speed of processing and divided attention (using the UFOV protocol) at 12 weeks follow-up in adults ages 60 to 81. The intervention incorporated perceptual and cognitive tasks (problem solving and responding to challenging situations) with aerobic activity. Examples are: walking while listening for auditory cues to perform fast and specific psychomotor responses). At 12 weeks, speed of processing and divided attention were significantly improved compared to baseline for the exercise group; at baseline, there was no difference between groups. Actual driving performance was not studied, and there was no exercise-only group to determine the contribution of physical activity alone on speed of processing or divided attention.	Research article provided by panelist following meeting; panelists did not get to comment on countermeasure for deficit. Merits further research.

CRASH TYPE 1: **Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: DIVIDED ATTENTION		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley et al. (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for divided attention deficits; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Collision warning systems	Oxley and Mitchell (1995): collision warning system tested in a simulator was effective in preventing older drivers from turning across traffic through gaps that were dangerously short.	Suggested by panelists as countermeasure that merits further research. Need forward as well as side-collision warning. Would be helpful if it caused the vehicle to brake, in addition to providing a warning.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.
Cognitive rehab (including memory training) for normally aging population	OTs noted that there are protocols and treatments for retraining attention, but cognitive rehab literature shows efficacy of attentional therapy in the broader rehab area ("Society for Cognitive Rehab"). It doesn't directly address driving, but builds subskills for the driving task.	Panelists indicate this is building subskills for the driving task. An OT panelist noted that you cannot just do a lot of the cognitive retraining tasks and assume that it will generalize to driving. You need to make that part of the therapy program. Countermeasure has tremendous promise but it is just in its infancy for developing the training protocols, and making sure it is appropriate. There is a real need for good research to make sure that we use this appropriately.
Compensatory cognitive/memory training for impaired/MCI population	Klavora et al. (1995) conducted a before-after study with 10 stroke patients with visual and attentional difficulties and rated unsafe to drive. Following training with a Dynavision apparatus, 6 of 10 participants earned a rating of "safe to resume driving and/or to receive on-road driving lessons."	Panelists were cautious about recommending cognitive interventions for people with early stage dementia, and indicated that strategies must be compensatory rather than restorative for this group.

CRASH TYPE 1: **Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.**

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: WORKING MEMORY

Associated Driver Performance Errors

- Lee, Lee, Cameron, and Li-Tsang (2005) found that poor performance on a working memory task by older drivers (ages 60-88) during simulated driving was significantly associated with self-reported crashes in the prior 1-year period.
- Hunt, Morris, Edwards, and Wilson (1993) found a significant correlation between pass/fail outcome on a road test and performance on the Logical memory subscale of the Wechsler Memory Scale (assessing immediate and delayed recall).
- Szlyk, Myers, Zhang, Wetzel, and Shapirio (2002) found that older drivers with poor performance on several measures of working memory had poorer performance in a driving simulator (drove at slower speed, and had more lane boundary crossings) than drivers with better performance on the working memory tasks.
- Panelists indicated a working memory deficit could be associated with the following critical driver performance errors: #2 gap judgment errors; #3 inability to predict the development of future conflicts from current traffic and contextual information.

Included Behavioral Countermeasures

- Physical aerobic/activity training
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Medical management (incl. pharmacy review)
- Cognitive rehab (incl. memory training) for normally aging population
- Compensatory cognitive/memory training for impaired/MCI population
- Pre-trip planning

CRASH TYPE 1: **Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: WORKING MEMORY		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Physical aerobic activity/training		Panelists indicated this countermeasure merits further research for remediation of working memory deficits, stating a large body of research showing aerobic exercise results in alertness--hippocampul regeneration.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)		Panelists state all 3 types of education may be useful for working memory deficits; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.
Cognitive rehab (including memory training) for normally aging population	OTs noted that there are protocols and treatments for retraining attention, but cognitive rehab literature shows efficacy of attentional therapy in the broader rehab area ("Society for Cognitive Rehab"). It doesn't directly address driving, but builds subskills for the driving task. Laderman, Szlyk, Kelsch, and Seiple (2000) found improvement in visual memory (remembering store names subjects had walked past) after practice in the laboratory recalling sequences of numbers, letters, and shapes presented briefly on 35-mm slides.	Panelists indicate this is building subskills for the driving task. An OT panelist noted that you cannot just do a lot of the cognitive retraining tasks and assume that it will generalize to driving. You need to make that part of the therapy program. Countermeasure has tremendous promise but it is just in its infancy for developing the training protocols, and making sure it is appropriate. There is a real need for good research to make sure that we use this appropriately.
Compensatory cognitive/memory training for impaired/MCI population		Panelists were cautious about recommending cognitive interventions for people with early stage dementia, and indicated that strategies must be compensatory rather than restorative for this group.
Pre-trip planning		Countermeasure suggested by panelists as meriting further research

CRASH TYPE 1: **Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.**

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: EXECUTIVE FUNCTION (JUDGMENT/DECISION-MAKING)

Associated Driver Performance Errors

- Association between poor performance on Trails B Test (a measure of executive function) and retrospective (Stutts et al., 1998; Goode et al., 1998; Daigneault et al., 2002) and prospective state-recorded crashes (Staplin et al., 2003) and poor simulator (Rizzo et al., 1997; Szlyk et al., 2002)) and on-road performance (Tarawneh et al., 1993), although type of crash not specified.
- Poor performance on a maze test (also measures executive functioning) was correlated with road test failure (Snellgrove, 2005; Ott et al., 2008). Age-related declines in executive control function include planning, scheduling, working memory, inhibitory processes, and multi-tasking.
- Panelists indicated that an executive function deficit could be associated with the following critical driver performance errors: #2 gap judgment errors; #3 inability to predict development of future conflicts; #4 slowed vehicle control response; #5 inadequate visual search; #6 slowed decision making; and #9 pedal errors (inappropriate response selection).

Included Behavioral Countermeasures

- Physical aerobic/activity training
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Medical management (incl. pharmacy review)
- Cognitive rehab (incl. memory training) for normally aging population
- Compensatory cognitive/memory training for impaired/MCI population
- Pre-trip planning

CRASH TYPE 1: Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: EXECUTIVE FUNCTION (JUDGMENT/DECISION-MAKING)		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Physical aerobic activity/training	• No studies on improvement in driving, however, Colcombe and Kramer (2003) found the largest positive effects of fitness training and cognitive functioning in older (non-demented) adults was on executive control processes. Programs combining aerobic training with strength and flexibility training had the largest effects. • Conflicting evidence was found by Marmeleira, Godinho, and Fernandes (2008); an exercise program incorporating walking with cognitive and perceptual tasks resulted in no improvement on tests of executive function (Stroop or Trails B) from baseline to 12-weeks post intervention.	Panelists indicated this may be an appropriate countermeasure for deficits in executive function, but requires further research. A panelist mentioned that the literature in the area of exercise and cognitive function is mixed, with some studies showing improvement and others showing no effect. One problem with the research may be that the exercise interventions are too brief to result in an improvement.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	• Marottoli (2007): AAA Safe Driving for Mature Operators presented in 2, 4-hour sessions with supplemental topics (including search strategies for intersections), plus 2, 1-hour BTW sessions focused on common errors made by older persons. BTW performance assessed at baseline and 8 weeks post-intervention included 31 T-type intersections and 32 crossing intersections, 11 of which were stop controlled. 15 left turns were made. Post-test scores were significantly higher than baseline, translating to 9.5% decrease in crash risk over 2-year period. One of the items showing the most improvement was judgment. • Eby, Molnar, Shope, Vivoda, and Fordyce (2003). Driving Decisions Workbook (a self assessment tool) was effective in increasing older drivers' awareness of changes in driving abilities related to aging, and effects of changes on driving. Participants stated they would seek 2nd tier assessment and change driving habits. • Skufca (2008): AARP DSP participants indicated course encouraged them to change certain driving behaviors (20% indicated avoiding left turns as a new behavior).	Panelists state all 3 types of education may be useful for deficits in executive functioning; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.
Cognitive rehab (including memory training) for normally aging population		Panelists indicate this is building subskills for the driving task. An OT panelist noted that you cannot just do a lot of the cognitive retraining tasks and assume that it will generalize to driving. You need to make that part of the therapy program. Countermeasure has tremendous promise but it is just in its infancy for developing the training protocols, and making sure it is appropriate. There is a real need for good research to make sure that we use this appropriately.
Compensatory cognitive/memory training for impaired/MCI population		Panelists were cautious about recommending cognitive interventions for people with early stage dementia, and indicated that strategies must be compensatory rather than restorative for this group.
Pre-trip planning		Countermeasure suggested by panelists as meriting further research.

CRASH TYPE 1: **Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.**

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: SPATIAL ABILITIES

Associated Driver Performance Errors

- Errors in distance judgment and difficulty predicting the development of traffic situations (Johansson & Lundberg, 1997). Poor performance on clock-drawing test (a measure of visuospatial functioning) accounted for 38% of the variance in road test performance in sample referred for fitness to drive assessment (excluded persons suspected of dementia or cognitive decline); Specific errors not described in correlational analysis (De Raedt & Ponjaert-Kristoffersen, 2001).
- Impaired pentagon copying performance was associated with adverse driving events (crashes, violations), but type not specified (Marottoli et al., 1994).
- Poor performance on the MVPT Visual Closure subscore was associated with crashes (type not specified) in 20-month follow-up period (Staplin et al., 2003), and on poor road test performance (Tarawneh et al., 1993).
- Older, crash-involved subjects with suspended licenses performed worse on tests of visuospatial abilities than older non-crash-involved drivers with suspended licenses, and older drivers with clean records. A main violation type leading to crashes and suspensions included failure to yield the right of way (Lundberg et al., 1998).
- Poor performance on tests of spatial ability (Rey-Osterreith Complex Figures & Wechsler Memory Scale) discriminated crash-involved from crash-free drivers in prior 5-year period (Goode et al., 1998).
- Panelists indicated that a deficit in spatial abilities could be associated with the following critical driver performance errors:#2 gap judgment errors; #3 inability to predict the development of future conflicts; #5 inadequate visual search/improper lookout; and #6 slowed decision making.

Included Behavioral Countermeasures

- Visual perceptual therapy
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Medical management (incl. pharmacy review)

CRASH TYPE 1: **Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: SPATIAL ABILITIES		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Visual perceptual therapy	McCoy et al. (1993): Evaluated workbook exercises to improve visual perception in 5 areas: spatial relationships, visual discrimination, figure ground, visual closure, and visual memory. Before-after on-road driving performance (DPM technique) improved by 7.7 percentage points, compared to no improvement in control group.	Panelists indicated this countermeasure merits further research for remediation of deficits in spatial abilities.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)		Panelists state all 3 types of education may be useful for deficits in spatial abilities; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. OTs note that if there is a serious deficit, driving should be ruled out. Spatial abilities deficits manifest themselves in lane control difficulty. They will start with easy situations and progress to more difficult situations if there is improvement. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.

CRASH TYPE 1: **Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.**

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: KNOWLEDGE

Associated Driver Performance Errors

- Older drivers may not be aware that cross traffic does not stop, at two-way stop-controlled intersections {FHWA Highway Design Handbook for Older Drivers and Pedestrians (Staplin et al., 2001)}.
- Driver misunderstanding of rules of the road and right-of-way at intersections controlled by stop signs. Older drivers often fail to come to a complete stop or to stop at all. Older drivers often stop and then pull out in front of oncoming traffic. {FHWA Highway Design Handbook for Older Drivers and Pedestrians (Staplin et al., 2001)}.
- Panelists indicated a knowledge deficit could be associated with the following critical driver performance errors: #3 inability to predict the development of future conflicts; #7 lack of understanding of rules of the road; #8 lack of understanding or failure to apply safe driving practices.

Included Behavioral Countermeasures

- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)
- Medical management (incl. pharmacy review)
- Pre-trip planning

CRASH TYPE 1: **Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: KNOWLEDGE		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Driver safety education (Theory/Classroom)	• Skufca (2008): AARP DSP participants indicated course encouraged them to change certain driving behaviors, specifically 20% indicated avoiding left turns as a consequence of information learned. • Kutner (2006): No difference in crash rate (self reported) in prior 12-month period for AARP Driver Safety program participants and comparison group of not-AARP DSP participants. • Bedard et al. (2004). Canadian Safety council adaptation of AARP DSP evaluated for treatment and comparison group using an on-road evaluation at baseline and post-treatment. On-road evaluation scores improved significantly for treatment and control group from baseline to post-intervention; no significant difference between treatment and comparison group on mean change score from the first to second evaluation. • Janke (1994). Completion of Mature Driver Improvement Program was associated with more total fatal injury crashes and fewer citations compared with group who did not attend course. • Eby, Molnar, Shope, Vivoda, and Fordyce (2003). Driving Decisions Workbook (a self assessment tool) was effective in increasing older drivers' awareness of changes in driving abilities related to aging, and effects of changes on driving. participants stated they would seek 2nd tier assessment and change driving habits; no evaluation on whether drivers followed through on these plans. • McCoy et al. (1993). Completion of AAA Safe Driving for Mature Operators was associated with a significant increase in on-road driving performance (baseline and post intervention road test using DPM technique) of 3.7 percentage points. Education plus physical therapy increased score by 8.7 percentage points; education plus perceptual therapy increased score by 13.9 percentage points. • Nasvadi and Vavrik (2007). Evaluation of British Columbia Safety Council adaptation of AARP DSP comparing police-reported at-fault crash and violation rate for participants vs. non-participants in prior 2-year period, to determine whether self-selection bias exists for those who attend remedial safety courses. Significantly more participants than controls had crashed, but there was no difference in violation rate. A follow-up comparison of crash rate for subsequent 2-year period for attendees and controls with matched pre-course crash rate showed that more attendees had crashes than non-attendees, but the difference was not significant. However, when stratifying by age group and gender, males age 75+ who attended the course were 3.8 times more likely to be involved in a crash than controls who did not attend class. No difference in crash rate for men ages 55-74 or women ages 55-74 and those 75+.	General consensus that it makes sense to provide education, even if it isn't adequate; people will be people, and it may work for some and not others. Education (theory) alone may never be enough; may need to be coupled with skills training.

CRASH TYPE 1: **Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: KNOWLEDGE		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Driver safety education (Theory + BTW)	Marottoli (2007): AAA Safe Driving for Mature Operators presented in 2, 4-hour sessions with supplemental topics (including search strategies for intersections), plus 2, 1-hour on-road driving sessions focused on common errors made by older persons. On road performance assessed at baseline and 8 weeks post-intervention included 31 T-type intersections and 32 crossing intersections, 11 of which were stop controlled. 15 left turns were made. Post-test scores were significantly higher than baseline, translating to 9.5% decrease in crash risk over 2-year period. One of the items showing the most improvement was judgment. Bedard et al. (2008): Significant improvement in knowledge, but no change in driving performance for the category of signal violations/right of way/inattention.	General consensus that it makes sense to provide education, even if it isn't adequate; people will be people, and it may work for some and not others. Education (theory) alone may never be enough; may need to be coupled with skills training.
Driver safety education (Interactive/computer-based)		Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)		Panelists state that vehicles have safety features but many need to be adjusted, and older drivers don't know how to do this. Education about driving aids is a positive theme to staying on the road longer. Countermeasure merits further research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.
Pre-trip planning		Countermeasure suggested by panelists as meriting further research

CRASH TYPE 1: **Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.**

GENERAL DEFICIT: PHYSICAL/PSYCHOMOTOR

SPECIFIC DEFICIT: HEAD/NECK/TRUCK RANGE OF MOTION

Associated Driver Performance Errors

- Impairment in head/neck range of motion would result in driver inability to detect vehicles approaching on cross street at sufficient distance to perform left turn maneuver safely.
- Maximum achieved head movement angles of a sample of older drivers would not be sufficient to bring approaching traffic at a T-intersection into central vision at distances exceeding 20 m without additional eye movements; deficits in peripheral vision would further delay perception of approaching vehicles (Isler et al., 1997).
- Limited range of motion of neck is significantly associated with adverse driving events (self reported, prior 5 years) (Marottoli et al., 1998).
- Range of motion significantly associated with pass/fail performance on road test (McCarthy & Mann, 2006).
- Decision time to make a left turn in a simulator study increased, with increases in the level of neck impairment (Hunter-Zaworski, 1990).
- Impaired ability to turn head (to check over shoulder) significantly predicted at-fault crashes in 20-month follow up period (Staplin et al., 2003).
- Crash-involved older drivers were 1.25 times more likely to have medical diagnosis of joint/spine disorders in 2-yr period prior to crash than non-crash-involved controls (Cui, 2001).
- Self-reported health symptoms relating to spine and lower body (limited strength or movement, lack of feeling or sensation, involuntary movement, chronic pain) related to self reported driving difficulties, and lack of physical activity related to difficulty with shoulder checking (Tuokko et al., 2007).
- Panelists indicated a deficit in head/neck trunk range of motion could be associated with the following critical driver performance errors: #1 failure to visually detect potential conflicts, hazards, or traffic control information; #4 slowed vehicle control response.

Included Behavioral Countermeasures

- Training in compensatory head/eye movements, scanning strategies
- Physical aerobic/activity training
- Strength and flexibility exercises
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)
- Collision warning systems
- Medical management (incl. pharmacy review)

CRASH TYPE 1: **Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: HEAD/NECK/TRUNK RANGE OF MOTION		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Training in compensatory head/eye movements, scanning strategies		Panelists agreed that this is an appropriate countermeasure, but candidates must be cognitively intact. This type of training has been used for telescopic and amorphic-lens drivers ("search and destroy" method) and has been effective in improving peripheral visual detection.
Physical aerobic/activity training	May be research from Art Kramer at the University of Illinois looking at physical exercise programs and driving (simulator).	Merits further research.
Strength and flexibility exercises	Ostrow et al. (1992). Exercise program: chin flexion/extension, neck rotations, head side bending, chin tucks, rotating shoulders backward, and trunk rotations. Sig. improvements in trunk rotation and shoulder flexibility across experimental subjects' 3 testing sessions (baseline, 8 and 11 weeks). S's in experimental group showed improvements in field-based assessment of driving skill: looked more frequently to the sides and rear of their vehicle than control drivers who did not participate in program. Marottoli et al. (2007) 12 week, in-home exercises 15 minutes daily, 7 days/week, with weekly in-home visit by physical therapist. Exercises focused on axial/extremity condition, upper extremity coordination/dexterity, and gait abnormalities. On-road driving performance was measured at baseline and post-intervention for treatment and control group. Significant improvement for treatment group compared to control group translated to 8 to 16% lower crash occurrence over 2 year period. Intervention group also made 37% fewer critical errors (inattention, turning or changing lanes w/o looking, and disobeying signs or signals) than control group at follow up. McCoy et al. (1993): Home-based exercises designed to improve posture, trunk rotation, neck flexibility, shoulder flexibility. 1-hour training session followed by 8 weeks of exercise, 4 times per week. Post intervention On-road drive test performance improved by 6.8 percentage points (significant), and when physical therapy was combined with driver education, improvement increased by 8.7 percent.	Panelists agreed that this is an appropriate countermeasure
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)		Panelists state all 3 types of education may be useful for deficits in head/neck/trunk range of motion; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.

CRASH TYPE 1: **Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: HEAD/NECK/TRUNK RANGE OF MOTION		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)		Panelists state that vehicles have safety features but many need to be adjusted, and older drivers don't know how to do this. Education about driving aids is a positive theme to staying on the road longer. Countermeasure merits further research.
Collision warning systems	Oxley and Mitchell (1995): collision warning system tested in a simulator was effective in preventing older drivers from turning across traffic through gaps that were dangerously short.	Suggested by panelists as countermeasure that merits further research. Need forward as well as side-collision warning. Would be helpful if it caused the vehicle to brake, in addition to providing a warning.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients. Impairments in psychomotor functioning may result from musculoskeletal disease leading to weakening, frailty, and/or restricted range of motion. Medical management of arthritis is important.

CRASH TYPE 1: **Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.**

GENERAL DEFICIT: PHYSICAL/PSYCHOMOTOR

SPECIFIC DEFICIT: ARM STRENGTH/RANGE OF MOTION/SPEED OF MOVEMENT

Associated Driver Performance Errors

- Slow steering through turn, resulting in longer maneuver time, resulting in shorter time to collision with vehicle approaching from right (Yan, Radwan, & Guo, 2007).
- Older women with difficulty extending arms above their shoulders had increased crash risk (Hu et al., 1998). Difficulty reaching out was significantly associated with crashes in prior 6 years (Sims et al., 1998).
- Crash type not specified in research studies. Range of motion significantly associated with pass/fail performance on road test (McCarthy & Mann, 2006).
- Panelists indicated a deficit in arm strength/range of motion/speed of movement could be associated with slowed vehicle control response (critical driver performance error #4) .

Included Behavioral Countermeasures

- Physical aerobic/activity training
- Strength and flexibility exercises
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)
- Medical management (incl. pharmacy review)

CRASH TYPE 1: **Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: ARM STRENGTH/RANGE OF MOTION/SPEED OF MOVEMENT		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Physical aerobic activity/training	May be research from Art Kramer at the University of Illinois looking at physical exercise programs and driving (simulator).	Merits further research.
Strength and flexibility exercises	Marottoli et al. (2007) 12 week, in-home exercises directed by physical therapist focusing on axial/extremity condition, upper extremity coordination/dexterity, and gait abnormalities. On-road driving performance was measured at baseline and post-intervention for treatment and control group. Significant improvement for treatment group compared to control group translated to 8 to 16 percent lower crash occurrence over 2 year period. Intervention group also made 37% fewer critical errors (inattention, turning or changing lanes w/o looking, and disobeying signs or signals) than control group at follow up.	Panelists agreed that this is an appropriate countermeasure
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)		Panelists state all 3 types of education may be useful for deficits in arm strength/range of motion/speed of motion; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)		Panelists state that vehicles have safety features but many need to be adjusted, and older drivers don't know how to do this. Education about driving aids is a positive theme to staying on the road longer. Countermeasure merits further research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients. Impairments in psychomotor functioning may result from musculoskeletal disease leading to weakening, frailty, and/or restricted range of motion. Medical management of arthritis is important.

CRASH TYPE 1: **Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.**

GENERAL DEFICIT: PHYSICAL/PSYCHOMOTOR

SPECIFIC DEFICIT: LEG STRENGTH/RANGE OF MOTION/SPEED OF MOVEMENT

Associated Driver Performance Errors

- Slow accelerating through turn and into traffic stream resulting in longer maneuver time, resulting in shorter time to collision with vehicle approaching from right (Yan, Radwan, & Guo, 2007).
- Poor performance on rapid pace walk is associated with adverse driving events (Crashes, violations) (Marottoli et al., 1994; Staplin et al., 2003), and pass/fail performance on road test (McCarthy & Mann, 2006).
- Range of motion significantly associated with pass/fail performance on road test (McCarthy & Mann, 2006).
- Older drivers reporting pain in the feet, hips, legs, or current treatment for arthritis had significantly slower brake reaction speeds (both initial reaction and physical response speed) than drivers with no complaints of pain in these areas (Zhang et al., 2007).
- Panelists indicated a deficit in leg strength/range of motion/speed of movement could be associated with slowed vehicle control response (critical driver performance error #4).

Included Behavioral Countermeasures

- Physical aerobic/activity training
- Strength and flexibility exercises
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)
- Medical management (incl. pharmacy review)

CRASH TYPE 1: **Left turn at an intersection with stop-sign control for the older driver's approach. Cross traffic does not stop.**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: LEG STRENGTH/RANGE OF MOTION/SPEED OF MOVEMENT		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Physical aerobic activity/training	May be research from Art Kramer at the University of Illinois looking at physical exercise programs and driving (simulator).	Merits further research.
Strength and flexibility exercises	Marottoli et al. (2007) 12 week, in-home exercises directed by physical therapist focusing on axial/extremity condition, upper extremity coordination/dexterity, and gait abnormalities. On-road driving performance was measured at baseline and post-intervention for treatment and control group. Significant improvement for treatment group compared to control group translated to 8 to 16 percent lower crash occurrence over 2 year period. Intervention group also made 37% fewer critical errors (inattention, turning or changing lanes w/o looking, and disobeying signs or signals) than control group at follow up.	Panelists agreed that this is an appropriate countermeasure
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)		Panelists state all 3 types of education may be useful for deficits in leg strength/range of motion/speed of movement; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)		Panelists state that vehicles have safety features but many need to be adjusted, and older drivers don't know how to do this. Education about driving aids is a positive theme to staying on the road longer. Countermeasure merits further research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients. Impairments in psychomotor functioning may result from musculoskeletal disease leading to weakening, frailty, and/or restricted range of motion. Medical management of arthritis is important.

CRASH TYPE 2: Left turn at an intersection with signal control; permissive phase for older driver's approach.

FUNCTIONAL DEFICITS THAT MAY INFLUENCE CRASH RISK

SENSORY/PERCEPTUAL (VISION)

- Acuity
- Contrast Sensitivity
- Visual Fields
- Depth and Motion Perception (Angular Motion Sensitivity)

ATTENTION/COGNITION

- Speed of Processing
- Selective Attention
- Divided Attention
- Working Memory
- Executive Function (Judgment and Decision Making)
- Spatial Abilities
- Knowledge (Rules of the Road and Safe Driving Strategies)

PHYSICAL/PSYCHOMOTOR

- Arm Strength/Range of Motion/Speed of Movement
- Leg Strength/Range of Motion/Speed of Movement

CRASH TYPE 2: **Left turn at intersection with signal control; permissive phase for older driver's approach.**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION)

SPECIFIC DEFICIT: ACUITY

Associated Driver Performance Errors

- Could contribute to a failure to visually detect a potential threat.
- Acuity poorer than 20/40 independently associated with self-reported crashes, moving violations, being stopped by police in prior 5-year period (Marottoli et al., 1998).
- Acuity (score and response time) related to unsafe driving incidents; correlations higher for time to respond to acuity stimuli than acuity errors (McKnight & McKnight, 1999).
- Acuity response time rather than acuity score related to driving exam score (Staplin et al., 1998).
- Acuity slightly worse than 20/30 independently associated with self-reported difficulty driving on interstates, at night, in the rain, on high-traffic roads, during rush hour, alone, and making left turns (McGwin, Chapman, Owsley, 2000).
- Poorer dynamic acuity related to crash involvement in prior 2-year period (Shinar, Mayer, Treat, 1975).
- Dynamic acuity included in model predictive of closed course driving performance (Wood, 2002).
- Significant relationship between acuity and improper lookout (Shinar, McDonald, & Treat, 1978).
- Visual impairment worse than 20/30 in the better eye was independently associated with self-reported difficulty making left turns in sample of 384 drivers ages 55-85 (McGwin, Chapman, & Owsley, 2000. Refractive error most frequent cause of impairment for the subsample with acuity worse than 20/40 but better than 20/60; cataract next most frequent cause (both conditions are correctable).
- Combined criterion using acuity, CS, and horizontal visual fields significantly related to prior crash involvement in drivers age 66+, but no visual measure alone was significantly associated (Decina and Staplin, 1993).

Included Behavioral Countermeasures

- Refractive correction (incl. Wavefront technology)
- Cataract surgery
- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Central vision enhancement systems (bioptic telescopic lenses, implantable telescopes)
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Collision warning systems
- Medical management (incl. pharmacy review).

CRASH TYPE 2: **Left turn at intersection with signal control; permissive phase for older driver's approach.**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: ACUITY		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Refractive correction (incl. Wavefront technology)	No before-after studies on refraction correction (updating prescription for corrective glasses) and driving safety uncovered. Panelist with expertise in the area stated that in the ophthalmology literature there is quite a bit of research on age and satisfaction for refractive errors corrective surgery. There is actually quite ample literature on people's feelings about their improved performance in everyday tasks there, clarity with which they can see things. It would seem reasonable that one would have asked the question about improved driving performance as a result of refractive error correction, but the panelist was not aware of anything done. Haddrill (2007): Ophthonix founder A. Dreher reports that iZon lenses (wavefront lenses) provide higher definition vision in the daytime and significantly improve night driving responses when compared with conventional lenses. Night vision improved a driver's ability to identify pedestrians by an average of 330 ms (30 ft sooner at 55 mi/h) when compared to conventional lenses. www.allaboutvision.com/lenses/wavefront-lenses.htm; http://ophthonix.izonlens.com/globals/faqs.asp; www.allaboutvision.com/whatsnew/lenses1.htm.	Even without research on effectiveness, panelists agreed that refractive correction should be advocated just on the prevalence of the problem and the inexpensiveness of the solution, particularly as there appears to be a decline in older people getting annual eye exams. Annual eye exams, refractive correction, and sooner diagnosis of treatable conditions (e.g., cataracts) are inexpensive solutions for reaching a substantial number of people for remediation. Vision specialist feedback to drivers regarding the driver licensing laws in their State in relation to their own level of impairment is important (and presently rare in practice); increasing awareness of impairments may lead to appropriate self-restriction. One of the early findings of the Salisbury Eye Study was that among the proportion of older individuals who had worse than 20/40 vision, more than half of them could be corrected just with glasses. A panel member (vision specialist) recommended inclusion of Wavefront technology as part of refractive correction. Wavefront technology diagnoses higher-order vision errors represented by the way the eye refracts or focuses light; such aberrations defocus images even with 20/40 acuity. Wavefront guided lenses can reduce certain higher-order aberrations, which potentially can improve low light image quality during activities such as driving at night. Panelist notes research on effectiveness for driving is currently limited to that conducted by lens manufacturer (see Haddrill 2007 description of Ophthonix iZon wavefront guided lenses). Another caution noted by the panelist regarding the lens company research is that improvements in vision with the wavefront lenses were compared to patients' vision as they appeared for the study. But it is well known that many patients especially over age 60 haven't had regular eye check-ups or new prescriptions.
Cataract surgery	McGwin, Scilley, Brown, and Owsley (2003) found improvements in acuity with cataract surgery, and that improvement in visual acuity had a significant, independent association with the change in activities of daily vision scale (that includes daytime and nighttime driving). Wood and Carberry (2006) found that improvement in acuity that accompanied cataract surgery was related to improvement in overall driving score.	Panelists agree this is a relatively inexpensive treatment and improvements result in crash reduction. Cataracts are often the only medical condition affecting driving performance. Even if crash reduction benefit is small, cataract surgery may provide a large public health benefit because of the large number of people affected by cataracts.
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	• Gallo, Rebok, and Lesikar (1999). Self-reported vision impairment was related to avoidance of challenging driving situations, but not to self-reported citations or crashes in prior 2 years. Authors conclude that vision impaired drivers who self restrict are less likely to crash. Vision impairment categories: no trouble seeing; a little trouble, a lot of trouble (i.e., may not be specific to acuity). • Ball, Owsley, Stalvey, Roenker, Sloane, and Graves (1998): No relationship between avoidance score and crashes in subsequent 3 year period. • De Raedt and Ponjaert-Kristoffersen (2000): poor performers on a road test but were free of (self-reported) at-fault crashes (prior 12 mo) used significantly more strategic compensation tactics (avoidance of challenging situations) than poor-performing drivers with a history of at-fault crashes.	Panelists indicate this may or may not be effective; "we don't know if this works." People try to self-regulate when there are alternative transportation options, but there are times when they "must" drive even if they'd rather not (e.g., winter when it gets dark earlier, or no other driver to take them). Making people aware of deficits is the first step in getting people to self restrict, if they will self restrict. Studies show that there are many unaware vision-impaired drivers. Ophthalmologists and optometrists need to be included as targets of outreach, similarly to the AMA guide, and other outreach efforts that NHTSA has done for specialized populations because, eyecare specialists are a group that does not know their red flags to tell patients that "these are the laws in our state and this is what you need to be concerned about."

CRASH TYPE 2: **Left turn at intersection with signal control; permissive phase for older driver's approach.**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: ACUITY		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Central vision enhancement systems (bioptic telescopic lenses, implantable telescopes)	Janke and Kazarian (1983): Crash rate in users is 1.5 times higher than population rate, but less than the crash rate of drivers licensed with other medical conditions. Clark (1996): Crash rates for BTL users 1.9 times higher than comparison group, but citation rates 0.7 of that for comparison group. Szlyk et al. (2000): Training in the use of BTL lenses (both lab and on-road) significantly increased performance in recognition, peripheral identification, and scanning compared to performance of non-trained BTL users.	Panelists in agreement with countermeasure if accompanied by training and assessment of driving safety after training. Recommend licensing with restrictions after low-driving program/rehab. Use lens only for spotting (5-10% of time). Training curriculum and design of lenses needs to be "nailed down." Training curriculum needs to be developed by Occupational Therapists. Countermeasure appropriate if no cognitive deficit.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for acuity deficit; raises awareness of deficit so they can self restrict. Also provide education to physicians and eyecare specialists so they can educate their patients. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. Panelist (a KEYS study author) noted that he has always questioned whether those self reported changes in driving habits were real; people may have been invested due to time spent in intervention and reported more avoidance than they really engaged in. Also, candidates for education intervention should not have advanced cognitive deficits (e.g., dementia). Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Collision warning systems	Oxley and Mitchell (1995): collision warning system tested in a simulator was effective in preventing older drivers from turning across traffic through gaps that were dangerously short.	Suggested by panelists as countermeasure that merits further research. Need forward as well as side-collision warning. Would be helpful if it caused the vehicle to brake, in addition to providing a warning. Concern is with complete reliance on the technology to detect hazards (especially for backing up) where older drivers back up without doing head/shoulder checks and have backed into (and killed) pedestrians. Also elderly people may be more distracted rather than assisted by some of the advanced technologies. And, most rehab center's adapted cars are not high-end/high tech, so it would be difficult for OTs to train people in the use of the technologies.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients

CRASH TYPE 2: **Left turn at intersection with signal control; permissive phase for older driver's approach.**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION)

SPECIFIC DEFICIT: CONTRAST SENSITIVITY

Associated Driver Performance Errors

- Could contribute to a failure to visually detect a potential threat.
- Poor contrast sensitivity been correlated with poor driving performance (Wood, 2002; Baldock et al., 2007) and increased crash risk in prior 5-year period (Owsley, Stalvey, Wells, Sloane, & McGwin, 2001).
- Decreased contrast sensitivity in the better eye was independently associated with self-reported difficulty making left turns (McGwin, Chapman, and Owsley (2000).
- Contrast sensitivity along with visual spatial memory and 2 measures of visual attention RT explained 35% of the variance in driving ability demonstrated in on-road test (Baldock, Mathias, McLean, & Berndt, 2007).

Included Behavioral Countermeasures

- Refractive correction (incl. Wavefront technology)
- Cataract surgery
- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Conformal vision enhancement system (e.g., in-vehicle enhancement of Stop Sign)
- Central vision enhancement systems (bioptic telescopic lenses, implantable telescopes)
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Collision warning systems
- Medical management (incl. pharmacy review)

CRASH TYPE 2: **Left turn at intersection with signal control; permissive phase for older driver's approach.**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: CONTRAST SENSITIVITY		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Refractive correction (incl. Wavefront technology)	Haddrill (2007): Ophthonix founder A. Dreher reports that iZon lenses (wavefront lenses) provide higher definition vision in the daytime and significantly improve night driving responses when compared with conventional lenses. Night vision improved a driver's ability to identify pedestrians by an average of 330 ms (30 ft sooner at 55 mi/h) when compared to conventional lenses. www.allaboutvision.com/lenses/wavefront-lenses.htm; http://ophthonix.izonlens.com/globals/faqs.asp; www.allaboutvision.com/whatsnew/lenses1.htm.	Wavefront technology diagnoses higher-order vision errors represented by the way the eye refracts or focuses light; such aberrations defocus images even with 20/40 acuity. Wavefront guided lenses can reduce certain higher-order aberrations, which potentially can improve low light image quality during activities such as driving at night. Panelist notes research on effectiveness for driving is limited to that conducted by lens manufacturer. Wavefront technology may address the contrast sensitivity issue without gizmos on the dashboard or other technology; there is a lot of promise there, but there needs to be some research in the area.
Cataract surgery	Monestam and Wachtmeister (1997): Self reported problems with distance judgment declined from 37% to 6% of sample following cataract surgery. McGwin et al. (2003): contrast sensitivity improved significantly in the sample that underwent surgery, and day and night driving scores on Activities of Daily Vision Scale significantly improved post-operatively in surgery group. Owsley et al. (2002):Patients with a cataract who underwent surgery and IOL implantation had half the crash rate of drivers with cataract who did not undergo surgery (4.74 crashes per million miles of travel vs. 8.95). Wood and Carberry (2006): Bilateral cataract surgery resulted in significant improvements in on-road performance, related to improvements in CS.	Panelists agree this is a relatively inexpensive treatment and improvements result in crash reduction. Cataracts are often the only medical condition affecting driving performance. Even if crash reduction benefit is small, cataract surgery may provide a large public health benefit because of the large number of people affected by cataracts.

CRASH TYPE 2: **Left turn at intersection with signal control; permissive phase for older driver's approach.**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: CONTRAST SENSITIVITY		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	• Gallo, Rebok, and Lesikar (1999). Self-reported vision impairment was related to avoidance of challenging driving situations, but not to self-reported citations or crashes in prior 2 years. Authors conclude that vision impaired drivers who self restrict are less likely to crash. Vision impairment categories: no trouble seeing; a little trouble, a lot of trouble (i.e., may not be specific to CS). • Ball, Owsley, Stalvey, Roenker, Sloane, and Graves (1998): No relationship between avoidance score and crashes in subsequent 3 year period. • De Raedt and Ponjaert-Kristoffersen (2000): poor performers on a road test but were free of (self-reported) at-fault crashes (prior 12 mo) used significantly more strategic compensation tactics (avoidance of challenging situations) than poor-performing drivers with a history of at-fault crashes. • Hennessy (1995): older drivers with poor CS and who (sometimes of often) avoided heavy traffic had a reduced crash risk compared to those with poor CS who did not avoid heavy traffic. Avoidance brought risk equal to that of drivers with good CS. Avoidance of the other situations did not moderate the relationship between CS and crash risk.	Panelists indicate this may or may not be effective; "we don't know if this works." People try to self-regulate when there are alternative transportation options, but there are times when they "must" drive even if they'd rather not (e.g., winter when it gets dark earlier, or no other driver to take them). Making people aware of deficits is the first step in getting people to self restrict, if they will self restrict.
Conformal vision enhancement system (e.g., in-vehicle enhancement of Stop Sign)	Caird, Horey, & Edwards (2001). Simulator study with 24 younger and 24 older drivers. Conformal enhancement of a traffic light resulted in fewer drivers running the light. Drivers indicated conformal VES would be helpful when environmental conditions restrict visibility, but not under heavy traffic, cluttered environments, or in daytime. Less than 25% indicated they would use VES regularly if available. Oxley and Mitchell (1995) reported that in a sample of older 31 UVES and 15 IVES users, 100% found it easy to use, and 60-73% indicated it would encourage them to drive outside of their usual driving situations. Gish, Staplin, and Perel (1999) found that 3 of 4 older drivers did not use VES to detect targets, but instead used it to detect curves in the road (controlled field study).	Panelists state older drivers in focus groups don't like anything in their cars that takes their focus away from the road (either on the windshield or on a heads-down display in the vehicle). They would choose not to drive in challenging situations rather than to use a device that may take their attention from the road, or that may be more difficult to operate. Another panelist indicated that following training in equipment use, older drivers are ok with such countermeasures; emphasizing that training is a critical component for new technologies to assist older drivers.
Central vision enhancement systems (bioptic telescopic lenses, implantable telescopes)	Janke and Kazarian (1983): Crash rate in users is 1.5 times higher than population rate, but less than the crash rate of drivers licensed with other medical conditions. Clark (1996): Crash rates for BTL users 1.9 times higher than comparison group, but citation rates 0.7 of that for comparison group. Szlyk et al. (2000): Training in the use of BTL lenses (both lab and on-road) significantly increased performance in recognition, peripheral identification, and scanning compared to performance of non-trained BTL users.	Panelists in agreement with countermeasure if accompanied by training and assessment of driving safety after training. Recommend licensing with restrictions after low-driving program/rehab. Use lens only for spotting (5-10% of time). Training curriculum and design of lenses needs to be "nailed down." Training curriculum needs to be developed by Occupational Therapists. Countermeasure appropriate if no cognitive deficit.

CRASH TYPE 2: **Left turn at intersection with signal control; permissive phase for older driver's approach.**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: CONTRAST SENSITIVITY		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for contrast sensitivity deficit; raises awareness of deficit so they can self restrict. Also provide education to physicians and eyecare specialists so they can educate their patients. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Collision warning systems	Oxley and Mitchell (1995): collision warning system tested in a simulator was effective in preventing older drivers from turning across traffic through gaps that were dangerously short.	Suggested by panelists as countermeasure that merits further research. Need forward as well as side-collision warning. Would be helpful if it caused the vehicle to brake, in addition to providing a warning.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.

CRASH TYPE 2: **Left turn at intersection with signal control; permissive phase for older driver's approach.**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION)

SPECIFIC DEFICIT: VISUAL FIELDS

Associated Driver Performance Errors

- Could contribute to a failure to visually detect a potential threat.
- Impaired detection capability for stimuli in the affected parts of the visual field (Lovsund, Hedin, & Tornros, 1991).
- Correlated with crashes (Ball et al., 1993; Johnson & Keltner, 1983; Ruben et al., 2007; Szlyk et al., 1991).
- Drivers with Glaucoma (McGwin, Owsley, & Ball, 1998; Hu et al., 1998) and macular degeneration (Owsley et al., 1998) have higher crash rate than those without, and these conditions can restrict visual field.
- Correlated with poor driving performance at intersections, including left turns at protected/permitted and permitted signalized intersections (Tarawneh et al., 1993).

Included Behavioral Countermeasures

- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Central vision enhancement systems (bioptic telescopic lenses, implantable telescopes)
- Training in compensatory head/eye movements, scanning strategies
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Education about driving aids (Car Fit, features/adaptive equipment, shoes, etc.)
- Medical management (incl. pharmacy review)

CRASH TYPE 2: **Left turn at intersection with signal control; permissive phase for older driver's approach.**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: VISUAL FIELDS		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	Hennessy (1995): poorer visual field ability (modified Synemed perimeter) was significantly associated with greater avoidance of driving at night, rain, dusk, dawn, and making left turns, but the predictive value of visual fields performance on crash rate (prior 3 yrs) was mediated only for avoidance of left turns; But avoidance did not reduce risk, it increased it (inadequate compensation).	Panelists indicate this may or may not be effective; "we don't know if this works." People try to self-regulate when there are alternative transportation options, but there are times when they "must" drive even if they'd rather not (e.g., winter when it gets dark earlier, or no other driver to take them). Making people aware of deficits is the first step in getting people to self restrict, if they will self restrict.
Central vision enhancement systems (bioptic telescopic lenses, implantable telescopes)	Janke and Kazarian (1983): Crash rate in users is 1.5 times higher than population rate, but less than the crash rate of drivers licensed with other medical conditions. Clark (1996): Crash rates for BTL users 1.9 times higher than comparison group, but citation rates 0.7 of that for comparison group. Szlyk et al. (2000): Training in the use of BTL lenses (both lab and on-road) significantly increased performance in recognition, peripheral identification, and scanning compared to performance of non-trained BTL users.	Panelists in agreement with countermeasure if accompanied by training and assessment of driving safety after training. Recommend licensing with restrictions after low-driving program/rehab. Use lens only for spotting (5-10% of time). Training curriculum and design of lenses needs to be "nailed down." Training curriculum needs to be developed by Occupational Therapists. Countermeasure appropriate if no cognitive deficit.
Training in compensatory head and eye movements, scanning strategies	Coeckelbergh et al. (2001): Training in compensatory viewing strategies, particularly on-road training, improved viewing behavior for persons with central or peripheral visual field constriction, and increased the number of subjects who passed a road test who previously failed. Ss had visual field defects due to ocular pathology; those with severe cognitive impairments were excluded from participation. Dynavision apparatus has been used in office rehab settings to train compensatory scanning strategies for visual inattention and visual field deficit in persons with intact attentional mechanisms. Klavora et al. (1995) found that Dynavision training with 10 older (age 46-73) post-CVA individuals resulted in significantly improved behind-the-wheel driving performance when compared with expected outcomes. All failed their first BTW assessment pre-Dynavision training. Training involved three 40-minute Dynavision Training sessions per week for 6 weeks. On the second BTW assessment, 6 of the 10 subjects earned a "safe to resume driving and/or receive on-road driving lessons." Laderman, Szlyk, Kelsch, and Seiple (2000): 4-week training on a task in a rehab center setting to teach peripheral detection, scanning, and tracking where the clients sat close to a screen and detected slide images in the periphery using amorphic lenses, then turning their heads toward the object to identify it more clearly through the carrier. 8-week training in-vehicle on closed course with driving instructor to practice skills. Before-after training results indicated 39% improvement in tasks involving peripheral detection, and 27% improvement in scanning tasks. Authors note further research is needed to define standards and evaluation methods for training curricula.	Panelists agreed that this is an appropriate countermeasure, but candidates must be cognitively intact. This type of training has been used for telescopic and amorphic-lens drivers ("search and destroy" method referred to by panelist, described by Laderman et al., 2000) and has been effective in improving peripheral visual detection. One panelist mentioned a book that may be useful in this training older adults to scan effectively by Ken Mills "Disciplined Attention: How to Improve Your Visual Attention When You Drive." The book (directed toward young driver training) is not a countermeasure that's ready to go, but it's one ready to be researched.

CRASH TYPE 2: **Left turn at intersection with signal control; permissive phase for older driver's approach.**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: VISUAL FIELDS		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for visual field deficits; raises awareness of deficit so they can self restrict. Also provide education to physicians and eyecare specialists so they can educate their patients. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills education. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Education about driving aids (CarFit, features/adaptive equipment, shoes, etc.)		Panelists state that vehicles have safety features but many need to be adjusted, and older drivers don't know how to do this. Education about driving aids is a positive theme to staying on the road longer. Countermeasure merits further research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.

CRASH TYPE 2: **Left turn at intersection with signal control; permissive phase for older driver's approach.**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION)

SPECIFIC DEFICIT: DEPTH AND MOTION PERCEPTION

Associated Driver Performance Errors

- Gap judgment error: driver turns left into too short a gap, resulting in an angle collision with oncoming vehicle.
- Drivers ages 70-79 made more evaluation errors (i.e., saw the other vehicle but misjudged whether there was enough time to proceed) in failure-to-yield crashes compared with drivers of other ages (Braitman et al., 2007).
- Older drivers (especially females) rely on distance instead of integrating speed and distance, especially for higher-speed roads (Andersen & Enriquez, 2006; Scialfa et al., 1991; Dazentas, McDowell, & Cooper, 1980; Braitman et al., 2007; De Raedt & Ponjaert-Kristoffersen, 2000).
- Older men, in particular allowed the shortest time margins to cross in front of an oncoming vehicle approaching at 60 mi/h (Scialfa et al., 1991).
- Sensitivity in detecting collisions decreases with increases in speed and increases in time to collision, with greater declines for older observers compared to younger observers (Andersen & Enriquez, 2006).
- Impairments in stereoacuity are related to retrospective crashes (Owsley, McGwin, & Ball, 1998; Ivers et al., 1999; Staplin et al., 1998).
- Poor structure from motion performance is related to simulator crashes (Rizzo et al., 1997) and at-fault safety errors on the road (Uc et al., 2005).
- Central motion sensitivity related to on-road driving performance (Wood, 2002).
- Panelists indicated that a deficit in depth and motion perception could be associated with inability to predict development of future conflicts (critical performance error #3), in addition to gap judgment errors (#2).

Included Behavioral Countermeasures

- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Education about driving aids (Car Fit, features/adaptive equipment, shoes, etc.)
- Medical management (incl. pharmacy review)

CRASH TYPE 2: **Left turn at intersection with signal control; permissive phase for older driver's approach.**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: DEPTH AND MOTION PERCEPTION		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	Ball, Owsley, Stalvey, Roenker, Sloane, and Graves (1998): No relationship between avoidance score and crashes in subsequent 3 year period. De Raedt and Ponjaert-Kristoffersen (2000): drivers who performed poorly on a road test but were free of (self-reported) at-fault crashes in the prior 12-mo period used significantly more strategic compensation tactics (avoidance of challenging situations) than poor-performing drivers with a history of at-fault crashes.	Panelists indicated that drivers could choose the route that has a protected turn.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for depth and motion perception deficits; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Education about driving aids (CarFit, features/adaptive equipment, shoes, etc.)		Panelists state that vehicles have safety features but many need to be adjusted, and older drivers don't know how to do this. Education about driving aids is a positive theme to staying on the road longer. Countermeasure merits further research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.

CRASH TYPE 2: **Left turn at intersection with signal control; permissive phase for older driver's approach.**

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: SPEED OF PROCESSING

Associated Driver Performance Errors

- Effect of slowed speed of processing (SOP) may be slowing of retrieval of knowledge of right-of-way rules, and slowed reasoning and decision-making about appropriate visual search and vehicle control.
- SOP deficits (UFOV subtest 1) accounted for 4.1% of the variance in crash involvement (prior 3-years) for drivers age 70+ (type not specified) adjusting for age, gender, and driving exposure (Hennessy, 1995).
- Slowed SOP was significantly related to avoidance of left turns (Hennessy, 1995).
- Older drivers who performed poorly on the Trails A test had significantly more retrospective crashes (Stutts, Stewart, & Martell, 1996, 1998; Goode, Ball, Sloane, Roenker, Roth, Myers, & Owsley, 1998) and prospective crashes (Lesikar, Gallo, Rebok, & Keyl, 2002) than drivers who performed well on this SOP measure. Crash type not specified in these studies.
- Older crash-involved drivers with licenses suspended for failure to yield the right of way performed significantly worse on Trails A than subjects w/o suspended licenses (Lundberg, Hakamies-Blomqvist, Almkvist, and Johannson, 1998).
- Panelists indicated that a speed of processing deficit could be associated with the following critical driver performance errors: #2 gap judgment errors; #3 inability to predict development of future conflicts; #4 slowed vehicle control response; #5 inadequate visual search/improper lookout; #6 slowed decision making; #9 pedal errors (inappropriate response selection).

Included Behavioral Countermeasures

- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Speed of processing training
- Physical aerobic activity/training
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Collision warning systems
- Medical management (incl. pharmacy review)

CRASH TYPE 2: **Left turn at intersection with signal control; permissive phase for older driver's approach.**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: SPEED OF PROCESSING		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	• Ball, Owsley, Stalvey, Roenker, Sloane, and Graves (1998): No relationship between avoidance score and crashes (prior 3 yrs). • Hennessy (1995): poorer SOP ability was significantly associated with greater avoidance of driving at night, rain, dusk, dawn, alone, left turns, and heavy traffic, but the predictive value of the SOP subtask on crash rate (prior 3 yrs) was mediated only for avoidance of left turns; But avoidance did not reduce risk, it increased it (inadequate compensation). • De Raedt and Ponjaert-Kristoffersen (2000): poor performers on a road test who were free of (self-reported) at-fault crashes in the prior 12-mo period used significantly more strategic compensation tactics (avoidance of challenging situations) than poor performers with history of at-fault crashes.	Panelists indicate this may or may not be effective; "we don't know if this works." People try to self-regulate when there are alternative transportation options, but there are times when they "must" drive even if they'd rather not (e.g., winter when it gets dark earlier, or no other driver to take them). Making people aware of deficits is the first step in getting people to self restrict, if they will self restrict.
Speed of processing training	Roenker et al. (2003): Speed of processing training using all 3 subtests of UFOV compared to Doron simulator training and untrained reference group. Global ratings of on-road driving performance improved for both training groups, but only SOP group maintained performance at 18 mo. For "dangerous maneuvers" component, both training groups showed improvements, but only SOP training maintained improvement at 18 mo. Dangerous maneuvers included 6 opportunities for unprotected turns across traffic and 9 left-turn entrances to a high-traffic road.	Panelists agreed this may be a viable countermeasure, but there is a need to establish the link between training on task and transfer to driving.
Physical aerobic activity/training	Marmeleira, Godinho, and Fernandes (2008) found that a 12-week exercise program with 3, 60-min sessions per week improved visual attention in speed of processing and divided attention (using the UFOV protocol) at 12 weeks follow-up in adults ages 60 to 81. The intervention incorporated perceptual and cognitive tasks (problem solving and responding to challenging situations) with aerobic activity. Examples are: walking while listening for auditory cues to perform fast and specific psychomotor responses). At 12 weeks, speed of processing and divided attention were significantly improved compared to baseline for the exercise group; at baseline, there was no difference between groups. Actual driving performance was not studied, and there was no exercise-only group to determine the contribution of physical activity alone on speed of processing or divided attention.	Research article provided by panelist following meeting; panelists did not get to comment on countermeasure for deficit. Merits further research.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for speed of processing deficits; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Collision warning systems	Oxley and Mitchell (1995): collision warning system tested in a simulator was effective in preventing older drivers from turning across traffic through gaps that were dangerously short.	Suggested by panelists as countermeasure that merits further research. Need forward as well as side-collision warning. Would be helpful if it caused the vehicle to brake, in addition to providing a warning.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.

CRASH TYPE 2: **Left turn at intersection with signal control; permissive phase for older driver's approach.**

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: SELECTIVE ATTENTION

Associated Driver Performance Errors

- Older drivers with selective attention deficits had shorter time to collision values, took longer to cross the road, and had shorter safety cushions (on-road study) than drivers with no impairment in selective attention ability (Pietras et al., 2006).
- Poor visual attention (number cancellation test) related to poor on-road driving performance, specifically scanning visual field for potentially dangerous objects, yielding the right of way, negotiating turns safely (Richardson & Marottoli, 2003).
- In a laboratory study using a change blindness technique to measure selective attention., older drivers were more likely to miss detecting relevant vehicles when making safe-not safe to turn decisions (Caird et al., 2005).
- Selective attention with visual search correlated significantly with global road test score, accounting for 19% of the variance (De Raedt & Ponjaert-Kristoffersen, 2000). It also correlated significantly w/visual behavior and communication (r= -.43) and perception and reaction to signals (r=-.37).
- Poor scores on Brief Test of Attention and on Trails A were related to slower perception-reaction times and slower brake movement times during a computerized test of simple RT (Zhang et al., 2007).
- Panelists indicated that a selective attention deficit could be associated with the following critical driver performance errors: #2 gap judgment errors; #3 inability to predict development of future conflicts; #4 slowed vehicle control response; #5 inadequate visual search/improper lookout; #6 slowed decision making; #9 pedal errors (inappropriate response selection).

Included Behavioral Countermeasures

- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Speed of processing training
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Collision warning systems
- Medical management (incl. pharmacy review)
- Cognitive rehab (incl. memory training) for normally aging population
- Compensatory cognitive/memory training for impaired/MCI population

CRASH TYPE 2: **Left turn at intersection with signal control; permissive phase for older driver's approach.**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: SELECTIVE ATTENTION		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	Ball, Owsley, Stalvey, Roenker, Sloane, and Graves (1998): No relationship between avoidance score and crashes in subsequent 3 year period. De Raedt and Ponjaert-Kristoffersen (2000): drivers who performed poorly on a road test but were free of (self-reported) at-fault crashes in the prior 12-mo period used significantly more strategic compensation tactics (avoidance of challenging situations) than poor-performing drivers with a history of at-fault crashes.	Panelists indicate this may or may not be effective; "we don't know if this works." People try to self-regulate when there are alternative transportation options, but there are times when they "must" drive even if they'd rather not (e.g., winter when it gets dark earlier, or no other driver to take them). Making people aware of deficits is the first step in getting people to self restrict, if they will self restrict.
Speed of processing training	Roenker et al. (2003): Speed of processing training using all 3 subtests of UFOV compared to Doron simulator training and untrained reference group. Global ratings of on-road driving performance improved for both training groups, but only SOP group maintained performance at 18 mo. For "dangerous maneuvers" component, both training groups showed improvements, but only SOP training maintained improvement at 18 mo. Dangerous maneuvers included 6 opportunities for unprotected turns across traffic and 9 left-turn entrances to a high-traffic road.	Panelists agreed this may be a viable countermeasure, but there is a need to establish the link between training on task and transfer to driving.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for selective attention deficits; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Collision warning systems	Oxley and Mitchell (1995): collision warning system tested in a simulator was effective in preventing older drivers from turning across traffic through gaps that were dangerously short.	Suggested by panelists as countermeasure that merits further research. Need forward as well as side-collision warning. Would be helpful if it caused the vehicle to brake, in addition to providing a warning.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.
Cognitive rehab (including memory training) for normally aging population	One panelist noted that reasoning training conducted as part of the ACTIVE trial described by Ball, Berch, Helmers, Jobe, Leveck, et al. (2002) showed an effect on decreased driving difficulty in the 6 years following enrollment in the study. These findings were presented at the 2008 GSA meeting, but not published as of the date of this report.	Panelists indicate this is building subskills for the driving task. An OT panelist noted that you cannot just do a lot of the cognitive retraining tasks and assume that it will generalize to driving. You need to make that part of the therapy program. Countermeasure has tremendous promise but it is just in its infancy for developing the training protocols, and making sure it is appropriate. There is a real need for good research to make sure that we use this appropriately.
Compensatory cognitive/memory training for impaired/MCI population		Panelists were cautious about recommending cognitive interventions for people with early stage dementia, and indicated that strategies must be compensatory rather than restorative for this group.

CRASH TYPE 2: **Left turn at intersection with signal control; permissive phase for older driver's approach.**

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: DIVIDED ATTENTION

Associated Driver Performance Errors

- Drivers with restrictions in UFOV (composite measure of all 3 tests, with a 40% or more deficit) had 15 times more intersection crashes (type not specified) in prior 5-year period than drivers with normal visual attention (Owsley et al., 1991).
- Drivers with UFOV divided attention deficit had a significantly higher odds of crashing (prospectively) than drivers with normal divided attn performance (crash type not specified) (Rubin et al., 2007; Staplin et al., 2003; Edwards et al., 2008).
- Divided attention deficit associated with prospective crashes, the majority of which were failure-to-yield the right of way (Owsley et al., 1998).
- Poor performance on the divided attention component of UFOV accounted for 4.7% of the variance in prior crash involvement for older drivers, and was significantly associated with avoidance of left turns (Hennessey, 1995).
- Impairment in UFOV independently associated with difficulty driving in the rain (McGwin, Chapman, Owsley (2000).
- In failure-to-yield crashes at intersections (e.g., proceeding after stopping at a stop sign, turning left at a green light, or right on a red light), the predominant error for drivers ages 80+ was search and detection errors; these occurred more frequently for drivers age 80+ (86%) than for drivers ages 35-54 (84%) and those age 70-79 (55%). Although drivers ages 35-54 made many search and detection errors, these were most often due to distraction, whereas drivers age 80+ most often "looked but did not see"/inadequate search (Braitman et al., 2007).
- UFOV performance predicted on-road driving performance, and was significantly correlated with tactical anticipatory behavior in changing situation; visual behavior; and insight, sense of context, and practical implementation (De Raedt & Ponjaert-Kristoffersen (2000).
- The greater the reduction in UFOV, the higher the likelihood of failing on-road test (Myers et al., 2000).
- Panelists indicated that a divided attention deficit could be associated with the following critical driver performance errors: #2 gap judgment errors; #3 inability to predict development of future conflicts; #4 slowed vehicle control response; #5 inadequate visual search/improper lookout; #6 slowed decision making; #9 pedal errors (inappropriate response selection).

Included Behavioral Countermeasures

- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Speed of processing training
- Physical aerobic/activity training
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Collision warning systems
- Medical management (incl. pharmacy review)
- Cognitive rehab (incl. memory training) for normally aging population
- Compensatory cognitive/memory training for impaired/MCI population

CRASH TYPE 2: **Left turn at intersection with signal control; permissive phase for older driver's approach.**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: DIVIDED ATTENTION		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	Ball, Owsley, Stalvey, Roenker, Sloane, and Graves (1998): No relationship between avoidance score and crashes in subsequent 3 year period. De Raedt and Ponjaert-Kristoffersen (2000): drivers who performed poorly on a road test but were free of (self-reported) at-fault crashes in the prior 12-mo period used significantly more strategic compensation tactics (avoidance of challenging situations) than poor-performing drivers with a history of at-fault crashes. Hennessy (1995): poorer divided attention ability was significantly associated with greater avoidance of driving at night, rain, dusk, dawn, alone, left turns, and heavy traffic, but the predictive value of the divided attention subtask of UFOV on crash rate (prior 3 yrs) was not mediated by any of the forms of self restriction. Owsley et al. (1998) found that older drivers with UFOV reduction of 40% or more and who reported driving fewer than 7 days per week had a 45% decreased crash risk compared to older drivers with a 40% or more reduction in UFOV who reported driving 7 days/week.	Panelists indicate this may or may not be effective; "we don't know if this works." People try to self-regulate when there are alternative transportation options, but there are times when they "must" drive even if they'd rather not (e.g., winter when it gets dark earlier, or no other driver to take them). Making people aware of deficits is the first step in getting people to self restrict, if they will self restrict.
Speed of processing training	Roenker et al. (2003): Speed of processing training using all 3 subtests of UFOV compared to Doron simulator training and untrained reference group. Global ratings of on-road driving performance improved for both training groups, but only SOP group maintained performance at 18 mo. For "dangerous maneuvers" component, both training groups showed improvements, but only SOP training maintained improvement at 18 mo. Dangerous maneuvers included 6 opportunities for unprotected turns across traffic and 9 left-turn entrances to a high-traffic road.	Panelists agreed this may be a viable countermeasure, but there is a need to establish the link between training on task and transfer to driving.
Physical aerobic activity/training	Marmeleira, Godinho, and Fernandes (2008) found that a 12-week exercise program with 3, 60-min sessions per week improved visual attention in speed of processing and divided attention (using the UFOV protocol) at 12 weeks follow-up in adults ages 60 to 81. The intervention incorporated perceptual and cognitive tasks (problem solving and responding to challenging situations) with aerobic activity. Examples are: walking while listening for auditory cues to perform fast and specific psychomotor responses). At 12 weeks, speed of processing and divided attention were significantly improved compared to baseline for the exercise group; at baseline, there was no difference between groups. Actual driving performance was not studied, and there was no exercise-only group to determine the contribution of physical activity alone on speed of processing or divided attention.	Research article provided by panelist following meeting; panelists did not get to comment on countermeasure for deficit. Merits further research.

CRASH TYPE 2: **Left turn at intersection with signal control; permissive phase for older driver's approach.**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: DIVIDED ATTENTION		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for divided attention deficits; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Collision warning systems	Oxley and Mitchell (1995): collision warning system tested in a simulator was effective in preventing older drivers from turning across traffic through gaps that were dangerously short.	Suggested by panelists as countermeasure that merits further research. Need forward as well as side-collision warning. Would be helpful if it caused the vehicle to brake, in addition to providing a warning.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.
Cognitive rehab (including memory training) for normally aging population	OTs noted that there are protocols and treatments for retraining attention, but cognitive rehab literature shows efficacy of attentional therapy in the broader rehab area ("Society for Cognitive Rehab"). It doesn't directly address driving, but builds subskills for the driving task.	Panelists indicate this is building subskills for the driving task. An OT panelist noted that you cannot just do a lot of the cognitive retraining tasks and assume that it will generalize to driving. You need to make that part of the therapy program. Countermeasure has tremendous promise but it is just in its infancy for developing the training protocols, and making sure it is appropriate. There is a real need for good research to make sure that we use this appropriately.
Compensatory cognitive/memory training for impaired/MCI population	Klavora et al. (1995) conducted a before-after study with 10 stroke patients with visual and attentional difficulties and rated unsafe to drive. Following training with a Dynavision apparatus, 6 of 10 participants earned a rating of "safe to resume driving and/or to receive on-road driving lessons."	Panelists were cautious about recommending cognitive interventions for people with early stage dementia, and indicated that strategies must be compensatory rather than restorative for this group.

CRASH TYPE 2: **Left turn at intersection with signal control; permissive phase for older driver's approach.**

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: WORKING MEMORY

Associated Driver Performance Errors

- Better working memory performance (5 sets of additions, where each set included 3, 2-digit numbers) was associated with larger gaps selected, in a simulator study of left turns across oncoming traffic (Guerrier et al., 1999).
- Lee, Lee, Cameron, and Li-Tsang (2005) found that poor performance on a working memory task by older drivers (ages 60-88) during simulated driving was significantly associated with self-reported crashes in the prior 1-year period.
- Hunt, Morris, Edwards, and Wilson (1993) found a significant correlation between pass/fail outcome on a road test and performance on the Logical Memory subscale of the Wechsler Memory Scale (assessing immediate and delayed recall).
- Szlyk, Myers, Zhang, Wetzel, and Shapirio (2002) found that older drivers with poor performance on several measures of working memory had poorer performance in a driving simulator (drove at slower speed, and had more lane boundary crossings) than drivers with better performance on the working memory tasks.
- Panelists indicated a working memory deficit could be associated with the following critical driver performance errors: #2 gap judgment errors; #3 inability to predict the development of future conflicts from current traffic and contextual information.

Included Behavioral Countermeasures

- Physical aerobic/activity training
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Medical management (incl. pharmacy review)
- Cognitive rehab (incl. memory training) for normally aging population
- Compensatory cognitive/memory training for impaired/MCI population
- Pre-trip planning

CRASH TYPE 2: **Left turn at intersection with signal control; permissive phase for older driver's approach.**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: WORKING MEMORY		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Physical aerobic activity/training		Panelists indicated this countermeasure merits further research for remediation of working memory deficits, stating a large body of research showing aerobic exercise results in alertness--hippocampul regeneration.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)		Panelists state all 3 types of education may be useful for working memory deficits; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.
Cognitive rehab (including memory training) for normally aging population	OTs noted that there are protocols and treatments for retraining attention, but cognitive rehab literature shows efficacy of attentional therapy in the broader rehab area ("Society for Cognitive Rehab"). It doesn't directly address driving, but builds subskills for the driving task. Laderman, Szlyk, Kelsch, and Seiple (2000) found improvement in visual memory (remembering store names subjects had walked past) after practice in the laboratory recalling sequences of numbers, letters, and shapes presented briefly on 35-mm slides.	Panelists indicate this is building subskills for the driving task. An OT panelist noted that you cannot just do a lot of the cognitive retraining tasks and assume that it will generalize to driving. You need to make that part of the therapy program. Countermeasure has tremendous promise but it is just in its infancy for developing the training protocols, and making sure it is appropriate. There is a real need for good research to make sure that we use this appropriately.
Compensatory cognitive/memory training for impaired/MCI population		Panelists were cautious about recommending cognitive interventions for people with early stage dementia, and indicated that strategies must be compensatory rather than restorative for this group.
Pre-trip planning		Countermeasure suggested by panelists as meriting further research

CRASH TYPE 2: **Left turn at intersection with signal control; permissive phase for older driver's approach.**

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: EXECUTIVE FUNCTION (JUDGMENT/DECISION-MAKING)

Associated Driver Performance Errors

- Association between poor performance on Trails B Test (a measure of executive function) and retrospective (Stutts et al., 1998; Goode et al., 1998; Daigneault et al., 2002) and prospective state-recorded crashes (Staplin et al., 2003) and poor simulator (Rizzo et al., 1997; Szlyk et al., 2002)) and on-road performance, including left turns at intersections (Tarawneh et al., 1993), although type of crash not specified.
- Poor performance on a maze test (also measures executive functioning) was correlated with road test failure (Snellgrove, 2005; Ott et al., 2008).
- Age-related declines in executive control function include planning, scheduling, working memory, inhibitory processes, and multi-tasking.
- Panelists indicated that an executive function deficit could be associated with the following critical driver performance errors: #2 gap judgment errors; #3 inability to predict development of future conflicts; #4 slowed vehicle control response; #5 inadequate visual search; #6 slowed decision making; and #9 pedal errors (inappropriate response selection).

Included Behavioral Countermeasures

- Physical aerobic/activity training
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Medical management (incl. pharmacy review)
- Cognitive rehab (incl. memory training) for normally aging population
- Compensatory cognitive/memory training for impaired/MCI population
- Pre-trip planning

CRASH TYPE 2: **Left turn at intersection with signal control; permissive phase for older driver's approach.**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: EXECUTIVE FUNCTION (JUDGMENT/DECISION-MAKING)		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Physical aerobic activity/training	No studies on improvement in driving, however, Colcombe and Kramer (2003) found the largest positive effects of fitness training and cognitive functioning in older (non-demented) adults was on executive control processes. Programs combining aerobic training with strength and flexibility training had the largest effects. Conflicting evidence was found by Marmeleira, Godinho, and Fernandes (2008); an exercise program incorporating walking with cognitive and perceptual tasks resulted in no improvement on tests of executive function (Stroop or Trails B) from baseline to 12-weeks post intervention.	Panelists indicated this may be an appropriate countermeasure for deficits in executive function, but requires further research. A panelist mentioned that the literature in the area of exercise and cognitive function is mixed, with some studies showing improvement and others showing no effect. One problem with the research may be that the exercise interventions are too brief to result in an improvement.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Marottoli (2007): AAA Safe Driving for Mature Operators presented in 2, 4-hour sessions with supplemental topics (including search strategies for intersections), plus 2, 1-hour BTW sessions focused on common errors made by older persons. BTW performance assessed at baseline and 8 weeks post-intervention included 31 T-type intersections and 32 crossing intersections, 11 of which were stop controlled. 15 left turns were made. Post-test scores were significantly higher than baseline, translating to 9.5% decrease in crash risk over 2-year period. One of the items showing the most improvement was judgment. Eby, Molnar, Shope, Vivoda, and Fordyce (2003). Driving Decisions Workbook (a self assessment tool) was effective in increasing older drivers' awareness of changes in driving abilities related to aging, and effects of changes on driving. Participants stated they would seek 2nd tier assessment and change driving habits. Skufca (2008): AARP DSP participants indicated course encouraged them to change certain driving behaviors (20% indicated avoiding left turns as a new behavior).	Panelists state all 3 types of education may be useful for deficits in executive functioning; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.
Cognitive rehab (including memory training) for normally aging population		Panelists indicate this is building subskills for the driving task. An OT panelist noted that you cannot just do a lot of the cognitive retraining tasks and assume that it will generalize to driving. You need to make that part of the therapy program. Countermeasure has tremendous promise but it is just in its infancy for developing the training protocols, and making sure it is appropriate. There is a real need for good research to make sure that we use this appropriately.
Compensatory cognitive/memory training for impaired/MCI population		Panelists were cautious about recommending cognitive interventions for people with early stage dementia, and indicated that strategies must be compensatory rather than restorative for this group.
Pre-trip planning		Countermeasure suggested by panelists as meriting further research.

CRASH TYPE 2: **Left turn at intersection with signal control; permissive phase for older driver's approach.**

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: SPATIAL ABILITIES

Associated Driver Performance Errors

- Errors in distance judgment and difficulty predicting the development of traffic situations (Johansson & Lundberg, 1997).
- Poor performance on clock-drawing test (a measure of visuospatial functioning) accounted for 38% of the variance in road test performance in sample referred for fitness to drive assessment (excluded persons suspected of dementia or cognitive decline). Specific errors not described in correlational analysis (De Raedt & Ponjaert-Kristoffersen, 2001).
- Impaired pentagon copying performance was associated with adverse driving events (crashes, violations), but type not specified (Marottoli et al., 1994).
- Poor performance on the MVPT Visual Closure subscore was associated with crashes (type not specified) in 20-month follow-up period (Staplin et al., 2003), and on poor road test performance (Tarawneh et al., 1993).
- Older, crash-involved subjects with suspended licenses performed worse on tests of visuospatial abilities than older non-crash-involved drivers with suspended licenses, and older drivers with clean records. A main violation type leading to crashes and suspensions included failure to yield the right of way (Lundberg et al., 1998).
- Poor performance on tests of spatial ability (Rey-Osterreith Complex Figures and Wechsler Memory Scale) discriminated crash-involved from crash-free drivers in prior 5-year period (Goode et al., 1998).
- Panelists indicated that a deficit in spatial abilities could be associated with the following critical driver performance errors:#2 gap judgment errors; #3 inability to predict the development of future conflicts; #5 inadequate visual search/improper lookout; and #6 slowed decision making.

Included Behavioral Countermeasures

- Visual perceptual therapy
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Medical management (incl. pharmacy review)

CRASH TYPE 2: **Left turn at intersection with signal control; permissive phase for older driver's approach.**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: SPATIAL ABILITIES		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Visual perceptual therapy	McCoy et al. (1993): Evaluated workbook exercises to improve visual perception in 5 areas: spatial relationships, visual discrimination, figure ground, visual closure, and visual memory. Before-after on-road driving performance (DPM technique) improved by 7.7 percentage points, compared to no improvement in control group.	Panelists indicated this countermeasure merits further research for remediation of deficits in spatial abilities.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)		Panelists state all 3 types of education may be useful for deficits in spatial abilities; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. OTs note that if there is a serious deficit, driving should be ruled out. Spatial abilities deficits manifest themselves in lane control difficulty. They will start with easy situations and progress to more difficult situations if there is improvement. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.

CRASH TYPE 2: **Left turn at intersection with signal control; permissive phase for older driver's approach.**

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: KNOWLEDGE

Associated Driver Performance Errors

- Driver misunderstanding of permissive displays (and accompanying right-of-way rules) for left turns at signalized intersections {FHWA Highway Design Handbook for Older Drivers and Pedestrians (Staplin et al., 2001)}.
- Older drivers less likely than younger drivers to position themselves in the intersection to improve sight distance when waiting to turn left and an opposing left-turning driver blocks the view of through traffic. {FHWA Highway Design Handbook for Older Drivers and Pedestrians (Staplin et al., 2001)}.
- Panelists indicated a knowledge deficit could be associated with the following critical driver performance errors: #3 inability to predict the development of future conflicts; #7 lack of understanding of rules of the road; #8 lack of understanding or failure to apply safe driving practices.

Included Behavioral Countermeasures

- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)
- Medical management (incl. pharmacy review)
- Pre-trip planning

CRASH TYPE 2: **Left turn at intersection with signal control; permissive phase for older driver's approach.**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: KNOWLEDGE		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Driver safety education (Theory/Classroom)	Skufca (2008): AARP DSP participants indicated course encouraged them to change certain driving behaviors, specifically 20% indicated avoiding left turns as a consequence of information learned. Kutner (2006): No difference in crash rate (self reported) in prior 12-month period for AARP Driver Safety program participants and comparison group of not-AARP DSP participants. Bedard et al. (2004). Canadian Safety Council adaptation of AARP DSP evaluated for treatment and comparison group using an on-road evaluation at baseline and post-treatment. On-road evaluation scores improved significantly for treatment and control group from baseline to post-intervention; no significant difference between treatment and comparison group on mean change score from the first to second evaluation. Janke (1994). Completion of Mature Driver Improvement Program was associated with more total fatal injury crashes and fewer citations compared with group who did not attend course. Eby, Molnar, Shope, Vivoda, and Fordyce (2003). Driving Decisions Workbook (a self assessment tool) was effective in increasing older drivers' awareness of changes in driving abilities related to aging, and effects of changes on driving. Participants stated they would seek 2nd tier assessment and change driving habits; no evaluation on whether drivers followed through on these plans. McCoy et al. (1993). Completion of AAA Safe Driving for Mature Operators was associated with a significant increase in on-road driving performance (baseline and post intervention road test using DPM technique) of 3.7 percentage points. Education plus physical therapy increased score by 8.7 percentage points; education plus perceptual therapy increased score by 13.9 percentage points. Nasvadi and Vavrik (2007). Evaluation of British Columbia Safety Council adaptation of AARP DSP comparing police-reported at-fault crash and violation rate for participants vs. non-participants in prior 2-year period, to determine whether self-selection bias exists for those who attend remedial safety courses. Significantly more participants than controls had crashed, but there was no difference in violation rate. A follow-up comparison of crash rate for subsequent 2-year period for attendees and controls with matched pre-course crash rate showed that more attendees had crashes than non-attendees, but the difference was not significant. However, when stratifying by age group and gender, males age 75+ who attended the course were 3.8 times more likely to be involved in a crash than controls who did not attend class. No difference in crash rate for men ages 55-74 or women ages 55-74 and those 75+.	General consensus that it makes sense to provide education, even if it isn't adequate; people will be people, and it may work for some and not others. Education (theory) alone may never be enough; may need to be coupled with skills training.

CRASH TYPE 2: **Left turn at intersection with signal control; permissive phase for older driver's approach.**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: KNOWLEDGE		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Driver safety education (Theory + BTW)	Marottoli (2007): AAA Safe Driving for Mature Operators presented in 2, 4-hour sessions with supplemental topics (including search strategies for intersections), plus 2, 1-hour on-road driving sessions focused on common errors made by older persons. On road performance assessed at baseline and 8 weeks post-intervention included 31 T-type intersections and 32 crossing intersections; 45 were signalized. 15 left turns were made. Post-test scores were significantly higher than baseline, translating to 9.5% decrease in crash risk over 2-year period. One of the items showing the most improvement was judgment. Bedard et al. (2008): Significant improvement in knowledge, but no change in driving performance for the category of signal violations/right of way/inattention.	General consensus that it makes sense to provide education, even if it isn't adequate; people will be people, and it may work for some and not others. Education (theory) alone may never be enough; may need to be coupled with skills training.
Driver safety education (Interactive/computer-based)		Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)		Panelists state that vehicles have safety features but many need to be adjusted, and older drivers don't know how to do this. Education about driving aids is a positive theme to staying on the road longer. Countermeasure merits further research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients
Pre-trip planning		Countermeasure suggested by panelists as meriting further research

CRASH TYPE 2: **Left turn at intersection with signal control; permissive phase for older driver's approach.**

GENERAL DEFICIT: PHYSICAL/PSYCHOMOTOR

SPECIFIC DEFICIT: ARM STRENGTH/RANGE OF MOTION/SPEED OF MOVEMENT

Associated Driver Performance Errors

- Slow steering through turn, resulting in longer maneuver time, resulting in shorter time to collision (Yan, Radwan, & Guo, 2007).
- Older women with difficulty extending arms above their shoulders had increased crash risk (Hu et al., 1998).
- Difficulty reaching out was significantly associated with crashes in prior 6 years (Sims et al., 1998). Crash type not specified in research studies.
- Range of motion significantly associated with pass/fail performance on road test (McCarthy & Mann, 2006).
- Panelists indicated a deficit in arm strength/range of motion/speed of movement could be associated with slowed vehicle control response (critical driver performance error #4).

Included Behavioral Countermeasures

- Physical aerobic/activity training
- Strength and flexibility exercises
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)
- Medical management (incl. pharmacy review)

CRASH TYPE 2: **Left turn at intersection with signal control; permissive phase for older driver's approach.**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: ARM STRENGTH/RANGE OF MOTION/SPEED OF MOVEMENT		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Physical aerobic activity/training	May be research from Art Kramer at the University of Illinois looking at physical exercise programs and driving (simulator).	Merits further research.
Strength and flexibility exercises	Marottoli et al. (2007) 12 week, in-home exercises directed by physical therapist focusing on axial/extremity condition, upper extremity coordination/dexterity, and gait abnormalities. On-road driving performance was measured at baseline and post-intervention for treatment and control group. Significant improvement for treatment group compared to control group translated to 8 to 16 percent lower crash occurrence over 2 year period. Intervention group also made 37% fewer critical errors (inattention, turning or changing lanes w/o looking, and disobeying signs or signals) than control group at follow up.	Panelists agreed that this is an appropriate countermeasure
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)		Panelists state all 3 types of education may be useful for deficits in arm strength/range of motion/speed of motion; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)		Panelists state that vehicles have safety features but many need to be adjusted, and older drivers don't know how to do this. Education about driving aids is a positive theme to staying on the road longer. Countermeasure merits further research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients. Impairments in psychomotor functioning may result from musculoskeletal disease leading to weakening, frailty, and/or restricted range of motion. Medical management of arthritis is important.

CRASH TYPE 2: **Left turn at intersection with signal control; permissive phase for older driver's approach.**

GENERAL DEFICIT: PHYSICAL/PSYCHOMOTOR

SPECIFIC DEFICIT: LEG STRENGTH/RANGE OF MOTION/SPEED OF MOVEMENT

Associated Driver Performance Errors

- Slow accelerating through turn and into traffic stream resulting in longer maneuver time, resulting in shorter time to collision (Yan, Radwan, & Guo, 2007).
- Poor performance on rapid pace walk is associated with adverse driving events (Crashes, violations) (Marottoli et al., 1994; Staplin et al., 2003), and pass/fail performance on road test (McCarthy & Mann, 2006).
- Range of motion significantly associated with pass/fail performance on road test (McCarthy & Mann, 2006).
- Older drivers reporting pain in the feet, hips, legs, or current treatment for arthritis had significantly slower brake reaction speeds (both initial reaction and physical response speed) than drivers with no complaints of pain in these areas (Zhang et al., 2007).
- Panelists indicated a deficit in leg strength/range of motion/speed of movement could be associated with slowed vehicle control response (critical driver performance error #4).

Included Behavioral Countermeasures

- Physical aerobic/activity training
- Strength and flexibility exercises
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)
- Medical management (incl. pharmacy review)

CRASH TYPE 2: **Left turn at intersection with signal control; permissive phase for older driver's approach.**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: LEG STRENGTH/RANGE OF MOTION/SPEED OF MOVEMENT		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Physical aerobic activity/training	May be research from Art Kramer at the University of Illinois looking at physical exercise programs and driving (simulator).	Merits further research.
Strength and flexibility exercises	Marottoli et al. (2007) 12 week, in-home exercises directed by physical therapist focusing on axial/extremity condition, upper extremity coordination/dexterity, and gait abnormalities. On-road driving performance was measured at baseline and post-intervention for treatment and control group. Significant improvement for treatment group compared to control group translated to 8 to 16 percent lower crash occurrence over 2 year period. Intervention group also made 37% fewer critical errors (inattention, turning or changing lanes w/o looking, and disobeying signs or signals) than control group at follow up.	Panelists agreed that this is an appropriate countermeasure
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)		Panelists state all 3 types of education may be useful for deficits in head/neck/trunk range of motion; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)		Panelists state that vehicles have safety features but many need to be adjusted, and older drivers don't know how to do this. Education about driving aids is a positive theme to staying on the road longer. Countermeasure merits further research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients. Impairments in psychomotor functioning may result from musculoskeletal disease leading to weakening, frailty, and/or restricted range of motion. Medical management of arthritis is important.

CRASH TYPE 3: Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)

FUNCTIONAL DEFICITS THAT MAY INFLUENCE CRASH RISK

SENSORY/PERCEPTUAL (VISION)

- Acuity
- Contrast Sensitivity
- Visual Fields
- Depth and Motion Perception (Angular Motion Sensitivity)
- Dark Adaptation and Glare Recovery

ATTENTION/COGNITION

- Speed of Processing
- Selective Attention
- Divided Attention
- Working Memory
- Executive Function (Judgment and Decision Making)
- Spatial Abilities
- Knowledge (Rules of the Road and Safe Driving Strategies)

PHYSICAL/PSYCHOMOTOR

- Head/Neck/Trunk Range of Motion
- Arm Strength/Range of Motion/Speed of Movement
- Leg Strength/Range of Motion/Speed of Movement

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION)

SPECIFIC DEFICIT: ACUITY

Associated Driver Performance Errors

- Could contribute to a failure to visually detect a potential threat.
- Acuity poorer than 20/40 independently associated with self-reported crashes, moving violations, being stopped by police in prior 5-year period (Marottoli et al. (1998).
- Combined criterion using acuity, CS, and horizontal visual fields significantly related to prior crash involvement in drivers age 66+, but no visual measure alone was significantly associated (Decina & Staplin (1993).
- Significant relationship between acuity and improper lookout (Shinar, McDonald, & Treat (1978).
- Acuity (score and response time) related to unsafe driving incidents; correlations higher for time to respond to acuity stimuli than acuity errors (McKnight & McKnight, 1999).
- Acuity response time rather than acuity score related to driving exam score (Staplin et al., 1998).
- Acuity slightly worse than 20/30 independently associated with self-reported difficulty driving on interstates, at night, in the rain, on high-traffic roads, during rush hour, alone, and making left turns (McGwin, Chapman, Owsley, 2000).
- Poorer dynamic acuity related to crash involvement in prior 2-year period (Shinar, Mayer, Treat, 1975).
- Dynamic acuity included in model predictive of closed course driving performance (Wood, 2002).

Included Behavioral Countermeasures

- Refractive correction (incl. Wavefront technology)
- Cataract surgery
- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Central vision enhancement systems (bioptic telescopic lenses, implantable telescopes)
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Collision warning systems
- Medical management (incl. pharmacy review).

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: ACUITY		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Refractive correction (incl. Wavefront technology)	No before-after studies on refraction correction (updating prescription for corrective glasses) and driving safety uncovered. Panelist with expertise in the area stated that in the ophthalmology literature there is quite a bit of research on age and satisfaction for refractive errors corrective surgery. There is actually quite ample literature on people's feelings about their improved performance in everyday tasks there, clarity with which they can see things. It would seem reasonable that one would have asked the question about improved driving performance as a result of refractive error correction, but the panelist was not aware of anything done. Haddrill (2007): Ophthonix founder A. Dreher reports that iZon lenses (wavefront lenses) provide higher definition vision in the daytime and significantly improve night driving responses when compared with conventional lenses. Night vision improved a driver's ability to identify pedestrians by an average of 330 ms (30 ft sooner at 55 mi/h) when compared to conventional lenses. www.allaboutvision.com/lenses/wavefront-lenses.htm; http://ophthonix.izonlens.com/globals/faqs.asp; www.allaboutvision.com/whatsnew/lenses1.htm.	Even without research on effectiveness, panelists agreed that refractive correction should be advocated just on the prevalence of the problem and the inexpensiveness of the solution, particularly as there appears to be a decline in older people getting annual eye exams. Annual eye exams, refractive correction, and sooner diagnosis of treatable conditions (e.g., cataracts) are inexpensive solutions for reaching a substantial number of people for remediation. Vision specialist feedback to drivers regarding the driver licensing laws in their State in relation to their own level of impairment is important (and presently rare in practice); increasing awareness of impairments may lead to appropriate self-restriction. One of the early findings of the Salisbury Eye Study was that among the proportion of older individuals who had worse than 20/40 vision, more than half of them could be corrected just with glasses. A panel member (vision specialist) recommended inclusion of Wavefront technology as part of refractive correction. Wavefront technology diagnoses higher-order vision errors represented by the way the eye refracts or focuses light; such aberrations defocus images even with 20/40 acuity. Wavefront guided lenses can reduce certain higher-order aberrations, which potentially can improve low light image quality during activities such as driving at night. Panelist notes research on effectiveness for driving is currently limited to that conducted by lens manufacturer (see Haddrill 2007 description of Ophthonix iZon wavefront guided lenses). Another caution noted by the panelist regarding the lens company research is that improvements in vision with the wavefront lenses were compared to patients' vision as they appeared for the study. But it is well known that many patients especially over age 60 haven't had regular eye check-ups or new prescriptions.
Cataract surgery	McGwin, Scilley, Brown, and Owsley (2003) found improvements in acuity with cataract surgery, and that improvement in visual acuity had a significant, independent association with the change in activities of daily vision scale (that includes daytime and nighttime driving). Wood and Carberry (2006) found that improvement in acuity that accompanied cataract surgery was related to improvement in overall driving score.	Panelists agree this is a relatively inexpensive treatment and improvements result in crash reduction. Cataracts are often the only medical condition affecting driving performance. Even if crash reduction benefit is small, cataract surgery may provide a large public health benefit because of the large number of people affected by cataracts.

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: ACUITY		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	• Gallo, Rebok, and Lesikar (1999). Self-reported vision impairment was related to avoidance of challenging driving situations, but not to self-reported citations or crashes in prior 2 years. Authors conclude that vision impaired drivers who self restrict are less likely to crash. Vision impairment categories: no trouble seeing; a little trouble, a lot of trouble (i.e., may not be specific to acuity). • Ball, Owsley, Stalvey, Roenker, Sloane, and Graves (1998): No relationship between avoidance score and crashes in subsequent 3 year period. • De Raedt and Ponjaert-Kristoffersen (2000): poor performers on a road test but were free of (self-reported) at-fault crashes (prior 12 mo) used significantly more strategic compensation tactics (avoidance of challenging situations) than poor-performing drivers with a history of at-fault crashes.	Panelists indicate this may or may not be effective; "we don't know if this works." People try to self-regulate when there are alternative transportation options, but there are times when they "must" drive even if they'd rather not (e.g., winter when it gets dark earlier, or no other driver to take them). Making people aware of deficits is the first step in getting people to self restrict, if they will self restrict. Studies show that there are many unaware vision-impaired drivers. Ophthalmologists and optometrists need to be included as targets of outreach, similarly to the AMA guide, and other outreach efforts that NHTSA has done for specialized populations because, eyecare specialists are a group that does not know their red flags to tell patients that "these are the laws in our state and this is what you need to be concerned about."
Central vision enhancement systems (bioptic telescopic lenses, implantable telescopes)	• Janke and Kazarian (1983): Crash rate in users is 1.5 times higher than population rate, but less than the crash rate of drivers licensed with other medical conditions. • Clark (1996): Crash rates for BTL users 1.9 times higher than comparison group, but citation rates 0.7 of that for comparison group. • Szlyk et al. (2000): Training in the use of BTL lenses (both lab and on-road) significantly increased performance in recognition, peripheral identification, and scanning compared to performance of non-trained BTL users.	Panelists in agreement with countermeasure if accompanied by training and assessment of driving safety after training. Recommend licensing with restrictions after low-driving program/rehab. Use lens only for spotting (5-10% of time). Training curriculum and design of lenses needs to be "nailed down." Training curriculum needs to be developed by Occupational Therapists. Countermeasure appropriate if no cognitive deficit.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for acuity deficit; raises awareness of deficit so they can self restrict. Also provide education to physicians and eyecare specialists so they can educate their patients. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. Panelist (a KEYS study author) noted that he has always questioned whether those self reported changes in driving habits were real; people may have been invested due to time spent in intervention and reported more avoidance than they really engaged in. Also, candidates for education intervention should not have advanced cognitive deficits (e.g., dementia). Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Collision warning systems	Oxley and Mitchell (1995): collision warning system tested in a simulator was effective in preventing older drivers from turning across traffic through gaps that were dangerously short.	Suggested by panelists as countermeasure that merits further research. Need forward as well as side-collision warning. Would be helpful if it caused the vehicle to brake, in addition to providing a warning. Concern is with complete reliance on the technology to detect hazards (especially for backing up) where older drivers back up without doing head/shoulder checks and have backed into (and killed) pedestrians. Also elderly people may be more distracted rather than assisted by some of the advanced technologies. And, most rehab center's adapted cars are not high-end/high tech, so it would be difficult for OTs to train people in the use of the technologies.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION)

SPECIFIC DEFICIT: CONTRAST SENSITIVITY

Associated Driver Performance Errors

- Could contribute to a failure to visually detect a potential threat.
- Acuity poorer than 20/40 independently associated with self-reported crashes, moving violations, being stopped by police in prior 5-year period (Marottoli et al. (1998).
- Combined criterion using acuity, CS, and horizontal visual fields significantly related to prior crash involvement in drivers age 66+, but no visual measure alone was significantly associated (Decina & Staplin (1993).
- Significant relationship between acuity and improper lookout (Shinar, McDonald, & Treat (1978).
- Acuity (score and response time) related to unsafe driving incidents; correlations higher for time to respond to acuity stimuli than acuity errors (McKnight & McKnight, 1999).
- Acuity response time rather than acuity score related to driving exam score (Staplin et al., 1998).
- Acuity slightly worse than 20/30 independently associated with self-reported difficulty driving on interstates, at night, in the rain, on high-traffic roads, during rush hour, alone, and making left turns (McGwin, Chapman, Owsley, 2000).
- Poorer dynamic acuity related to crash involvement in prior 2-year period (Shinar, Mayer, Treat, 1975).
- Dynamic acuity included in model predictive of closed course driving performance (Wood, 2002).
- Has been correlated with poor driving performance (Wood, 2002; Baldock et al., 2007) and increased crash risk in prior 5-year period (Owsley, Stalvey, Wells, Sloane, & McGwin, 2001).
- Baldock, Mathias, McLean and Berndt (2007): CS along with visual spatial memory and 2 measures of visual attention RT explained 35% of the variance in driving ability demonstrated in on-road test.

Included Behavioral Countermeasures

- Refractive correction (incl. Wavefront technology)
- Cataract surgery
- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Conformal vision enhancement system (e.g., in-vehicle enhancement of Stop Sign)
- Central vision enhancement systems (bioptic telescopic lenses, implantable telescopes)
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Collision warning systems
- Medical management (incl. pharmacy review)

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: CONTRAST SENSITIVITY		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Refractive correction (incl. Wavefront technology)	No before-after studies on refraction correction (updating prescription for corrective glasses) and driving safety uncovered. Panelist with expertise in the area stated that in the ophthalmology literature there is quite a bit of research on age and satisfaction for refractive errors corrective surgery. There is actually quite ample literature on people's feelings about their improved performance in everyday tasks there, clarity with which they can see things. It would seem reasonable that one would have asked the question about improved driving performance as a result of refractive error correction, but the panelist was not aware of anything done. Haddrill (2007): Ophthonix founder A. Dreher reports that iZon lenses (wavefront lenses) provide higher definition vision in the daytime and significantly improve night driving responses when compared with conventional lenses. Night vision improved a driver's ability to identify pedestrians by an average of 330 ms (30 ft sooner at 55 mi/h) when compared to conventional lenses. www.allaboutvision.com/lenses/wavefront-lenses.htm; http://ophthonix.izonlens.com/globals/faqs.asp; www.allaboutvision.com/whatsnew/lenses1.htm.	Even without research on effectiveness, panelists agreed that refractive correction should be advocated just on the prevalence of the problem and the inexpensiveness of the solution, particularly as there appears to be a decline in older people getting annual eye exams. Annual eye exams, refractive correction, and sooner diagnosis of treatable conditions (e.g., cataracts) are inexpensive solutions for reaching a substantial number of people for remediation. Vision specialist feedback to drivers regarding the driver licensing laws in their State in relation to their own level of impairment is important (and presently rare in practice); increasing awareness of impairments may lead to appropriate self-restriction. One of the early findings of the Salisbury Eye Study was that among the proportion of older individuals who had worse than 20/40 vision, more than half of them could be corrected just with glasses. A panel member (vision specialist) recommended inclusion of Wavefront technology as part of refractive correction. Wavefront technology diagnoses higher-order vision errors represented by the way the eye refracts or focuses light; such aberrations defocus images even with 20/40 acuity. Wavefront guided lenses can reduce certain higher-order aberrations, which potentially can improve low light image quality during activities such as driving at night. Panelist notes research on effectiveness for driving is currently limited to that conducted by lens manufacturer (see Haddrill 2007 description of Ophthonix iZon wavefront guided lenses). Another caution noted by the panelist regarding the lens company research is that improvements in vision with the wavefront lenses were compared to patients' vision as they appeared for the study. But it is well known that many patients especially over age 60 haven't had regular eye check-ups or new prescriptions.
Cataract surgery	Monestam and Wachtmeister (1997): Self reported problems with distance judgment declined from 37% to 6% of sample following cataract surgery. McGwin et al. (2003): contrast sensitivity improved significantly in the sample that underwent surgery, and day and night driving scores on Activities of Daily Vision Scale significantly improved post-operatively in surgery group. Owsley et al. (2002): Patients with a cataract who underwent surgery and IOL implantation had half the crash rate of drivers with cataract who did not undergo surgery (4.74 crashes per million miles of travel vs. 8.95). Wood and Carberry (2006): Bilateral cataract surgery resulted in significant improvements in on-road performance, related to improvements in CS.	Panelists agree this is a relatively inexpensive treatment and improvements result in crash reduction. Cataracts are often the only medical condition affecting driving performance. Even if crash reduction benefit is small, cataract surgery may provide a large public health benefit because of the large number of people affected by cataracts.

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: CONTRAST SENSITIVITY		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	• Gallo, Rebok, and Lesikar (1999). Self-reported vision impairment was related to avoidance of challenging driving situations, but not to self-reported citations or crashes in prior 2 years. Authors conclude that vision impaired drivers who self restrict are less likely to crash. Vision impairment categories: no trouble seeing; a little trouble, a lot of trouble (i.e., may not be specific to CS). • Ball, Owsley, Stalvey, Roenker, Sloane, and Graves (1998): No relationship between avoidance score and crashes in subsequent 3 year period. • De Raedt and Ponjaert-Kristoffersen (2000): poor performers on a road test but were free of (self-reported) at-fault crashes (prior 12 mo) used significantly more strategic compensation tactics (avoidance of challenging situations) than poor performers with a history of at-fault crashes. • Hennessy (1995): older drivers with poor CS and who (sometimes of often) avoided heavy traffic had a reduced crash risk compared to those with poor CS who did not avoid heavy traffic. Avoidance brought risk equal to that of drivers with good CS.	Panelists indicate this may or may not be effective; "we don't know if this works." People try to self-regulate when there are alternative transportation options, but there are times when they "must" drive even if they'd rather not (e.g., winter when it gets dark earlier, or no other driver to take them). Making people aware of deficits is the first step in getting people to self restrict, if they will self restrict.
Conformal vision enhancement system (e.g., in-vehicle enhancement of Stop Sign)	Caird, Horey, & Edwards (2001). Simulator study with 24 younger and 24 older drivers. Conformal enhancement of a traffic light resulted in fewer drivers running the light. Drivers indicated conformal VES would be helpful when environmental conditions restrict visibility, but not under heavy traffic, cluttered environments, or in daytime. Less than 25% indicated they would use VES regularly if available. Oxley and Mitchell (1995) reported that in a sample of older 31 UVES and 15 IVES users, 100% found it easy to use, and 60-73% indicated it would encourage them to drive outside of their usual driving situations. Gish, Staplin, and Perel (1999) found that 3 of 4 older drivers did not use VES to detect targets, but instead used it to detect curves in the road (controlled field study).	Panelists state older drivers in focus groups don't like anything in their cars that takes their focus away from the road (either on the windshield or on a heads-down display in the vehicle). They would choose not to drive in challenging situations rather than to use a device that may take their attention from the road, or that may be more difficult to operate. Another panelist indicated that following training in equipment use, older drivers are ok with such countermeasures; emphasizing that training is a critical component for new technologies to assist older drivers.
Central vision enhancement systems (bioptic telescopic lenses, implantable telescopes)	Janke and Kazarian (1983): Crash rate in users is 1.5 times higher than population rate, but less than the crash rate of drivers licensed with other medical conditions. Clark (1996): Crash rates for BTL users 1.9 times higher than comparison group, but citation rates 0.7 of that for comparison group. Szlyk et al. (2000): Training in the use of BTL lenses (both lab and on-road) significantly increased performance in recognition, peripheral identification, and scanning compared to performance of non-trained BTL users.	Panelists in agreement with countermeasure if accompanied by training and assessment of driving safety after training. Recommend licensing with restrictions after low-driving program/rehab. Use lens only for spotting (5-10% of time). Training curriculum and design of lenses needs to be "nailed down." Training curriculum needs to be developed by Occupational Therapists. Countermeasure appropriate if no cognitive deficit.

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: CONTRAST SENSITIVITY		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for contrast sensitivity deficit; raises awareness of deficit so they can self restrict. Also provide education to physicians and eyecare specialists so they can educate their patients. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Collision warning systems	Oxley and Mitchell (1995): collision warning system tested in a simulator was effective in preventing older drivers from turning across traffic through gaps that were dangerously short.	Suggested by panelists as countermeasure that merits further research. Need forward as well as side-collision warning. Would be helpful if it caused the vehicle to brake, in addition to providing a warning.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION)

SPECIFIC DEFICIT: VISUAL FIELDS

Associated Driver Performance Errors

- Could contribute to a failure to visually detect a potential threat.
- Impaired detection capability for stimuli in the affected parts of the visual field (Lovsund, Hedin, & Tornros, 1991).
- Correlated with crashes (Ball et al., 1993; Johnson & Keltner, 1983; Ruben et al., 2007; Szlyk et al., 1991).
- Drivers with Glaucoma (McGwin, Owsley, & Ball, 1998; Hu et al., 1998) and macular degeneration (Owsley et al., 1998) have higher crash rate than those without, and these conditions can restrict visual field.
- Significant relationship between right visual field size and driving performance (on-road test included 2 right-turn intersections) (Tarawneh et al. (1993).
- Combination of peripheral vision deficit and restricted head movement increases the difficulty of bringing an approaching vehicle on a perpendicular roadway into central vision, and may explain why older drivers have higher rates of intersection crashes that result in injury or death (Isler, Parsonson & Hansson (1997).

Included Behavioral Countermeasures

- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Central vision enhancement systems (bioptic telescopic lenses, implantable telescopes)
- Visual field expansion systems (prism, bioptic amorphic lenses, video feeds)
- Training in Compensatory Head/Eye Movements, Scanning Strategies
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Education about driving aids (Car Fit, features/adaptive equipment, shoes, etc.)
- Medical management (incl. pharmacy review)

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: VISUAL FIELDS		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	Hennessy (1995): poorer visual field ability (modified Synemed perimeter) was significantly associated with greater avoidance of driving at night, rain, dusk, dawn, and making left turns, but the predictive value of visual fields performance on crash rate (prior 3 yrs) was mediated only for avoidance of left turns; But avoidance did not reduce risk, it increased it (inadequate compensation).	Panelists indicate this may or may not be effective; "we don't know if this works." People try to self-regulate when there are alternative transportation options, but there are times when they "must" drive even if they'd rather not (e.g., winter when it gets dark earlier, or no other driver to take them). Making people aware of deficits is the first step in getting people to self restrict, if they will self restrict.
Central vision enhancement systems (bioptic telescopic lenses, implantable telescopes)	Janke and Kazarian (1983): Crash rate in users is 1.5 times higher than population rate, but less than the crash rate of drivers licensed with other medical conditions. Clark (1996): Crash rates for BTL users 1.9 times higher than comparison group, but citation rates 0.7 of that for comparison group. Szlyk et al. (2000): Training in the use of BTL lenses (both lab and on-road) significantly increased performance in recognition, peripheral identification, and scanning compared to performance of non-trained BTL users.	Panelists in agreement with countermeasure if accompanied by training and assessment of driving safety after training. Recommend licensing with restrictions after low-driving program/rehab. Use lens only for spotting (5-10% of time). Training curriculum and design of lenses needs to be "nailed down." Training curriculum needs to be developed by Occupational Therapists. Countermeasure appropriate if no cognitive deficit.
Visual field expansion systems (prisms, bioptic amorphic lenses, video feeds)	Szlyk et al. (1998): Following training with the lenses (lab and on-road), patients showed improvements in all visual skill categories, including peripheral detection and selecting appropriate gaps. Authors note further research necessary to determine safety while driving.	Panelist states that 100 degree binocular field is a good minimum standard; if < 100 degrees and adamant about driving, a driver should be offered these systems to see if he/she can adapt to it (should be the standard of care). Target audience would be a driver with 50 degree binocular fields in a State with no visual field requirement, and prisms (ref Eli Peli) could be used to expand the field to 100 degrees to make driving safer. Video feed may be better than amorphic lenses.

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: VISUAL FIELDS		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Training in compensatory head and eye movements, scanning strategies	Coeckelbergh et al. (2001): Training in compensatory viewing strategies, particularly on-road training, improved viewing behavior for persons with central or peripheral visual field constriction, and increased the number of subjects who passed a road test who previously failed. Ss had visual field defects due to ocular pathology; those with severe cognitive impairments were excluded from participation. Dynavision apparatus has been used in office rehab settings to train compensatory scanning strategies for visual inattention and visual field deficit in persons with intact attentional mechanisms. Klavora et al. (1995) found that Dynavision training with 10 older (age 46-73) post-CVA individuals resulted in significantly improved behind-the-wheel driving performance when compared with expected outcomes. All failed their first BTW assessment pre-Dynavision training. Training involved three 40-minute Dynavision Training sessions per week for 6 weeks. On the second BTW assessment, 6 of the 10 subjects earned a "safe to resume driving and/or receive on-road driving lessons." Laderman, Szlyk, Kelsch, and Seiple (2000): 4-week training on a task in a rehab center setting to teach peripheral detection, scanning, and tracking where the clients sat close to a screen and detected slide images in the periphery using amorphic lenses, then turning their heads toward the object to identify it more clearly through the carrier. 8-week training in-vehicle on closed course with driving instructor to practice skills. Before-after training results indicated 39% improvement in tasks involving peripheral detection, and 27% improvement in scanning tasks. Authors note further research is needed to define standards and evaluation methods for training curricula.	Panelists agreed that this is an appropriate countermeasure, but candidates must be cognitively intact. This type of training has been used for telescopic and amorphic-lens drivers ("search and destroy" method referred to by panelist, described by Laderman et al., 2000) and has been effective in improving peripheral visual detection. One panelist mentioned a book that may be useful in this training older adults to scan effectively by Ken Mills "Disciplined Attention: How to Improve Your Visual Attention When You Drive." The book (directed toward young driver training) is not a countermeasure that's ready to go, but it's one ready to be researched.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for visual field deficits; raises awareness of deficit so they can self restrict. Also provide education to physicians and eyecare specialists so they can educate their patients. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills education. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Education about driving aids (CarFit, features/adaptive equipment, shoes, etc.)		Panelists state that vehicles have safety features but many need to be adjusted, and older drivers don't know how to do this. Education about driving aids is a positive theme to staying on the road longer. Countermeasure merits further research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION)

SPECIFIC DEFICIT: DEPTH AND MOTION PERCEPTION

Associated Driver Performance Errors

- Could contribute to gap judgment error: driver turns right into too short a gap, and traffic approaching from left must slow to avoid a crash.
- Older drivers (especially females) rely on distance instead of integrating speed and distance, especially for higher-speed roads (Yan, Radwan, & Guo, 2007; Andersen & Enriquez, 2006; Scialfa et al., 1991; Dazentas, McDowell, & Cooper, 1980; Braitman et al., 2007; De Raedt & Ponjaert-Kristoffersen, 2000).
- Impairments in stereoacuity are related to retrospective crashes (Owsley, McGwin, & Ball, 1998; Ivers et al., 1999; Staplin et al., 1998).
- Poor structure from motion performance is related to simulator crashes (Rizzo et al., 1997 and at-fault safety errors on the road (Uc et al., 2005).
- Central motion sensitivity related to on road driving performance (Wood, 2002).
- In failure-to-yield crashes at intersections, drivers ages 70-79 made more evaluation errors than drivers ages 35-54 and those age 80+; evaluation errors occurred when the driver saw the other vehicle but misjudged whether there was adequate time to proceed (Braitman et al., 2007).
- Panelists indicated that a deficit in depth and motion perception could be associated with inability to predict development of future conflicts (critical performance error #3), in addition to gap judgment errors (#2).

Included Behavioral Countermeasures

- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Education about driving aids (Car Fit, features/adaptive equipment, shoes, etc.)
- Medical management (incl. pharmacy review)

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: DEPTH AND MOTION PERCEPTION		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	Ball, Owsley, Stalvey, Roenker, Sloane, and Graves (1998): No relationship between avoidance score and crashes in subsequent 3 year period. De Raedt and Ponjaert-Kristoffersen (2000): drivers who performed poorly on a road test but were free of (self-reported) at-fault crashes in the prior 12-mo period used significantly more strategic compensation tactics (avoidance of challenging situations) than poor-performing drivers with a history of at-fault crashes.	Panelists indicated that drivers could choose the route that has a protected turn.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for depth and motion perception deficits; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Education about driving aids (CarFit, features/adaptive equipment, shoes, etc.)		Panelists state that vehicles have safety features but many need to be adjusted, and older drivers don't know how to do this. Education about driving aids is a positive theme to staying on the road longer. Countermeasure merits further research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION)

SPECIFIC DEFICIT: DARK ADAPTATION AND GLARE RECOVERY

Associated Driver Performance Errors

- Difficulty determining what lane an approaching vehicle is in when making gap judgment.
- Older drivers with 3+ letters lost in the presence of glare on Peli-Robson Chart were 2.32 times more likely to crash in 4-year follow-up period (after adjusting for age, race, sex, cognitive performance, education, comorbidities, depression, and living alone. But no relationship found between disability glare and crashes in 3-year follow-up period (Owsley et al.,1998).
- Panelists indicated this deficit could be associated with a failure to detect potential conflicts, hazards, or traffic control information.

Included Behavioral Countermeasures

- Cataract surgery
- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Education about driving aids (CarFit, features/adaptive equipment, shoes, etc.)
- Medical management (incl. pharmacy review).

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: DARK ADAPTATION AND GLARE RECOVERY		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Cataract surgery	McGwin et al. (2003): disability glare improved significantly post surgery in group of patients with cataract. First surgery eye improvement in acuity significantly related to change in overall activities of daily vision scale and night driving and glare disability subscales. Change in disability glare in second surgery eye significantly assoc. w/change in ADVS score as well as change scores in night driving, near vision, and disability glare subscales.	Panelists agree this is a relatively inexpensive treatment and improvements result in crash reduction. Cataracts are often the only medical condition affecting driving performance. Even if crash reduction benefit is small, cataract surgery may provide a large public health benefit because of the large number of people affected by cataracts.
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	Ball, Owsley, Stalvey, Roenker, Sloane, and Graves (1998): No relationship between avoidance score and crashes in subsequent 3 year period. De Raedt and Ponjaert-Kristoffersen (2000): drivers who performed poorly on a road test but were free of (self-reported) at-fault crashes in the prior 12-mo period used significantly more strategic compensation tactics (avoidance of challenging situations) than poor-performing drivers with a history of at-fault crashes.	Panelists indicate this may or may not be effective; "we don't know if this works." People try to self-regulate when there are alternative transportation options, but there are times when they "must" drive even if they'd rather not (e.g., winter when it gets dark earlier, or no other driver to take them). Making people aware of deficits is the first step in getting people to self restrict, if they will self restrict.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be dark adaptation/glare recovery deficits; raises awareness of deficit so they can self restrict. Also provide education to physicians and eyecare specialists so they can educate their patients. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills education. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Education about driving aids (CarFit, features/adaptive equipment, shoes, etc.)		Panelists state that vehicles have safety features but many need to be adjusted, and older drivers don't know how to do this. Education about driving aids is a positive theme to staying on the road longer. Countermeasure merits further research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: SPEED OF PROCESSING

Associated Driver Performance Errors

- Effect of slowed SOP may be slowing of retrieval of knowledge of right-of-way rules, and slowed reasoning and decision-making about appropriate visual search and vehicle control.
- Speed of processing deficits (UFOV subtest 1) accounted for 4.1% of the variance in crash involvement (prior 3-years) for drivers age 70+ (type not specified) adjusting for age, gender, and driving exposure (Hennessy, 1995).
- Older drivers who performed poorly on the Trails A test had significantly more retrospective crashes (Stutts, Stewart, & Martell, 1996, 1998; Goode, Ball, Sloane, Roenker, Roth, Myers, & Owsley, 1998) and prospective crashes (Lesikar, Gallo, Rebok, & Keyl, 2002) than drivers who performed well on this SOP measure. Crash type not specified in these studies.
- Older crash-involved drivers with licenses suspended for failure to yield the right of way performed significantly worse on Trails A than subjects w/o suspended licenses (Lundberg, Hakamies-Blomqvist, Almkvist, & Johannson, 1998).
- Panelists indicated that a speed of processing deficit could be associated with the following critical driver performance errors: #2 gap judgment errors; #3 inability to predict development of future conflicts; #4 slowed vehicle control response; #5 inadequate visual search/improper lookout; #6 slowed decision making; #9 pedal errors (inappropriate response selection).

Included Behavioral Countermeasures

- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Speed of processing training
- Physical aerobic activity/training
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Collision warning systems
- Medical management (incl. pharmacy review)

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: SPEED OF PROCESSING		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	• Ball, Owsley, Stalvey, Roenker, Sloane, and Graves (1998): No relationship between avoidance score and crashes (prior 3 yrs). • Hennessy (1995): poorer SOP ability was significantly associated with greater avoidance of driving at night, rain, dusk, dawn, alone, left turns, and heavy traffic, but the predictive value of the SOP subtask on crash rate (prior 3 yrs) was mediated only for avoidance of left turns; But avoidance did not reduce risk, it increased it (inadequate compensation). • De Raedt and Ponjaert-Kristoffersen (2000): poor performers on a road test who were free of (self-reported) at-fault crashes in the prior 12-mo period used significantly more strategic compensation tactics (avoidance of challenging situations) than poor performers with history of at-fault crashes.	Panelists indicate this may or may not be effective; "we don't know if this works." People try to self-regulate when there are alternative transportation options, but there are times when they "must" drive even if they'd rather not (e.g., winter when it gets dark earlier, or no other driver to take them). Making people aware of deficits is the first step in getting people to self restrict, if they will self restrict.
Speed of processing training	Roenker et al. (2003): Speed of processing training using all 3 subtests of UFOV compared to Doron simulator training and untrained reference group. Global ratings of on-road driving performance improved for both training groups, but only SOP group maintained performance at 18 mo. For "dangerous maneuvers" component, both training groups showed improvements, but only SOP training maintained improvement at 18 mo. Dangerous maneuvers included 6 opportunities for unprotected turns across traffic and 9 left-turn entrances to a high-traffic road.	Panelists agreed this may be a viable countermeasure, but there is a need to establish the link between training on task and transfer to driving.
Physical aerobic activity/training	Marmeleira, Godinho, and Fernandes (2008) found that a 12-week exercise program with 3, 60-min sessions per week improved visual attention in speed of processing and divided attention (using the UFOV protocol) at 12 weeks follow-up in adults ages 60 to 81. The intervention incorporated perceptual and cognitive tasks (problem solving and responding to challenging situations) with aerobic activity. Examples are: walking while listening for auditory cues to perform fast and specific psychomotor responses). At 12 weeks, speed of processing and divided attention were significantly improved compared to baseline for the exercise group; at baseline, there was no difference between groups. Actual driving performance was not studied, and there was no exercise-only group to determine the contribution of physical activity alone on speed of processing or divided attention.	Research article provided by panelist following meeting; panelists did not get to comment on countermeasure for deficit. Merits further research
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for selective attention deficits; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Collision warning systems	Oxley and Mitchell (1995): collision warning system tested in a simulator was effective in preventing older drivers from turning across traffic through gaps that were dangerously short.	Suggested by panelists as countermeasure that merits further research. Need forward as well as side-collision warning. Would be helpful if it caused the vehicle to brake, in addition to providing a warning.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: SELECTIVE ATTENTION

Associated Driver Performance Errors

- Older drivers with selective attention deficits had shorter time to collision values, took longer to cross the road, and had shorter safety cushions (on-road study) than drivers with no impairment in selective attention ability (Pietras et al., 2006).
- Poor visual attention (number cancellation test) related to poor on-road driving performance, specifically scanning visual field for potentially dangerous objects, yielding the right of way, negotiating turns safely (Richardson & Marottoli, 2003).
- In a laboratory study using a change blindness technique to measure selective attention, older drivers were more likely to miss detecting relevant vehicles when making safe-not safe to turn decisions (Caird et al., 2005).
- Selective attention with visual search correlated significantly with global road test score, accounting for 19% of the variance (De Raedt & Ponjaert-Kristoffersen, 2000). It also correlated significantly w/visual behavior and communication (r= -.43) and perception and reaction to signals (r=-.37).
- Poor scores on Brief Test of Attention and on Trails A were related to slower perception-reaction times and slower brake movement times during a computerized test of simple RT (Zhang et al., 2007).
- Panelists indicated that a selective attention deficit could be associated with the following critical driver performance errors: #2 gap judgment errors; #3 inability to predict development of future conflicts; #4 slowed vehicle control response; #5 inadequate visual search/improper lookout; #6 slowed decision making; #9 pedal errors (inappropriate response selection).

Included Behavioral Countermeasures

- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Conformal vision enhancement system
- Speed of processing training
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Collision warning systems
- Medical management (incl. pharmacy review)
- Cognitive rehab (incl. memory training) for normally aging population
- Compensatory cognitive/memory training for impaired/MCI population

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: SELECTIVE ATTENTION		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	Ball, Owsley, Stalvey, Roenker, Sloane, and Graves (1998): No relationship between avoidance score and crashes in subsequent 3 year period. De Raedt and Ponjaert-Kristoffersen (2000): drivers who performed poorly on a road test but were free of (self-reported) at-fault crashes in the prior 12-mo period used significantly more strategic compensation tactics (avoidance of challenging situations) than poor-performing drivers with a history of at-fault crashes.	Panelists indicate this may or may not be effective; "we don't know if this works." People try to self-regulate when there are alternative transportation options, but there are times when they "must" drive even if they'd rather not (e.g., winter when it gets dark earlier, or no other driver to take them). Making people aware of deficits is the first step in getting people to self restrict, if they will self restrict.
Conformal vision enhancement system (e.g., in-vehicle enhancement of Stop Sign)	Caird, Horey, & Edwards (2001). Simulator study with 24 younger and 24 older drivers. Conformal enhancement of a traffic light resulted in fewer drivers running the light. Drivers indicated conformal VES would be helpful when environmental conditions restrict visibility, but not under heavy traffic, cluttered environments, or in daytime. Less than 25% indicated they would use VES regularly if available. Oxley and Mitchell (1995) reported that in a sample of older 31 UVES and 15 IVES users, 100% found it easy to use, and 60-73% indicated it would encourage them to drive outside of their usual driving situations. Gish, Staplin, and Perel (1999) found that 3 of 4 older drivers did not use VES to detect targets, but instead used it to detect curves in the road (controlled field study).	Panelists state older drivers in focus groups don't like anything in their cars that takes their focus away from the road (either on the windshield or on a heads-down display in the vehicle). They would choose not to drive in challenging situations rather than to use a device that may take their attention from the road, or that may be more difficult to operate. Another panelist indicated that following training in equipment use, older drivers are ok with such countermeasures; emphasizing that training is a critical component for new technologies to assist older drivers.
Speed of processing training	Roenker et al. (2003): Speed of processing training using all 3 subtests of UFOV compared to Doron simulator training and untrained reference group. Global ratings of on-road driving performance improved for both training groups, but only SOP group maintained performance at 18 mo. For "dangerous maneuvers" component, both training groups showed improvements, but only SOP training maintained improvement at 18 mo. Dangerous maneuvers included 6 opportunities for unprotected turns across traffic and 9 left-turn entrances to a high-traffic road.	Panelists agreed this may be a viable countermeasure, but there is a need to establish the link between training on task and transfer to driving.

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: SELECTIVE ATTENTION		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for selective attention deficits; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Collision warning systems	Oxley and Mitchell (1995): collision warning system tested in a simulator was effective in preventing older drivers from turning across traffic through gaps that were dangerously short.	Suggested by panelists as countermeasure that merits further research. Need forward as well as side-collision warning. Would be helpful if it caused the vehicle to brake, in addition to providing a warning.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.
Cognitive rehab (including memory training) for normally aging population	One panelist noted that reasoning training conducted as part of the ACTIVE trial described by Ball, Berch, Helmers, Jobe, Leveck, et al. (2002) showed an effect on decreased driving difficulty in the 6 years following enrollment in the study. These findings were presented at the 2008 GSA meeting, but not published as of the date of this report.	Panelists indicate this is building subskills for the driving task. An OT panelist noted that you cannot just do a lot of the cognitive retraining tasks and assume that it will generalize to driving. You need to make that part of the therapy program. Countermeasure has tremendous promise but it is just in its infancy for developing the training protocols, and making sure it is appropriate. There is a real need for good research to make sure that we use this appropriately.
Compensatory cognitive/memory training for impaired/MCI population		Panelists were cautious about recommending cognitive interventions for people with early stage dementia, and indicated that strategies must be compensatory rather than restorative for this group.

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: DIVIDED ATTENTION

Associated Driver Performance Errors

- Maneuver requires looking to the left for an appropriate gap to merge into, watching ahead to avoid hitting a lead vehicle, and possibly looking behind (over shoulder/mirror check) to find safe gap (for parallel acceleration lane). Also, divided attention requirements are increased if there is a pedestrian crossing the channelized lane or the receiving lane.
- Drivers with restrictions in UFOV (composite measure of all 3 tests, with a 40% or more deficit) had 15 times more intersection crashes (type not specified) in prior 5-year period than drivers with normal visual attention (Owsley et al., 1991).
- Drivers with UFOV divided attention deficit had a significantly higher odds of crashing (prospectively) than drivers with normal divided attn performance (crash type not specified) (Rubin et al., 2007; Staplin et al., 2003; Edwards et al., 2008).
- Divided attention deficit associated with prospective crashes, the majority of which were failure-to-yield the right of way (Owsley et al., 1998).
- In failure-to-yield crashes at intersections (e.g., proceeding after stopping at a stop sign, turning left at a green light, or right on a red light), the predominant error for drivers ages 80+ was search and detection errors; these occurred more frequently for drivers age 80+ (86%) than for drivers ages 35-54 (84%) and those age 70-79 (55%). Although drivers ages 35-54 made many search and detection errors, these were most often due to distraction, whereas drivers age 80+ most often "looked but did not see"/inadequate search (Braitman et al., 2007).
- Impairment in UFOV independently associated with difficulty driving in the rain (McGwin, Chapman, Owsley (2000).
- UFOV performance predicted on-road driving performance, and was significantly correlated with tactical anticipatory behavior in changing situation; visual behavior; and insight, sense of context, and practical implementation (De Raedt & Ponjaert-Kristoffersen (2000). The greater the reduction in UFOV, the higher the likelihood of failing on-road test (Myers et al., 2000).
- Panelists indicated that a divided attention deficit could be associated with the following critical driver performance errors: #2 gap judgment errors; #3 inability to predict development of future conflicts; #4 slowed vehicle control response; #5 inadequate visual search/improper lookout; #6 slowed decision making; #9 pedal errors (inappropriate response selection).

Included Behavioral Countermeasures

- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Speed of processing training
- Physical aerobic/activity training
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Collision warning systems
- Medical management (incl. pharmacy review)
- Cognitive rehab (incl. memory training) for normally aging population
- Compensatory cognitive/memory training for impaired/MCI population

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: DIVIDED ATTENTION		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	Ball, Owsley, Stalvey, Roenker, Sloane, and Graves (1998): No relationship between avoidance score and crashes in subsequent 3 yrs. Hennessy (1995): poorer divided attention ability was significantly associated with greater avoidance of driving at night, rain, dusk, dawn, alone, left turns, and heavy traffic, but the predictive value of the divided attention subtask of UFOV on crash rate (prior 3 yrs) was not mediated by any of the forms of self restriction. De Raedt and Ponjaert-Kristoffersen (2000): poor performers on a road test who were free of (self-reported) at-fault crashes in the prior 12-mo period used significantly more strategic compensation tactics (avoidance of challenging situations) than poor performers with a history of at-fault crashes. Owsley et al. (1998) found that older drivers with UFOV reduction of 40% or more and who reported driving fewer than 7 days per week had a 45% decreased crash risk compared to older drivers with a 40% or more reduction in UFOV who reported driving 7 days/week.	Panelists indicate this may or may not be effective; "we don't know if this works." People try to self-regulate when there are alternative transportation options, but there are times when they "must" drive even if they'd rather not (e.g., winter when it gets dark earlier, or no other driver to take them). Making people aware of deficits is the first step in getting people to self restrict, if they will self restrict.
Speed of processing training	Roenker et al. (2003): Speed of processing training using all 3 subtests of UFOV compared to Doron simulator training and untrained reference group. Global ratings of on-road driving performance improved for both training groups, but only SOP group maintained performance at 18 mo. For "dangerous maneuvers" component, both training groups showed improvements, but only SOP training maintained improvement at 18 mo. Dangerous maneuvers included 6 opportunities for unprotected turns across traffic and 9 left-turn entrances to a high-traffic road.	Panelists agreed this may be a viable countermeasure, but there is a need to establish the link between training on task and transfer to driving.
Physical aerobic activity/training	Marmeleira, Godinho, and Fernandes (2008) found that a 12-week exercise program with 3, 60-min sessions per week improved visual attention in speed of processing and divided attention (using the UFOV protocol) at 12 weeks follow-up in adults ages 60 to 81. The intervention incorporated perceptual and cognitive tasks (problem solving and responding to challenging situations) with aerobic activity. Examples are: walking while listening for auditory cues to perform fast and specific psychomotor responses). At 12 weeks, speed of processing and divided attention were significantly improved compared to baseline for the exercise group; at baseline, there was no difference between groups. Actual driving performance was not studied, and there was no exercise-only group to determine the contribution of physical activity alone on speed of processing or divided attention.	Research article provided by panelist following meeting; panelists did not get to comment on countermeasure for deficit. Merits further research.

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: DIVIDED ATTENTION		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for divided attention deficits; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Collision warning systems	Oxley and Mitchell (1995): collision warning system tested in a simulator was effective in preventing older drivers from turning across traffic through gaps that were dangerously short.	Suggested by panelists as countermeasure that merits further research. Need forward as well as side-collision warning. Would be helpful if it caused the vehicle to brake, in addition to providing a warning.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.
Cognitive rehab (including memory training) for normally aging population	OTs noted that there are protocols and treatments for retraining attention, but cognitive rehab literature shows efficacy of attentional therapy in the broader rehab area ("Society for Cognitive Rehab"). It doesn't directly address driving, but builds subskills for the driving task.	Panelists indicate this is building subskills for the driving task. An OT panelist noted that you cannot just do a lot of the cognitive retraining tasks and assume that it will generalize to driving. You need to make that part of the therapy program. Countermeasure has tremendous promise but it is just in its infancy for developing the training protocols, and making sure it is appropriate. There is a real need for good research to make sure that we use this appropriately.
Compensatory cognitive/memory training for impaired/MCI population	Klavora et al. (1995) conducted a before-after study with 10 stroke patients with visual and attentional difficulties and rated unsafe to drive. Following training with a Dynavision apparatus, 6 of 10 participants earned a rating of "safe to resume driving and/or to receive on-road driving lessons."	Panelists were cautious about recommending cognitive interventions for people with early stage dementia, and indicated that strategies must be compensatory rather than restorative for this group.

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: WORKING MEMORY

Associated Driver Performance Errors

- Better working memory performance (5 sets of additions, where each set included 3, 2-digit numbers) was associated with larger gaps selected, in a simulator study of left turns across oncoming traffic (Guerrier et al., 1999).
- Lee, Lee, Cameron, and Li-Tsang (2005) found that poor performance on a working memory task by older drivers (ages 60-88) during simulated driving was significantly associated with self-reported crashes in the prior 1-year period.
- Hunt, Morris, Edwards, and Wilson (1993) found a significant correlation between pass/fail outcome on a road test and performance on the Logical memory subscale of the Wechsler Memory Scale (assessing immediate and delayed recall).
- Szlyk, Myers, Zhang, Wetzel, and Shapirio (2002) found that older drivers with poor performance on several measures of working memory had poorer performance in a driving simulator (drove at slower speed, and had more lane boundary crossings) than drivers with better performance on the working memory tasks.
- Panelists indicated a working memory deficit could be associated with the following critical driver performance errors: #2 gap judgment errors; #3 inability to predict the development of future conflicts from current traffic and contextual information.

Included Behavioral Countermeasures

- Physical aerobic/activity training
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Medical management (incl. pharmacy review)
- Cognitive rehab (incl. memory training) for normally aging population
- Compensatory cognitive/memory training for impaired/MCI population
- Pre-trip planning

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: WORKING MEMORY		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Physical aerobic activity/training		Panelists indicated this countermeasure merits further research for remediation of working memory deficits, stating a large body of research showing aerobic exercise results in alertness--hippocampul regeneration.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)		Panelists state all 3 types of education may be useful for working memory deficits; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.
Cognitive rehab (including memory training) for normally aging population	OTs noted that there are protocols and treatments for retraining attention, but cognitive rehab literature shows efficacy of attentional therapy in the broader rehab area ("Society for Cognitive Rehab"). It doesn't directly address driving, but builds subskills for the driving task. Laderman, Szlyk, Kelsch, and Seiple (2000) found improvement in visual memory (remembering store names subjects had walked past) after practice in the laboratory recalling sequences of numbers, letters, and shapes presented briefly on 35-mm slides.	Panelists indicate this is building subskills for the driving task. An OT panelist noted that you cannot just do a lot of the cognitive retraining tasks and assume that it will generalize to driving. You need to make that part of the therapy program. Countermeasure has tremendous promise but it is just in its infancy for developing the training protocols, and making sure it is appropriate. There is a real need for good research to make sure that we use this appropriately.
Compensatory cognitive/memory training for impaired/MCI population		Panelists were cautious about recommending cognitive interventions for people with early stage dementia, and indicated that strategies must be compensatory rather than restorative for this group.
Pre-trip planning		Countermeasure suggested by panelists as meriting further research

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: EXECUTIVE FUNCTION (JUDGMENT/DECISION-MAKING)

Associated Driver Performance Errors

- Age-related declines in executive control function include planning, scheduling, working memory, inhibitory processes, and multi-tasking.
- Association between poor performance on Trails B Test (a measure of executive function) and retrospective (Stutts et al., 1998; Goode et al., 1998; Daigneault et al., 2002) and prospective state-recorded crashes (Staplin et al., 2003) and poor simulator (Rizzo et al., 1997; Szlyk et al., 2002)) and on-road performance (Tarawneh et al., 1993), although type of crash not specified.
- Poor performance on a maze test (also measures executive functioning) was correlated with road test failure (Snellgrove, 2005; Ott et al., 2008).
- Panelists indicated that an executive function deficit could be associated with the following critical driver performance errors: #2 gap judgment errors; #3 inability to predict development of future conflicts; #4 slowed vehicle control response; #5 inadequate visual search; #6 slowed decision making; and #9 pedal errors (inappropriate response selection).

Included Behavioral Countermeasures

- Physical aerobic/activity training
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Medical management (incl. pharmacy review)
- Cognitive rehab (incl. memory training) for normally aging population
- Compensatory cognitive/memory training for impaired/MCI population
- Pre-trip planning

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: EXECUTIVE FUNCTION (JUDGMENT/DECISION-MAKING)		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Physical aerobic activity/training	No studies on improvement in driving, however, Colcombe and Kramer (2003) found the largest positive effects of fitness training and cognitive functioning in older (non-demented) adults was on executive control processes. Programs combining aerobic training with strength and flexibility training had the largest effects. Conflicting evidence was found by Marmeleira, Godinho, and Fernandes (2008); an exercise program incorporating walking with cognitive and perceptual tasks resulted in no improvement on tests of executive function (Stroop or Trails B) from baseline to 12-weeks post intervention.	Panelists indicated this may be an appropriate countermeasure for deficits in executive function, but requires further research. A panelist mentioned that the literature in the area of exercise and cognitive function is mixed, with some studies showing improvement and others showing no effect. One problem with the research may be that the exercise interventions are too brief to result in an improvement.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Marottoli (2007): AAA Safe Driving for Mature Operators presented in 2, 4-hour sessions with supplemental topics (including search strategies for intersections), plus 2, 1-hour on-road driving sessions focused on common errors made by older persons. On road performance assessed at baseline and 8 weeks post-intervention included 31 T-type intersections and 32 crossing intersections. There were 15 right turns, 12 merges, and several opportunities for right turns on red. Post-test scores were significantly higher than baseline, translating to 9.5% decrease in crash risk over 2-year period. The items showing the most improvement included scanning to the rear, lane selection, right turns, and judgment. Eby, Molnar, Shope, Vivoda, and Fordyce (2003). Driving Decisions Workbook (a self assessment tool) was effective in increasing older drivers' awareness of changes in driving abilities related to aging, and effects of changes on driving. Participants stated they would seek 2nd tier assessment and change driving habits. Skufca (2008): AARP DSP participants indicated course encouraged them to change certain driving behaviors (20% indicated avoiding left turns as a new behavior).	Panelists state all 3 types of education may be useful for deficits in executive functioning; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.
Cognitive rehab (including memory training) for normally aging population		Panelists indicate this is building subskills for the driving task. An OT panelist noted that you cannot just do a lot of the cognitive retraining tasks and assume that it will generalize to driving. You need to make that part of the therapy program. Countermeasure has tremendous promise but it is just in its infancy for developing the training protocols, and making sure it is appropriate. There is a real need for good research to make sure that we use this appropriately.
Compensatory cognitive/memory training for impaired/MCI population		Panelists were cautious about recommending cognitive interventions for people with early stage dementia, and indicated that strategies must be compensatory rather than restorative for this group.
Pre-trip planning		Countermeasure suggested by panelists as meriting further research.

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: SPATIAL ABILITIES

Associated Driver Performance Errors

- Errors in distance judgment and difficulty predicting the development of traffic situations (Johansson & Lundberg, 1997).
- Poor performance on clock-drawing test (a measure of visuospatial functioning) accounted for 38% of the variance in road test performance in sample referred for fitness to drive assessment (excluded persons suspected of dementia or cognitive decline); Specific errors not described in correlational analysis (De Raedt & Ponjaert-Kristoffersen, 2001).
- Impaired pentagon copying performance was associated with adverse driving events (crashes, violations), but type not specified (Marottoli et al., 1994).
- Poor performance on the MVPT Visual Closure subscore was associated with crashes (type not specified) in 20-month follow-up period (Staplin et al., 2003), and on poor road test performance (Tarawneh et al., 1993).
- Older, crash-involved subjects with suspended licenses performed worse on tests of visuospatial abilities than older non-crash-involved drivers with suspended licenses, and older drivers with clean records. A main violation type leading to crashes and suspensions included failure to yield the right of way (Lundberg et al., 1998).
- Poor performance on tests of spatial ability (Rey-Osterreith Complex Figures and Wechsler Memory Scale) discriminated crash-involved from crash-free drivers in prior 5-year period (Goode et al., 1998).
- Panelists indicated that a deficit in spatial abilities could be associated with the following critical driver performance errors:#2 gap judgment errors; #3 inability to predict the development of future conflicts; #5 inadequate visual search/improper lookout; and #6 slowed decision making.

Included Behavioral Countermeasures

- Visual perceptual therapy
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Medical management (incl. pharmacy review)

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: SPATIAL ABILITIES		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Visual perceptual therapy	McCoy et al. (1993): Evaluated workbook exercises to improve visual perception in 5 areas: spatial relationships, visual discrimination, figure ground, visual closure, and visual memory. Before-after on-road driving performance (DPM technique) improved by 7.7 percentage points, compared to no improvement in control group.	Panelists indicated this countermeasure merits further research for remediation of deficits in spatial abilities.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)		Panelists state all 3 types of education may be useful for deficits in spatial abilities; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. OTs note that if there is a serious deficit, driving should be ruled out. Spatial abilities deficits manifest themselves in lane control difficulty. They will start with easy situations and progress to more difficult situations if there is improvement. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: KNOWLEDGE

Associated Driver Performance Errors

- Misunderstanding of the behavioral requirements when approaching a yield sign ; older drivers often stop at yield signs at channelized right turns {FHWA Highway Design Handbook for Older Drivers and Pedestrians (Staplin et al., 2001)}.
- Panelists indicated a knowledge deficit could be associated with the following critical driver performance errors: #3 inability to predict the development of future conflicts; #7 lack of understanding of rules of the road; #8 lack of understanding or failure to apply safe driving practices.

Included Behavioral Countermeasures

- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)
- Medical management (incl. pharmacy review)
- Pre-trip planning

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: KNOWLEDGE		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Driver safety education (Theory/Classroom)	Skufca (2008): AARP DSP participants indicated course encouraged them to change certain driving behaviors, specifically paying more attention when exiting or entering highways (49%) and yielding the right of way (44%) as a consequence of information learned. Kutner (2006): No difference in crash rate (self reported) in prior 12-month period for AARP Driver Safety program participants and comparison group of not-AARP DSP participants. Bedard et al. (2004). Canadian Safety council adaptation of AARP DSP evaluated for treatment and comparison group using an on-road evaluation at baseline and post-treatment. On-road evaluation scores improved significantly for treatment and control group from baseline to post-intervention; no significant difference between treatment and comparison group on mean change score from the first to second evaluation. Janke (1994). Completion of Mature Driver Improvement Program was associated with more total fatal injury crashes and fewer citations compared with group who did not attend course. Eby, Molnar, Shope, Vivoda, and Fordyce (2003). Driving Decisions Workbook (a self assessment tool) was effective in increasing older drivers' awareness of changes in driving abilities related to aging, and effects of changes on driving. participants stated they would seek 2nd tier assessment and change driving habits; no evaluation on whether drivers followed through on these plans. McCoy et al. (1993). Completion of AAA Safe Driving for Mature Operators was associated with a significant increase in on-road driving performance (baseline and post intervention road test using DPM technique) of 3.7 percentage points. Education plus physical therapy increased score by 8.7 percentage points; education plus perceptual therapy increased score by 13.9 percentage points. Nasvadi and Vavrik (2007). Evaluation of British Columbia Safety Council adaptation of AARP DSP comparing police-reported at-fault crash and violation rate for participants vs. non-participants in prior 2-year period, to determine whether self-selection bias exists for those who attend remedial safety courses. Significantly more participants than controls had crashed, but there was no difference in violation rate. A follow-up comparison of crash rate for subsequent 2-year period for attendees and controls with matched pre-course crash rate showed that more attendees had crashes than non-attendees, but the difference was not significant. However, when stratifying by age group and gender, males age 75+ who attended the course were 3.8 times more likely to be involved in a crash than controls who did not attend class. No difference in crash rate for men ages 55-74 or women ages 55-74 and those 75+.	General consensus that it makes sense to provide education, even if it isn't adequate; people will be people, and it may work for some and not others. Education (theory) alone may never be enough; may need to be coupled with skills training.

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: KNOWLEDGE		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Driver safety education (Theory + BTW)	Marottoli (2007): AAA Safe Driving for Mature Operators presented in 2, 4-hour sessions with supplemental topics (including search strategies for intersections), plus 2, 1-hour on-road driving sessions focused on common errors made by older persons. On road performance assessed at baseline and 8 weeks post-intervention included 31 T-type intersections and 32 crossing intersections. There were 15 right turns, 12 merges, and several opportunities for right turns on red. Post-test scores were significantly higher than baseline, translating to 9.5% decrease in crash risk over 2-year period. The items showing the most improvement included scanning to the rear, lane selection, right turns, and judgment. Bedard et al. (2008): Significant improvement in knowledge, but no change in driving performance for the category of signal violations/right of way/inattention.	General consensus that it makes sense to provide education, even if it isn't adequate; people will be people, and it may work for some and not others. Education (theory) alone may never be enough; may need to be coupled with skills training.
Driver safety education (Interactive/computer-based)		Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)		Panelists state that vehicles have safety features but many need to be adjusted, and older drivers don't know how to do this. Education about driving aids is a positive theme to staying on the road longer. Countermeasure merits further research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.
Pre-trip planning		Countermeasure suggested by panelists as meriting further research

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: PHYSICAL/PSYCHOMOTOR

SPECIFIC DEFICIT: HEAD/NECK/TRUCK RANGE OF MOTION

Associated Driver Performance Errors

- Difficulty turning head to left to look for gap in approaching traffic (and failure to detect potential conflict vehicles, or to detect them at safe maneuvering distance); difficulty increases for skewed angles of intersection.
- Impaired ability to turn head to check over shoulder significantly predicted at-fault crashes in 20-month follow up period (Staplin et al., 2003).
- Limited range of motion of neck is significantly associated with adverse driving events (self reported, prior 5 years) (Marottoli et al., 1998).
- Range of motion significantly associated with pass/fail performance on road test (McCarthy & Mann, 2006).
- Maximum achieved head movement angles of a sample of older drivers would not be sufficient to bring approaching traffic at a T-intersection into central vision at distances exceeding 20 m without additional eye movements; deficits in peripheral vision would further delay perception of approaching vehicles (Isler et al., 1997).
- Decision time to make a go/no go response to turn at a simulated T-intersection increased with age and level of impairment in range of neck movement (Hunter-Zaworski, 1990).
- Maximum achieved head movement angles of a sample of older drivers would not be sufficient to bring approaching traffic at a T-intersection into central vision at distances exceeding 20 m without additional eye movements; deficits in peripheral vision would further delay perception of approaching vehicles (Isler et al., 1997). Crash-involved older drivers were 1.25 times more likely to have medical diagnosis of joint/spine disorders in 2-yr period prior to crash than non-crash-involved controls (Cui, 2001). Self-reported health symptoms relating to spine and lower body (limited strength or movement, lack of feeling or sensation, involuntary movement, chronic pain) related to self reported driving difficulties, and lack of physical activity related to difficulty with shoulder checking (Tuokko et al., 2007).
- Panelists indicated a deficit in head/neck trunk range of motion could be associated with the following critical driver performance errors: #1 failure to visually detect potential conflicts, hazards, or traffic control information; #4 slowed vehicle control response.

Included Behavioral Countermeasures

- Training in compensatory head/eye movements, scanning strategies
- Physical aerobic/activity training
- Strength and flexibility exercises
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)
- Collision warning systems
- After-market, non-planar, driver-side mirror
- Medical management (incl. pharmacy review)

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: HEAD/NECK/TRUNK RANGE OF MOTION		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Training in compensatory head/eye movements, scanning strategies		Panelists agreed that this is an appropriate countermeasure, but candidates must be cognitively intact. This type of training has been used for telescopic and amorphic-lens drivers ("search and destroy" method) and has been effective in improving peripheral visual detection.
Physical aerobic/activity training	May be research from Art Kramer at the University of Illinois looking at physical exercise programs and driving (simulator).	Merits further research.
Strength and flexibility exercises	Ostrow et al. (1992). Exercise program consisting of chin flexion/extension, neck rotations, head side bending, chin tucks, rotating shoulders backward, and trunk rotations. Sig. improvements in trunk rotation and shoulder flexibility across experimental subjects' 3 testing sessions (baseline, 8 and 11 weeks). Subjects in experimental group showed improvements in field-based assessment of driving skill: looked more frequently to the sides and rear of their vehicle than control drivers who did not participate in program. Marottoli et al. (2007) 12 week, in-home exercises 15 minutes daily, 7 days/week, with weekly in-home visit by physical therapist. Exercises focused on axial/extremity condition, upper extremity coordination/dexterity, and gait abnormalities. On-road driving performance was measured at baseline and post-intervention for treatment and control group. Significant improvement for treatment group compared to control group translated to 8 to 16 percent lower crash occurrence over 2 year period. Intervention group also made 37% fewer critical errors (inattention, turning or changing lanes w/o looking, and disobeying signs or signals) than control group at follow up. McCoy et al. (1993): Home-based exercises designed to improve posture, trunk rotation, neck flexibility, shoulder flexibility. 1-hour training session followed by 8 weeks of exercise, 4 times per week. Post intervention On-road drive test performance improved by 6.8 percentage points (significant), and when physical therapy was combined with driver education, improvement increased by 8.7 percent.	Panelists agreed that this is an appropriate countermeasure
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)		Panelists state all 3 types of education may be useful for deficits in head/neck/trunk range of motion; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: HEAD/NECK/TRUNK RANGE OF MOTION		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)		Panelists state that vehicles have safety features but many need to be adjusted, and older drivers don't know how to do this. Education about driving aids is a positive theme to staying on the road longer. Concern about liability for re- aiming mirrors for drivers during CarFit; OTs put the mirrors back to their original position when the drivers arrive at the evaluation. Countermeasure merits further research.
Collision warning systems	Oxley and Mitchell (1995): collision warning system tested in a simulator was effective in preventing older drivers from turning across traffic through gaps that were dangerously short.	Suggested by panelists as countermeasure that merits further research. Need forward as well as side-collision warning. Would be helpful if it caused the vehicle to brake, in addition to providing a warning.
After-market, non-planar, driver-side mirror	No research on "bulls eye" convex mirror affixed to standard planar mirror, however Staplin et al. (1998) found that approx 13% of older driver sample in laboratory simulator study made unsafe gap acceptance judgments to change lanes in front of an adjacent-lane vehicle overtaking at 25 mi/h differential while using full-sized non-planar mirrors. Also one-third of sample indicated sole reliance on mirror when changing lanes. De Vos (2000): older drivers look over their shoulders less frequently than younger drivers when changing lanes. Drivers accept smaller gaps when using non-planar mirrors, due to image minification.	Panelist OTs concerned that the recommendation could be a liability, but merits further research. Even aiming mirrors for drivers during CarFit is a liability and OTs put the mirrors back to their original position when the drivers arrived at the evaluation. Non-planar mirrors would require optical distortion training, and there is currently no standard of care.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients. Impairments in psychomotor functioning may result from musculoskeletal disease leading to weakening, frailty, and/or restricted range of motion. Medical management of arthritis is important.

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: PHYSICAL/PSYCHOMOTOR

SPECIFIC DEFICIT: ARM STRENGTH/RANGE OF MOTION/SPEED OF MOVEMENT

Associated Driver Performance Errors

- Slow steering through turn, resulting in longer maneuver time, resulting in shorter time to collision with approaching vehicle (Yan, Radwan, & Guo, 2007,).
- Older women with difficulty extending arms above their shoulders had increased crash risk (Hu et al., 1998).
- Difficulty reaching out was significantly associated with crashes in prior 6 years (Sims et al., 1998). Crash type not specified in research studies.
- Range of motion significantly associated with pass/fail performance on road test (McCarthy & Mann, 2006).
- Panelists indicated a deficit in arm strength/range of motion/speed of movement could be associated with slowed vehicle control response (critical driver performance error #4).

Included Behavioral Countermeasures

- Physical aerobic/activity training
- Strength and flexibility exercises
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)
- Medical management (incl. pharmacy review)

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: ARM STRENGTH/RANGE OF MOTION/SPEED OF MOVEMENT		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Physical aerobic activity/training	May be research from Art Kramer at the University of Illinois looking at physical exercise programs and driving (simulator).	Merits further research.
Strength and flexibility exercises	Marottoli et al. (2007) 12 week, in-home exercises directed by physical therapist focusing on axial/extremity condition, upper extremity coordination/dexterity, and gait abnormalities. On-road driving performance was measured at baseline and post-intervention for treatment and control group. Significant improvement for treatment group compared to control group translated to 8 to 16 percent lower crash occurrence over 2 year period. Intervention group also made 37% fewer critical errors (inattention, turning or changing lanes w/o looking, and disobeying signs or signals) than control group at follow up.	Panelists agreed that this is an appropriate countermeasure
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)		Panelists state all 3 types of education may be useful for deficits in arm strength/range of motion/speed of motion; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)		Panelists state that vehicles have safety features but many need to be adjusted, and older drivers don't know how to do this. Education about driving aids is a positive theme to staying on the road longer. Countermeasure merits further research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients. Impairments in psychomotor functioning may result from musculoskeletal disease leading to weakening, frailty, and/or restricted range of motion. Medical management of arthritis is important.

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: PHYSICAL/PSYCHOMOTOR

SPECIFIC DEFICIT: LEG STRENGTH/RANGE OF MOTION/SPEED OF MOVEMENT

Associated Driver Performance Errors

- Slow accelerating through turn and into traffic stream resulting in longer maneuver time, resulting in shorter time to collision with approaching vehicle (Yan, Radwan, & Guo, 2007).
- Poor performance on rapid pace walk is associated with adverse driving events (crashes, violations) (Marottoli et al., 1994; Staplin et al., 2003), and pass/fail performance on road test (McCarthy & Mann, 2006).
- Range of motion significantly associated with pass/fail performance on road test (McCarthy & Mann, 2006).
- Older drivers reporting pain in the feet, hips, legs, or current treatment for arthritis had significantly slower brake reaction speeds (both initial reaction and physical response speed) than drivers with no complaints of pain in these areas (Zhang et al., 2007).
- Panelists indicated a deficit in leg strength/range of motion/speed of movement could be associated with slowed vehicle control response (critical driver performance error #4).

Included Behavioral Countermeasures

- Physical aerobic/activity training
- Strength and flexibility exercises
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)
- Medical management (incl. pharmacy review)

CRASH TYPE 3: **Right turn at yield sign in channelized right turn lane, merging with traffic approaching from the left on a principal arterial (40-45 mi/h)**

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: LEG STRENGTH/RANGE OF MOTION/SPEED OF MOVEMENT		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Physical aerobic activity/training	May be research from Art Kramer at the University of Illinois looking at physical exercise programs and driving (simulator).	Merits further research.
Strength and flexibility exercises	Marottoli et al. (2007) 12 week, in-home exercises directed by physical therapist focusing on axial/extremity condition, upper extremity coordination/dexterity, and gait abnormalities. On-road driving performance was measured at baseline and post-intervention for treatment and control group. Significant improvement for treatment group compared to control group translated to 8 to 16 percent lower crash occurrence over 2 year period. Intervention group also made 37% fewer critical errors (inattention, turning or changing lanes w/o looking, and disobeying signs or signals) than control group at follow up.	Panelists agreed that this is an appropriate countermeasure
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)		Panelists state all 3 types of education may be useful for deficits in arm strength/range of motion/speed of motion; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)		Panelists state that vehicles have safety features but many need to be adjusted, and older drivers don't know how to do this. Education about driving aids is a positive theme to staying on the road longer. Countermeasure merits further research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients. Impairments in psychomotor functioning may result from musculoskeletal disease leading to weakening, frailty, and/or restricted range of motion. Medical management of arthritis is important.

CRASH TYPE 4: Merge at yield sign onto limited access highway.

FUNCTIONAL DEFICITS THAT MAY INFLUENCE CRASH RISK

SENSORY/PERCEPTUAL (VISION)

- Acuity
- Contrast Sensitivity
- Visual Fields
- Depth and Motion Perception (Angular Motion Sensitivity)
- Dark Adaptation and Glare Recovery

ATTENTION/COGNITION

- Speed of Processing
- Selective Attention
- Divided Attention
- Working Memory
- Executive Function (Judgment and Decision Making)
- Spatial Abilities
- Knowledge (Rules of the Road and Safe Driving Strategies)

PHYSICAL/PSYCHOMOTOR

- Head/Neck/Trunk Range of Motion
- Arm Strength/Range of Motion/Speed of Movement
- Leg Strength/Range of Motion/Speed of Movement

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION)

SPECIFIC DEFICIT: ACUITY

Associated Driver Performance Errors

- Could contribute to a failure to visually detect a potential threat.
- Acuity poorer than 20/40 independently associated with self-reported crashes, moving violations, being stopped by police in prior 5-year period (Marottoli et al., 1998).
- Combined criterion using acuity, CS, and horizontal visual fields significantly related to prior crash involvement in drivers age 66+, but no visual measure alone was significantly associated (Decina & Staplin (1993).
- Significant relationship between acuity and improper lookout (Shinar, McDonald, & Treat (1978).
- Acuity (score and response time) related to unsafe driving incidents; correlations higher for time to respond to acuity stimuli than acuity errors (McKnight & McKnight, 1999).
- Acuity response time rather than acuity score related to driving exam score (Staplin et al., 1998).
- Acuity slightly worse than 20/30 independently associated with self-reported difficulty driving on interstates, at night, in the rain, on high-traffic roads, during rush hour, alone, and making left turns (McGwin, Chapman, Owsley, 2000).
- Poorer dynamic acuity related to crash involvement in prior 2-year period (Shinar, Mayer, Treat, 1975).
- Dynamic acuity included in model predictive of closed course driving performance (Wood, 2002).

Included Behavioral Countermeasures

- Refractive correction (incl. Wavefront technology)
- Cataract surgery
- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Central vision enhancement systems (bioptic telescopic lenses, implantable telescopes)
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Collision warning systems
- Medical management (incl. pharmacy review).

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: ACUITY		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Refractive correction (incl. Wavefront technology)	No before-after studies on refraction correction (updating prescription for corrective glasses) and driving safety uncovered. Panelist with expertise in the area stated that in the ophthalmology literature there is quite a bit of research on age and satisfaction for refractive errors corrective surgery. There is actually quite ample literature on people's feelings about their improved performance in everyday tasks there, clarity with which they can see things. It would seem reasonable that one would have asked the question about improved driving performance as a result of refractive error correction, but the panelist was not aware of anything done. Haddrill (2007): Ophthonix founder A. Dreher reports that iZon lenses (wavefront lenses) provide higher definition vision in the daytime and significantly improve night driving responses when compared with conventional lenses. Night vision improved a driver's ability to identify pedestrians by an average of 330 ms (30 ft sooner at 55 mi/h) when compared to conventional lenses. www.allaboutvision.com/lenses/wavefront-lenses.htm; http://ophthonix.izonlens.com/globals/faqs.asp; www.allaboutvision.com/whatsnew/lenses1.htm.	Even without research on effectiveness, panelists agreed that refractive correction should be advocated just on the prevalence of the problem and the inexpensiveness of the solution, particularly as there appears to be a decline in older people getting annual eye exams. Annual eye exams, refractive correction, and sooner diagnosis of treatable conditions (e.g., cataracts) are inexpensive solutions for reaching a substantial number of people for remediation. Vision specialist feedback to drivers regarding the driver licensing laws in their State in relation to their own level of impairment is important (and presently rare in practice); increasing awareness of impairments may lead to appropriate self-restriction. One of the early findings of the Salisbury Eye Study was that among the proportion of older individuals who had worse than 20/40 vision, more than half of them could be corrected just with glasses. A panel member (vision specialist) recommended inclusion of Wavefront technology as part of refractive correction. Wavefront technology diagnoses higher-order vision errors represented by the way the eye refracts or focuses light; such aberrations defocus images even with 20/40 acuity. Wavefront guided lenses can reduce certain higher-order aberrations, which potentially can improve low light image quality during activities such as driving at night. Panelist notes research on effectiveness for driving is currently limited to that conducted by lens manufacturer (see Haddrill 2007 description of Ophthonix iZon wavefront guided lenses). Another caution noted by the panelist regarding the lens company research is that improvements in vision with the wavefront lenses were compared to patients' vision as they appeared for the study. But it is well known that many patients especially over age 60 haven't had regular eye check-ups or new prescriptions.
Cataract surgery	McGwin, Scilley, Brown, and Owsley (2003) found improvements in acuity with cataract surgery, and that improvement in visual acuity had a significant, independent association with the change in activities of daily vision scale (that includes daytime and nighttime driving). Wood and Carberry (2006) found that improvement in acuity that accompanied cataract surgery was related to improvement in overall driving score.	Panelists agree this is a relatively inexpensive treatment and improvements result in crash reduction. Cataracts are often the only medical condition affecting driving performance. Even if crash reduction benefit is small, cataract surgery may provide a large public health benefit because of the large number of people affected by cataracts.
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	• Gallo, Rebok, and Lesikar (1999). Self-reported vision impairment was related to avoidance of challenging driving situations, but not to self-reported citations or crashes in prior 2 years. Authors conclude that vision impaired drivers who self restrict are less likely to crash. Vision impairment categories: no trouble seeing; a little trouble, a lot of trouble (i.e., may not be specific to acuity). • Ball, Owsley, Stalvey, Roenker, Sloane, and Graves (1998): No relationship between avoidance score and crashes in subsequent 3 year period. • De Raedt and Ponjaert-Kristoffersen (2000): poor performers on a road test but were free of (self-reported) at-fault crashes (prior 12 mo) used significantly more strategic compensation tactics (avoidance of challenging situations) than poor-performing drivers with a history of at-fault crashes.	Panelists indicate this may or may not be effective; "we don't know if this works." People try to self-regulate when there are alternative transportation options, but there are times when they "must" drive even if they'd rather not (e.g., winter when it gets dark earlier, or no other driver to take them). Making people aware of deficits is the first step in getting people to self restrict, if they will self restrict. Studies show that there are many unaware vision-impaired drivers. Ophthalmologists and optometrists need to be included as targets of outreach, similarly to the AMA guide, and other outreach efforts that NHTSA has done for specialized populations because, eyecare specialists are a group that does not know their red flags to tell patients that "these are the laws in our state and this is what you need to be concerned about."

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: ACUITY		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Central vision enhancement systems (bioptic telescopic lenses, implantable telescopes)	Janke and Kazarian (1983): Crash rate in users is 1.5 times higher than population rate, but less than the crash rate of drivers licensed with other medical conditions. Clark (1996): Crash rates for BTL users 1.9 times higher than comparison group, but citation rates 0.7 of that for comparison group. Szlyk et al. (2000): Training in the use of BTL lenses (both lab and on-road) significantly increased performance in recognition, peripheral identification, and scanning compared to performance of non-trained BTL users.	Panelists in agreement with countermeasure if accompanied by training and assessment of driving safety after training. Recommend licensing with restrictions after low-driving program/rehab. Use lens only for spotting (5-10% of time). Training curriculum and design of lenses needs to be "nailed down." Training curriculum needs to be developed by Occupational Therapists. Countermeasure appropriate if no cognitive deficit.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for acuity deficit; raises awareness of deficit so they can self restrict. Also provide education to physicians and eyecare specialists so they can educate their patients. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. Panelist (a KEYS study author) noted that he has always questioned whether those self reported changes in driving habits were real; people may have been invested due to time spent in intervention and reported more avoidance than they really engaged in. Also, candidates for education intervention should not have advanced cognitive deficits (e.g., dementia). Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Collision warning systems	Oxley and Mitchell (1995): collision warning system tested in a simulator was effective in preventing older drivers from turning across traffic through gaps that were dangerously short.	Suggested by panelists as countermeasure that merits further research. Need forward as well as side-collision warning. Would be helpful if it caused the vehicle to brake, in addition to providing a warning. Concern is with complete reliance on the technology to detect hazards (especially for backing up) where older drivers back up without doing head/shoulder checks and have backed into (and killed) pedestrians. Also elderly people may be more distracted rather than assisted by some of the advanced technologies. And, most rehab center's adapted cars are not high-end/high tech, so it would be difficult for OTs to train people in the use of the technologies.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION)

SPECIFIC DEFICIT: CONTRAST SENSITIVITY

Associated Driver Performance Errors

- Could contribute to a failure to visually detect a potential threat.
- Has been correlated with poor driving performance (Wood, 2002; Baldock et al., 2007) and increased crash risk in prior 5-year period (Owsley, Stalvey, Wells, Sloane, & McGwin, 2001).
- CS along with visual spatial memory and 2 measures of visual attention RT explained 35% of the variance in driving ability demonstrated in on-road test (Baldock, Mathias, McLean & Berndt, 2007).
- Acuity poorer than 20/40 independently associated with self-reported crashes, moving violations, being stopped by police in prior 5-year period (Marottoli et al., 1998).
- Combined criterion using acuity, CS, and horizontal visual fields significantly related to prior crash involvement in drivers age 66+, but no visual measure alone was significantly associated (Decina & Staplin, 1993).
- Significant relationship between acuity and improper lookout (Shinar, McDonald, & Treat, 1978).
- Acuity (score and response time) related to unsafe driving incidents; correlations higher for time to respond to acuity stimuli than acuity errors (McKnight & McKnight, 1999).
- Acuity response time rather than acuity score related to driving exam score (Staplin et al., 1998).
- Acuity slightly worse than 20/30 independently associated with self-reported difficulty driving on interstates, at night, in the rain, on high-traffic roads, during rush hour, alone, and making left turns (McGwin, Chapman, Owsley, 2000).
- Poorer dynamic acuity related to crash involvement in prior 2-year period (Shinar, Mayer, Treat, 1975). Dynamic acuity included in model predictive of closed course driving performance (Wood, 2002).

Included Behavioral Countermeasures

- Refractive correction (incl. Wavefront technology)
- Cataract surgery
- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Conformal vision enhancement system (e.g., in-vehicle enhancement of Stop Sign)
- Central vision enhancement systems (bioptic telescopic lenses, implantable telescopes)
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Collision warning systems
- Medical management (incl. pharmacy review)

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: CONTRAST SENSITIVITY		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Refractive correction (incl. Wavefront technology)	No before-after studies on refraction correction (updating prescription for corrective glasses) and driving safety uncovered. Panelist with expertise in the area stated that in the ophthalmology literature there is quite a bit of research on age and satisfaction for refractive errors corrective surgery. There is actually quite ample literature on people's feelings about their improved performance in everyday tasks there, clarity with which they can see things. It would seem reasonable that one would have asked the question about improved driving performance as a result of refractive error correction, but the panelist was not aware of anything done. Haddrill (2007): Ophthonix founder A. Dreher reports that iZon lenses (wavefront lenses) provide higher definition vision in the daytime and significantly improve night driving responses when compared with conventional lenses. Night vision improved a driver's ability to identify pedestrians by an average of 330 ms (30 ft sooner at 55 mi/h) when compared to conventional lenses. www.allaboutvision.com/lenses/wavefront-lenses.htm; http://ophthonix.izonlens.com/globals/faqs.asp; www.allaboutvision.com/whatsnew/lenses1.htm.	Even without research on effectiveness, panelists agreed that refractive correction should be advocated just on the prevalence of the problem and the inexpensiveness of the solution, particularly as there appears to be a decline in older people getting annual eye exams. Annual eye exams, refractive correction, and sooner diagnosis of treatable conditions (e.g., cataracts) are inexpensive solutions for reaching a substantial number of people for remediation. Vision specialist feedback to drivers regarding the driver licensing laws in their State in relation to their own level of impairment is important (and presently rare in practice); increasing awareness of impairments may lead to appropriate self-restriction. One of the early findings of the Salisbury Eye Study was that among the proportion of older individuals who had worse than 20/40 vision, more than half of them could be corrected just with glasses. A panel member (vision specialist) recommended inclusion of Wavefront technology as part of refractive correction. Wavefront technology diagnoses higher-order vision errors represented by the way the eye refracts or focuses light; such aberrations defocus images even with 20/40 acuity. Wavefront guided lenses can reduce certain higher-order aberrations, which potentially can improve low light image quality during activities such as driving at night. Panelist notes research on effectiveness for driving is currently limited to that conducted by lens manufacturer (see Haddrill 2007 description of Ophthonix iZon wavefront guided lenses). Another caution noted by the panelist regarding the lens company research is that improvements in vision with the wavefront lenses were compared to patients' vision as they appeared for the study. But it is well known that many patients especially over age 60 haven't had regular eye check-ups or new prescriptions.
Cataract surgery	Monestam and Wachtmeister (1997): Self reported problems with distance judgment declined from 37% to 6% of sample following cataract surgery. McGwin et al. (2003): contrast sensitivity improved significantly in the sample that underwent surgery, and day and night driving scores on Activities of Daily Vision Scale significantly improved post-operatively in surgery group. Owsley et al. (2002): Patients with a cataract who underwent surgery and IOL implantation had half the crash rate of drivers with cataract who did not undergo surgery (4.74 crashes per million miles of travel vs. 8.95).	Panelists agree this is a relatively inexpensive treatment and improvements result in crash reduction. Cataracts are often the only medical condition affecting driving performance. Even if crash reduction benefit is small, cataract surgery may provide a large public health benefit because of the large number of people affected by cataracts.

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: CONTRAST SENSITIVITY		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	Gallo, Rebok, and Lesikar (1999). Self-reported vision impairment was related to avoidance of challenging driving situations, but not to self-reported citations or crashes in prior 2 years. Authors conclude that vision impaired drivers who self restrict are less likely to crash. Vision impairment categories: no trouble seeing; a little trouble, a lot of trouble (i.e., may not be specific to CS). Ball, Owsley, Stalvey, Roenker, Sloane, and Graves (1998): No relationship between avoidance score and crashes in subsequent 3 year period. De Raedt and Ponjaert-Kristoffersen (2000): poor performers on a road test but were free of (self-reported) at-fault crashes (prior 12 mo) used significantly more strategic compensation tactics (avoidance of challenging situations) than poor performers with a history of at-fault crashes. Hennessy (1995): older drivers with poor CS and who (sometimes of often) avoided heavy traffic had a reduced crash risk compared to those with poor CS who did not avoid heavy traffic. Avoidance brought risk equal to that of drivers with good CS.	Panelists indicate this may or may not be effective; "we don't know if this works." People try to self-regulate when there are alternative transportation options, but there are times when they "must" drive even if they'd rather not (e.g., winter when it gets dark earlier, or no other driver to take them). Making people aware of deficits is the first step in getting people to self restrict, if they will self restrict.
Conformal vision enhancement system (e.g., in-vehicle enhancement of Stop Sign)	Caird, Horey, & Edwards (2001). Simulator study with 24 younger and 24 older drivers. Conformal enhancement of a traffic light resulted in fewer drivers running the light. Drivers indicated conformal VES would be helpful when environmental conditions restrict visibility, but not under heavy traffic, cluttered environments, or in daytime. Less than 25% indicated they would use VES regularly if available. Oxley and Mitchell (1995) reported that in a sample of older 31 UVES and 15 IVES users, 100% found it easy to use, and 60-73% indicated it would encourage them to drive outside of their usual driving situations. Gish, Staplin, and Perel (1999) found that 3 of 4 older drivers did not use VES to detect targets, but instead used it to detect curves in the road (controlled field study).	Panelists state older drivers in focus groups don't like anything in their cars that takes their focus away from the road (either on the windshield or on a heads-down display in the vehicle). They would choose not to drive in challenging situations rather than to use a device that may take their attention from the road, or that may be more difficult to operate. Another panelist indicated that following training in equipment use, older drivers are ok with such countermeasures; emphasizing that training is a critical component for new technologies to assist older drivers.
Central vision enhancement systems (bioptic telescopic lenses, implantable telescopes)	Janke and Kazarian (1983): Crash rate in users is 1.5 times higher than population rate, but less than the crash rate of drivers licensed with other medical conditions. Clark (1996): Crash rates for BTL users 1.9 times higher than comparison group, but citation rates 0.7 of that for comparison group. Szlyk et al. (2000): Training in the use of BTL lenses (both lab and on-road) significantly increased performance in recognition, peripheral identification, and scanning compared to performance of non-trained BTL users.	Panelists in agreement with countermeasure if accompanied by training and assessment of driving safety after training. Recommend licensing with restrictions after low-driving program/rehab. Use lens only for spotting (5-10% of time). Training curriculum and design of lenses needs to be "nailed down." Training curriculum needs to be developed by Occupational Therapists. Countermeasure appropriate if no cognitive deficit.

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: CONTRAST SENSITIVITY		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for contrast sensitivity deficit; raises awareness of deficit so they can self restrict. Also provide education to physicians and eyecare specialists so they can educate their patients. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Collision warning systems	Oxley and Mitchell (1995): collision warning system tested in a simulator was effective in preventing older drivers from turning across traffic through gaps that were dangerously short.	Suggested by panelists as countermeasure that merits further research. Need forward as well as side-collision warning. Would be helpful if it caused the vehicle to brake, in addition to providing a warning.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION)

SPECIFIC DEFICIT: VISUAL FIELDS

Associated Driver Performance Errors

- Could contribute to a failure to visually detect a potential threat.
- Impaired detection capability for stimuli in the affected parts of the visual field (Lovsund, Hedin, & Tornros, 1991).
- Correlated with crashes (Ball et al., 1993; Johnson & Keltner, 1983; Ruben et al., 2007; Szlyk et al., 1991).
- Drivers with Glaucoma (McGwin, Owsley, & Ball, 1998; Hu et al., 1998) and macular degeneration (Owsley et al., 1998) have higher crash rate than those without, and these conditions can restrict visual field.
- Tarawneh et al. (1993) significant relationship between right visual field size and driving performance (on-road test included 2 right-turn intersections).
- Combination of peripheral vision deficit and restricted head movement increases the difficulty of bringing an approaching vehicle on a perpendicular roadway into central vision, and may explain why older drivers have higher rates of intersection crashes that result in injury or death (Isler, Parsonson & Hansson, 1997).

Included Behavioral Countermeasures

- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Central vision enhancement systems (bioptic telescopic lenses, implantable telescopes)
- Visual field expansion systems (prism, bioptic amorphic lenses, video feeds)
- Training in Compensatory Head/Eye Movements, Scanning Strategies
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Education about driving aids (Car Fit, features/adaptive equipment, shoes, etc.)
- Medical management (incl. pharmacy review)

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: VISUAL FIELDS		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	Hennessy (1995): poorer visual field ability (modified Synemed perimeter) was significantly associated with greater avoidance of driving at night, rain, dusk, dawn, and making left turns, but the predictive value of visual fields performance on crash rate (prior 3 yrs) was mediated only for avoidance of left turns; But avoidance did not reduce risk, it increased it (inadequate compensation).	Panelists indicate this may or may not be effective; "we don't know if this works." People try to self-regulate when there are alternative transportation options, but there are times when they "must" drive even if they'd rather not (e.g., winter when it gets dark earlier, or no other driver to take them). Making people aware of deficits is the first step in getting people to self restrict, if they will self restrict.
Central vision enhancement systems (bioptic telescopic lenses, implantable telescopes)	Janke and Kazarian (1983): Crash rate in users is 1.5 times higher than population rate, but less than the crash rate of drivers licensed with other medical conditions. Clark (1996): Crash rates for BTL users 1.9 times higher than comparison group, but citation rates 0.7 of that for comparison group. Szlyk et al. (2000): Training in the use of BTL lenses (both lab and on-road) significantly increased performance in recognition, peripheral identification, and scanning compared to performance of non-trained BTL users.	Panelists in agreement with countermeasure if accompanied by training and assessment of driving safety after training. Recommend licensing with restrictions after low-driving program/rehab. Use lens only for spotting (5-10% of time). Training curriculum and design of lenses needs to be "nailed down." Training curriculum needs to be developed by Occupational Therapists. Countermeasure appropriate if no cognitive deficit.
Visual field expansion systems (prisms, bioptic amorphic lenses, video feeds)	Szlyk et al. (1998): Following training with the lenses (lab and on-road), patients showed improvements in all visual skill categories, including peripheral detection and selecting appropriate gaps. Authors note further research necessary to determine safety while driving.	Panelist states that 100 degree binocular field is a good minimum standard; if < 100 degrees and adamant about driving, a driver should be offered these systems to see if he/she can adapt to it (should be the standard of care). Target audience would be a driver with 50 degree binocular fields in a State with no visual field requirement, and prisms (ref Eli Peli) could be used to expand the field to 100 degrees to make driving safer. Video feed may be better than amorphic lenses.

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: VISUAL FIELDS		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Training in compensatory head and eye movements, scanning strategies	Coeckelbergh et al. (2001): Training in compensatory viewing strategies, particularly on-road training, improved viewing behavior for persons with central or peripheral visual field constriction, and increased the number of subjects who passed a road test who previously failed. Ss had visual field defects due to ocular pathology; those with severe cognitive impairments were excluded from participation. Dynavision apparatus has been used in office rehab settings to train compensatory scanning strategies for visual inattention and visual field deficit in persons with intact attentional mechanisms. Klavora et al. (1995) found that Dynavision training with 10 older (age 46-73) post-CVA individuals resulted in significantly improved behind-the-wheel driving performance when compared with expected outcomes. All failed their first BTW assessment pre-Dynavision training. Training involved three 40-minute Dynavision Training sessions per week for 6 weeks. On the second BTW assessment, 6 of the 10 subjects earned a "safe to resume driving and/or receive on-road driving lessons." Laderman, Szlyk, Kelsch, and Seiple (2000): 4-week training on a task in a rehab center setting to teach peripheral detection, scanning, and tracking where the clients sat close to a screen and detected slide images in the periphery using amorphic lenses, then turning their heads toward the object to identify it more clearly through the carrier. 8-week training in-vehicle on closed course with driving instructor to practice skills. Before-after training results indicated 39% improvement in tasks involving peripheral detection, and 27% improvement in scanning tasks. Authors note further research is needed to define standards and evaluation methods for training curricula.	Panelists agreed that this is an appropriate countermeasure, but candidates must be cognitively intact. This type of training has been used for telescopic and amorphic-lens drivers ("search and destroy" method referred to by panelist, described by Laderman et al., 2000) and has been effective in improving peripheral visual detection. One panelist mentioned a book that may be useful in this training older adults to scan effectively by Ken Mills "Disciplined Attention: How to Improve Your Visual Attention When You Drive." The book (directed toward young driver training) is not a countermeasure that's ready to go, but it's one ready to be researched.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for visual field deficits; raises awareness of deficit so they can self restrict. Also provide education to physicians and eyecare specialists so they can educate their patients. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills education. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Education about driving aids (CarFit, features/adaptive equipment, shoes, etc.)		Panelists state that vehicles have safety features but many need to be adjusted, and older drivers don't know how to do this. Education about driving aids is a positive theme to staying on the road longer. Countermeasure merits further research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION)

SPECIFIC DEFICIT: DEPTH AND MOTION PERCEPTION

Associated Driver Performance Errors

- Could contribute to gap judgment error: driver turns right into too short a gap, and traffic approaching from left must slow to avoid a crash.
- Older drivers (especially females) rely on distance instead of integrating speed and distance, especially for higher-speed roads (Yan, Radwan, & Guo, 2007; Andersen & Enriquez, 2006; Scialfa et al., 1991; Dazentas, McDowell, & Cooper, 1980; Braitman et al., 2007; De Raedt & Ponjaert-Kristoffersen, 2000).
- Impairments in stereoacuity are related to retrospective crashes (Owsley, McGwin, & Ball, 1998; Ivers et al., 1999; Staplin et al., 1998).
- Poor structure from motion performance is related to simulator crashes (Rizzo et al., 1997 and at-fault safety errors on the road (Uc et al., 2005).
- Central motion sensitivity related to on road driving performance (Wood, 2002).
- In failure-to-yield crashes at intersections, drivers ages 70-79 made more evaluation errors than drivers ages 35-54 and those age 80+; evaluation errors occurred when the driver saw the other vehicle but misjudged whether there was adequate time to proceed (Braitman et al., 2007).
- Panelists indicated that a deficit in depth and motion perception could be associated with inability to predict development of future conflicts (critical performance error #3), in addition to gap judgment errors (#2).

Included Behavioral Countermeasures

- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Education about driving aids (Car Fit, features/adaptive equipment, shoes, etc.)
- Medical management (incl. pharmacy review)

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: DEPTH AND MOTION PERCEPTION		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	Ball, Owsley, Stalvey, Roenker, Sloane, and Graves (1998): No relationship between avoidance score and crashes in subsequent 3 year period. De Raedt & Ponjaert-Kristoffersen (2000): drivers who performed poorly on a road test but were free of (self-reported) at-fault crashes in the prior 12-mo period used significantly more strategic compensation tactics (avoidance of challenging situations) than poor-performing drivers with a history of at-fault crashes.	Panelists indicated that drivers could choose the route that has a protected turn.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for depth and motion perception deficits; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Education about driving aids (CarFit, features/adaptive equipment, shoes, etc.)		Panelists state that vehicles have safety features but many need to be adjusted, and older drivers don't know how to do this. Education about driving aids is a positive theme to staying on the road longer. Countermeasure merits further research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION)

SPECIFIC DEFICIT: DARK ADAPTATION AND GLARE RECOVERY

Associated Driver Performance Errors

- Disability glare would result in difficulty determining what lane an approaching vehicle is in when making gap judgment.
- Older drivers with 3+ letters lost in the presence of glare on Peli-Robson Chart were 2.32 times more likely to crash in 4-year follow-up period. (after adjusting for age, race, sex, cognitive performance, education, comorbidities, depression, and living alone. But no relationship found between disability glare and crashes in 3-year follow-up period (Owsley et al.,1998).
- Panelists indicated this deficit could be associated with a failure to detect potential conflicts, hazards, or traffic control information.

Included Behavioral Countermeasures

- Cataract surgery
- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Education about driving aids (CarFit, features/adaptive equipment, shoes, etc.)
- Medical management (incl. pharmacy review).

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: DARK ADAPTATION AND GLARE RECOVERY		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Cataract surgery	McGwin et al. (2003): disability glare improved significantly post surgery in group of patients with cataract. First surgery eye improvement in acuity significantly related to change in overall activities of daily vision scale and night driving and glare disability subscales. Change in disability glare in second surgery eye significantly assoc. w/change in ADVS score as well as change scores in night driving, near vision, and disability glare subscales.	Panelists agree this is a relatively inexpensive treatment and improvements result in crash reduction. Cataracts are often the only medical condition affecting driving performance. Even if crash reduction benefit is small, cataract surgery may provide a large public health benefit because of the large number of people affected by cataracts.
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	Ball, Owsley, Stalvey, Roenker, Sloane, and Graves (1998): No relationship between avoidance score and crashes in subsequent 3 year period. De Raedt and Ponjaert-Kristoffersen (2000): drivers who performed poorly on a road test but were free of (self-reported) at-fault crashes in the prior 12-mo period used significantly more strategic compensation tactics (avoidance of challenging situations) than poor-performing drivers with a history of at-fault crashes.	Panelists indicate this may or may not be effective; "we don't know if this works." People try to self-regulate when there are alternative transportation options, but there are times when they "must" drive even if they'd rather not (e.g., winter when it gets dark earlier, or no other driver to take them). Making people aware of deficits is the first step in getting people to self restrict, if they will self restrict.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be dark adaptation/glare recovery deficits; raises awareness of deficit so they can self restrict. Also provide education to physicians and eyecare specialists so they can educate their patients. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills education. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Education about driving aids (CarFit, features/adaptive equipment, shoes, etc.)		Panelists state that vehicles have safety features but many need to be adjusted, and older drivers don't know how to do this. Education about driving aids is a positive theme to staying on the road longer. Countermeasure merits further research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: SPEED OF PROCESSING

Associated Driver Performance Errors

- Effect of slowed speed of processing (SOP) may be slowing of retrieval of knowledge of right-of-way rules, and slowed reasoning and decision-making about appropriate visual search and vehicle control.
- SOP deficits (UFOV subtest 1) accounted for 4.1% of the variance in crash involvement (prior 3-years) for drivers age 70+ (type not specified) adjusting for age, gender, and driving exposure (Hennessy, 1995).
- Older drivers who performed poorly on the Trails A test had significantly more retrospective crashes (Stutts, Stewart, & Martell, 1996, 1998; Goode, Ball, Sloane, Roenker, Roth, Myers, & Owsley, 1998) and prospective crashes (Lesikar, Gallo, Rebok, & Keyl, 2002) than drivers who performed well on this SOP measure. Crash type not specified in these studies.
- Older crash-involved drivers with licenses suspended for failure to yield the right of way performed significantly worse on Trails A than subjects w/o suspended licenses (Lundberg, Hakamies-Blomqvist, Almkvist, & Johannson, 1998).
- Panelists indicated that a speed of processing deficit could be associated with the following critical driver performance errors: #2 gap judgment errors; #3 inability to predict development of future conflicts; #4 slowed vehicle control response; #5 inadequate visual search/improper lookout; and #6 slowed decision making.

Included Behavioral Countermeasures

- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Speed of processing training
- Physical aerobic activity/training
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Collision warning systems
- Medical management (incl. pharmacy review)

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: SPEED OF PROCESSING		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	Ball, Owsley, Stalvey, Roenker, Sloane, and Graves (1998): No relationship between avoidance score and crashes (prior 3 yrs). Hennessy (1995): poorer SOP ability was significantly associated with greater avoidance of driving at night, rain, dusk, dawn, alone, left turns, and heavy traffic, but the predictive value of the SOP subtask on crash rate (prior 3 yrs) was mediated only for avoidance of left turns; But avoidance did not reduce risk, it increased it (inadequate compensation). De Raedt and Ponjaert-Kristoffersen (2000): poor performers on a road test who were free of (self-reported) at-fault crashes in the prior 12-mo period used significantly more strategic compensation tactics (avoidance of challenging situations) than poor performers with history of at-fault crashes.	Panelists indicate this may or may not be effective; "we don't know if this works." People try to self-regulate when there are alternative transportation options, but there are times when they "must" drive even if they'd rather not (e.g., winter when it gets dark earlier, or no other driver to take them). Making people aware of deficits is the first step in getting people to self restrict, if they will self restrict.
Speed of processing training	Roenker et al. (2003): Speed of processing training using all 3 subtests of UFOV compared to Doron simulator training and untrained reference group. Global ratings of on-road driving performance improved for both training groups, but only SOP group maintained performance at 18 mo. For "dangerous maneuvers" component, both training groups showed improvements, but only SOP training maintained improvement at 18 mo. Dangerous maneuvers included 6 opportunities for unprotected turns across traffic and 9 left-turn entrances to a high-traffic road.	Panelists agreed this may be a viable countermeasure, but there is a need to establish the link between training on task and transfer to driving.
Physical aerobic activity/training	Marmeleira, Godinho, and Fernandes (2008) found that a 12-week exercise program with 3, 60-min sessions per week improved visual attention in speed of processing and divided attention (using the UFOV protocol) at 12 weeks follow-up in adults ages 60 to 81. The intervention incorporated perceptual and cognitive tasks (problem solving and responding to challenging situations) with aerobic activity. Examples are: walking while listening for auditory cues to perform fast and specific psychomotor responses). At 12 weeks, speed of processing and divided attention were significantly improved compared to baseline for the exercise group; at baseline, there was no difference between groups. Actual driving performance was not studied, and there was no exercise-only group to determine the contribution of physical activity alone on speed of processing or divided attention.	Research article provided by panelist following meeting; panelists did not get to comment on countermeasure for deficit. Merits further research
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for speed of processing deficits; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Collision warning systems	Oxley and Mitchell (1995): collision warning system tested in a simulator was effective in preventing older drivers from turning across traffic through gaps that were dangerously short.	Suggested by panelists as countermeasure that merits further research. Need forward as well as side-collision warning. Would be helpful if it caused the vehicle to brake, in addition to providing a warning.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: SELECTIVE ATTENTION

Associated Driver Performance Errors

- Older drivers with selective attention deficits had shorter time to collision values, took longer to cross the road, and had shorter safety cushions (on-road study) than drivers with no impairment in selective attention ability (Pietras et al., 2006).
- Poor visual attention (number cancellation test) related to poor on-road driving performance, specifically scanning visual field for potentially dangerous objects, yielding the right of way, negotiating turns safely, exiting, merging, and lane changing (Richardson & Marottoli, 2003).
- Selective attention with visual search correlated significantly with global road test score, accounting for 19% of the variance (De Raedt & Ponjaert-Kristoffersen, 2000). It also correlated significantly w/visual behavior and communication (r= -.43) and perception and reaction to signals (r=-.37).
- Poor scores on Brief Test of Attention and on Trails A were related to slower perception-reaction times and slower brake movement times during a computerized test of simple RT (Zhang et al., 2007).
- Panelists indicated that a selective attention deficit could be associated with the following critical driver performance errors: #2 gap judgment errors; #3 inability to predict development of future conflicts; #4 slowed vehicle control response; #5 inadequate visual search/improper lookout; #6 slowed decision making

Included Behavioral Countermeasures

- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Conformal vision enhancement system
- Speed of processing training
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Collision warning systems
- Medical management (incl. pharmacy review)
- Cognitive rehab (incl. memory training) for normally aging population
- Compensatory cognitive/memory training for impaired/MCI population

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: SELECTIVE ATTENTION		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	Ball, Owsley, Stalvey, Roenker, Sloane, and Graves (1998): No relationship between avoidance score and crashes in subsequent 3 year period. De Raedt and Ponjaert-Kristoffersen (2000): drivers who performed poorly on a road test but were free of (self-reported) at-fault crashes in the prior 12-mo period used significantly more strategic compensation tactics (avoidance of challenging situations) than poor-performing drivers with a history of at-fault crashes.	Panelists indicate this may or may not be effective; "we don't know if this works." People try to self-regulate when there are alternative transportation options, but there are times when they "must" drive even if they'd rather not (e.g., winter when it gets dark earlier, or no other driver to take them). Making people aware of deficits is the first step in getting people to self restrict, if they will self restrict.
Conformal vision enhancement system (e.g., in-vehicle enhancement of Stop Sign)	Caird, Horey, & Edwards (2001). Simulator study with 24 younger and 24 older drivers. Conformal enhancement of a traffic light resulted in fewer drivers running the light. Drivers indicated conformal VES would be helpful when environmental conditions restrict visibility, but not under heavy traffic, cluttered environments, or in daytime. Less than 25% indicated they would use VES regularly if available. Oxley & Mitchell (1995) reported that in a sample of older 31 UVES and 15 IVES users, 100% found it easy to use, and 60-73% indicated it would encourage them to drive outside of their usual driving situations. Gish, Staplin, and Perel (1999) found that 3 of 4 older drivers did not use VES to detect targets, but instead used it to detect curves in the road (controlled field study).	Panelists state older drivers in focus groups don't like anything in their cars that takes their focus away from the road (either on the windshield or on a heads-down display in the vehicle). They would choose not to drive in challenging situations rather than to use a device that may take their attention from the road, or that may be more difficult to operate. Another panelist indicated that following training in equipment use, older drivers are ok with such countermeasures; emphasizing that training is a critical component for new technologies to assist older drivers.
Speed of processing training	Roenker et al. (2003): Speed of processing training using all 3 subtests of UFOV compared to Doron simulator training and untrained reference group. Global ratings of on-road driving performance improved for both training groups, but only SOP group maintained performance at 18 mo. For "dangerous maneuvers" component, both training groups showed improvements, but only SOP training maintained improvement at 18 mo. Dangerous maneuvers included 6 opportunities for unprotected turns across traffic and 9 left-turn entrances to a high-traffic road.	Panelists agreed this may be a viable countermeasure, but there is a need to establish the link between training on task and transfer to driving.

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: SELECTIVE ATTENTION		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for selective attention deficits; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Collision warning systems	Oxley and Mitchell (1995): collision warning system tested in a simulator was effective in preventing older drivers from turning across traffic through gaps that were dangerously short.	Suggested by panelists as countermeasure that merits further research. Need forward as well as side-collision warning. Would be helpful if it caused the vehicle to brake, in addition to providing a warning.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.
Cognitive rehab (including memory training) for normally aging population	One panelist noted that reasoning training conducted as part of the ACTIVE trial described by Ball, Berch, Helmers, Jobe, Leveck, et al. (2002) showed an effect on decreased driving difficulty in the 6 years following enrollment in the study. These findings were presented at the 2008 GSA meeting, but not published as of the date of this report.	Panelists indicate this is building subskills for the driving task. An OT panelist noted that you cannot just do a lot of the cognitive retraining tasks and assume that it will generalize to driving. You need to make that part of the therapy program. Countermeasure has tremendous promise but it is just in its infancy for developing the training protocols, and making sure it is appropriate. There is a real need for good research to make sure that we use this appropriately.
Compensatory cognitive/memory training for impaired/MCI population		Panelists were cautious about recommending cognitive interventions for people with early stage dementia, and indicated that strategies must be compensatory rather than restorative for this group.

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: DIVIDED ATTENTION

Associated Driver Performance Errors

- Maneuver requires looking to the left for an appropriate gap to merge into, watching ahead to avoid hitting a lead vehicle on the ramp, and looking behind (over shoulder/mirror check) to find safe gap.
- Drivers with restrictions in UFOV (composite measure of all 3 tests, with a 40% or more deficit) had 15 times more intersection crashes (type not specified) in prior 5-year period than drivers with normal visual attention (Owsley et al., 1991).
- Drivers with UFOV divided attention deficit had a significantly higher odds of crashing (prospectively) than drivers with normal divided attn performance (crash type not specified) (Rubin et al., 2007; Staplin et al., 2003; Edwards et al., 2008).
- Divided attention deficit associated with prospective crashes, the majority of which were failure-to-yield the right of way (Owsley et al., 1998).
- Impairment in UFOV independently associated with difficulty driving in the rain (McGwin, Chapman, Owsley (2000).
- UFOV performance predicted on-road driving performance, and was significantly correlated with tactical anticipatory behavior in changing situation; visual behavior; and insight, sense of context, and practical implementation (De Raedt & Ponjaert-Kristoffersen (2000).
- The greater the reduction in UFOV, the higher the likelihood of failing on-road test (Myers et al., 2000).
- Panelists indicated that a divided attention deficit could be associated with the following critical driver performance errors: #2 gap judgment errors; #3 inability to predict development of future conflicts; #4 slowed vehicle control response; #5 inadequate visual search/improper lookout; #6 slowed decision making.

Included Behavioral Countermeasures

- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Speed of processing training
- Physical aerobic/activity training
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Collision warning systems
- Medical management (incl. pharmacy review)
- Cognitive rehab (incl. memory training) for normally aging population
- Compensatory cognitive/memory training for impaired/MCI population

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: DIVIDED ATTENTION		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	Ball, Owsley, Stalvey, Roenker, Sloane, and Graves (1998): No relationship between avoidance score and crashes in subsequent 3 yrs. Hennessy (1995): poorer divided attention ability was significantly associated with greater avoidance of driving at night, rain, dusk, dawn, alone, left turns, and heavy traffic, but the predictive value of the divided attention subtask of UFOV on crash rate (prior 3 yrs) was not mediated by any of the forms of self restriction. De Raedt and Ponjaert-Kristoffersen (2000): poor performers on a road test who were free of (self-reported) at-fault crashes in the prior 12-mo period used significantly more strategic compensation tactics (avoidance of challenging situations) than poor performers with a history of at-fault crashes. Owsley et al. (1998) found that older drivers with UFOV reduction of 40% or more and who reported driving fewer than 7 days per week had a 45% decreased crash risk compared to older drivers with a 40% or more reduction in UFOV who reported driving 7 days/week.	Panelists indicate this may or may not be effective; "we don't know if this works." People try to self-regulate when there are alternative transportation options, but there are times when they "must" drive even if they'd rather not (e.g., winter when it gets dark earlier, or no other driver to take them). Making people aware of deficits is the first step in getting people to self restrict, if they will self restrict.
Speed of processing training	Roenker et al. (2003): Speed of processing training using all 3 subtests of UFOV compared to Doron simulator training and untrained reference group. Global ratings of on-road driving performance improved for both training groups, but only SOP group maintained performance at 18 mo. For "dangerous maneuvers" component, both training groups showed improvements, but only SOP training maintained improvement at 18 mo. Dangerous maneuvers included 6 opportunities for unprotected turns across traffic and 9 left-turn entrances to a high-traffic road.	Panelists agreed this may be a viable countermeasure, but there is a need to establish the link between training on task and transfer to driving.
Physical aerobic activity/training	Marmeleira, Godinho, and Fernandes (2008) found that a 12-week exercise program with 3, 60-min sessions per week improved visual attention in speed of processing and divided attention (using the UFOV protocol) at 12 weeks follow-up in adults ages 60 to 81. The intervention incorporated perceptual and cognitive tasks (problem solving and responding to challenging situations) with aerobic activity. Examples are: walking while listening for auditory cues to perform fast and specific psychomotor responses). At 12 weeks, speed of processing and divided attention were significantly improved compared to baseline for the exercise group; at baseline, there was no difference between groups. Actual driving performance was not studied, and there was no exercise-only group to determine the contribution of physical activity alone on speed of processing or divided attention.	Research article provided by panelist following meeting; panelists did not get to comment on countermeasure for deficit. Merits further research.

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: DIVIDED ATTENTION		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for divided attention deficits; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Collision warning systems	To avoid hitting leading vehicle on ramp while looking for gap in traffic approaching from behind on mainline. Maltz et al. (2004): older drivers benefited from use of headway and detection alerting device.	Merits further research
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.
Cognitive rehab (including memory training) for normally aging population	OTs noted that there are protocols and treatments for retraining attention, but cognitive rehab literature shows efficacy of attentional therapy in the broader rehab area ("Society for Cognitive Rehab"). It doesn't directly address driving, but builds subskills for the driving task.	Panelists indicate this is building subskills for the driving task. An OT panelist noted that you cannot just do a lot of the cognitive retraining tasks and assume that it will generalize to driving. You need to make that part of the therapy program. Countermeasure has tremendous promise but it is just in its infancy for developing the training protocols, and making sure it is appropriate. There is a real need for good research to make sure that we use this appropriately.
Compensatory cognitive/memory training for impaired/MCI population	Klavora et al. (1995) conducted a before-after study with 10 stroke patients with visual and attentional difficulties and rated unsafe to drive. Following training with a Dynavision apparatus, 6 of 10 participants earned a rating of "safe to resume driving and/or to receive on-road driving lessons."	Panelists were cautious about recommending cognitive interventions for people with early stage dementia, and indicated that strategies must be compensatory rather than restorative for this group.

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: WORKING MEMORY

Associated Driver Performance Errors

- Better working memory performance (5 sets of additions, where each set included 3, 2-digit numbers) was associated with larger gaps selected, in a simulator study of left turns across oncoming traffic (Guerrier et al., 1999).
- Lee, Lee, Cameron, and Li-Tsang (2005) found that poor performance on a working memory task by older drivers (ages 60-88) during simulated driving was significantly associated with self-reported crashes in the prior 1-year period.
- Hunt, Morris, Edwards, and Wilson (1993) found a significant correlation between pass/fail outcome on a road test and performance on the Logical memory subscale of the Wechsler Memory Scale (assessing immediate and delayed recall).
- Szlyk, Myers, Zhang, Wetzel, and Shapirio (2002) found that older drivers with poor performance on several measures of working memory had poorer performance in a driving simulator (drove at slower speed, and had more lane boundary crossings) than drivers with better performance on the working memory tasks.

Included Behavioral Countermeasures

- Physical aerobic/activity training
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Medical management (incl. pharmacy review)
- Cognitive rehab (incl. memory training) for normally aging population
- Compensatory cognitive/memory training for impaired/MCI population
- Pre-trip planning

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: WORKING MEMORY		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Physical aerobic activity/training		Panelists indicated this countermeasure merits further research for remediation of working memory deficits, stating a large body of research showing aerobic exercise results in alertness--hippocampul regeneration.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)		Panelists state all 3 types of education may be useful for working memory deficits; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.
Cognitive rehab (including memory training) for normally aging population	OTs noted that there are protocols and treatments for retraining attention, but cognitive rehab literature shows efficacy of attentional therapy in the broader rehab area ("Society for Cognitive Rehab"). It doesn't directly address driving, but builds subskills for the driving task. Laderman, Szlyk, Kelsch, and Seiple (2000) found improvement in visual memory (remembering store names subjects had walked past) after practice in the laboratory recalling sequences of numbers, letters, and shapes presented briefly on 35-mm slides.	Panelists indicate this is building subskills for the driving task. An OT panelist noted that you cannot just do a lot of the cognitive retraining tasks and assume that it will generalize to driving. You need to make that part of the therapy program. Countermeasure has tremendous promise but it is just in its infancy for developing the training protocols, and making sure it is appropriate. There is a real need for good research to make sure that we use this appropriately.
Compensatory cognitive/memory training for impaired/MCI population		Panelists were cautious about recommending cognitive interventions for people with early stage dementia, and indicated that strategies must be compensatory rather than restorative for this group.
Pre-trip planning		Countermeasure suggested by panelists as meriting further research

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: EXECUTIVE FUNCTION (JUDGMENT/DECISION-MAKING)

Associated Driver Performance Errors

- Association between poor performance on Trails B Test (a measure of executive function) and retrospective (Stutts et al., 1998; Goode et al., 1998; Daigneault et al., 2002) and prospective state-recorded crashes (Staplin et al., 2003) and poor simulator (Rizzo et al., 1997; Szlyk et al., 2002)) and on-road performance (Tarawneh et al., 1993), although type of crash not specified.
- Poor performance on a maze test (also measures executive functioning) was correlated with road test failure (Snellgrove, 2005; Ott et al., 2008).
- Age-related declines in executive control function include planning, scheduling, working memory, inhibitory processes, and multi-tasking.
- Panelists indicated that an executive function deficit could be associated with the following critical driver performance errors: #2 gap judgment errors; #3 inability to predict development of future conflicts; #4 slowed vehicle control response; #5 inadequate visual search; #6 slowed decision making.

Included Behavioral Countermeasures

- Physical aerobic/activity training
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Medical management (incl. pharmacy review)
- Cognitive rehab (incl. memory training) for normally aging population
- Compensatory cognitive/memory training for impaired/MCI population
- Pre-trip planning

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: EXECUTIVE FUNCTION (JUDGMENT/DECISION-MAKING)		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Physical aerobic activity/training	No studies on improvement in driving, however, Colcombe and Kramer (2003) found the largest positive effects of fitness training and cognitive functioning in older (non-demented) adults was on executive control processes. Programs combining aerobic training with strength and flexibility training had the largest effects. Conflicting evidence was found by Marmeleira, Godinho, and Fernandes (2008); an exercise program incorporating walking with cognitive and perceptual tasks resulted in no improvement on tests of executive function (Stroop or Trails B) from baseline to 12-weeks post intervention.	Panelists indicated this may be an appropriate countermeasure for deficits in executive function, but requires further research. A panelist mentioned that the literature in the area of exercise and cognitive function is mixed, with some studies showing improvement and others showing no effect. One problem with the research may be that the exercise interventions are too brief to result in an improvement.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Marottoli (2007): AAA Safe Driving for Mature Operators presented in 2, 4-hour sessions with supplemental topics (including search strategies for intersections), plus 2, 1-hour on-road driving sessions focused on common errors made by older persons. On road performance assessed at baseline and 8 weeks post-intervention included 31 T-type intersections and 32 crossing intersections. There were 15 right turns, 12 merges, and several opportunities for right turns on red. Post-test scores were significantly higher than baseline, translating to 9.5% decrease in crash risk over 2-year period. The items showing the most improvement included scanning to the rear, lane selection, right turns, and judgment. Eby, Molnar, Shope, Vivoda, and Fordyce (2003). Driving Decisions Workbook (a self assessment tool) was effective in increasing older drivers' awareness of changes in driving abilities related to aging, and effects of changes on driving. Participants stated they would seek 2nd tier assessment and change driving habits. Skufca (2008): AARP DSP participants indicated course encouraged them to change certain driving behaviors (20% indicated avoiding left turns as a new behavior).	Panelists state all 3 types of education may be useful for deficits in executive functioning; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.
Cognitive rehab (including memory training) for normally aging population		Panelists indicate this is building subskills for the driving task. An OT panelist noted that you cannot just do a lot of the cognitive retraining tasks and assume that it will generalize to driving. You need to make that part of the therapy program. Countermeasure has tremendous promise but it is just in its infancy for developing the training protocols, and making sure it is appropriate. There is a real need for good research to make sure that we use this appropriately.
Compensatory cognitive/memory training for impaired/MCI population		Panelists were cautious about recommending cognitive interventions for people with early stage dementia, and indicated that strategies must be compensatory rather than restorative for this group.
Pre-trip planning		Countermeasure suggested by panelists as meriting further research.

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: SPATIAL ABILITIES

Associated Driver Performance Errors

- Errors in distance judgment and difficulty predicting the development of traffic situations (Johansson & Lundberg, 1997).
- Poor performance on clock-drawing test (a measure of visuospatial functioning) accounted for 38% of the variance in road test performance in sample referred for fitness to drive assessment (excluded persons suspected of dementia or cognitive decline); Specific errors not described in correlational analysis (De Raedt & Ponjaert-Kristoffersen, 2001).
- Impaired pentagon copying performance was associated with adverse driving events (crashes, violations), but type not specified (Marottoli et al., 1994).
- Poor performance on the MVPT Visual Closure subscore was associated with crashes (type not specified) in 20-month follow-up period (Staplin et al., 2003), and on poor road test performance (Tarawneh et al., 1993).
- Older, crash-involved subjects with suspended licenses performed worse on tests of visuospatial abilities than older non-crash-involved drivers with suspended licenses, and older drivers with clean records. A main violation type leading to crashes and suspensions included failure to yield the right of way (Lundberg et al., 1998).
- Poor performance on tests of spatial ability (Rey-Osterreith Complex Figures and Wechsler Memory Scale) discriminated crash-involved from crash-free drivers in prior 5-year period (Goode et al., 1998).
- Panelists indicated that a deficit in spatial abilities could be associated with the following critical driver performance errors: #2 gap judgment errors; #3 inability to predict the development of future conflicts; #5 inadequate visual search/improper lookout; and #6 slowed decision making.

Included Behavioral Countermeasures

- Visual perceptual therapy
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Medical management (incl. pharmacy review)

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: SPATIAL ABILITIES		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Visual perceptual therapy	McCoy et al. (1993): Evaluated workbook exercises to improve visual perception in 5 areas: spatial relationships, visual discrimination, figure ground, visual closure, and visual memory. Before-after on-road driving performance (DPM technique) improved by 7.7 percentage points, compared to no improvement in control group.	Panelists indicated this countermeasure merits further research for remediation of deficits in spatial abilities.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)		Panelists state all 3 types of education may be useful for deficits in spatial abilities; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. OTs note that if there is a serious deficit, driving should be ruled out. Spatial abilities deficits manifest themselves in lane control difficulty. They will start with easy situations and progress to more difficult situations if there is improvement. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: KNOWLEDGE

Associated Driver Performance Errors

- Misunderstanding of the behavioral requirements when approaching a yield sign on an entrance ramp.
- In a survey of 692 older drivers, 25 percent reported that they stop on a freeway entrance ramp before merging onto the highway, and 17 percent indicated that they have trouble finding a large enough gap in which to merge onto the mainline (Knoblauch, Nitzburg, & Seifert, 1997 in FHWA Highway Design Handbook for Older Drivers and Pedestrians (Staplin et al., 2001).
- Malfetti and Winter (1987), in a critical incident study of merging and yielding problems, reported that older drivers on freeway acceleration lanes merged so slowly that traffic was disrupted, or they stopped completely at the end of the ramp instead of attempting to approach the speed of the traffic flow before entering the mainline (in FHWA Highway Design Handbook for Older Drivers and Pedestrians (Staplin et al., 2001).
- Panelists indicated a knowledge deficit could be associated with the following critical driver performance errors: #3 inability to predict the development of future conflicts; #7 lack of understanding of rules of the road; #8 lack of understanding or failure to apply safe driving practices.

Included Behavioral Countermeasures

- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)
- Medical management (incl. pharmacy review)
- Pre-trip planning

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: KNOWLEDGE		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Driver safety education (Theory/Classroom)	Skufca (2008): AARP DSP participants indicated course encouraged them to change certain driving behaviors, specifically paying more attention when exiting or entering highways (49%), yielding the right of way (44%), limiting travel on freeways (18%), and always checking blind spots (74%) as a consequence of information learned. Kutner (2006): No difference in crash rate (self reported) in prior 12-month period for AARP Driver Safety program participants and comparison group of not-AARP DSP participants. Bedard et al. (2004). Canadian Safety council adaptation of AARP DSP evaluated for treatment and comparison group using an on-road evaluation at baseline and post-treatment. On-road evaluation scores improved significantly for treatment and control group from baseline to post-intervention; no significant difference between treatment and comparison group on mean change score from the first to second evaluation. Janke (1994). Completion of Mature Driver Improvement Program was associated with more total fatal injury crashes and fewer citations compared with group who did not attend course. Eby, Molnar, Shope, Vivoda, and Fordyce (2003). Driving Decisions Workbook (a self assessment tool) was effective in increasing older drivers' awareness of changes in driving abilities related to aging, and effects of changes on driving. participants stated they would seek 2nd tier assessment and change driving habits; no evaluation on whether drivers followed through on these plans. McCoy et al. (1993). Completion of AAA Safe Driving for Mature Operators was associated with a significant increase in on-road driving performance (baseline and post intervention road test using DPM technique) of 3.7 percentage points. Education plus physical therapy increased score by 8.7 percentage points; education plus perceptual therapy increased score by 13.9 percentage points. Nasvadi and Vavrik (2007). Evaluation of British Columbia Safety Council adaptation of AARP DSP comparing police-reported at-fault crash and violation rate for participants vs. non-participants in prior 2-year period, to determine whether self-selection bias exists for those who attend remedial safety courses. Significantly more participants than controls had crashed, but there was no difference in violation rate. A follow-up comparison of crash rate for subsequent 2-year period for attendees and controls with matched pre-course crash rate showed that more attendees had crashes than non-attendees, but the difference was not significant. However, when stratifying by age group and gender, males age 75+ who attended the course were 3.8 times more likely to be involved in a crash than controls who did not attend class. No difference in crash rate for men ages 55-74 or women ages 55-74 and those 75+. Porter et al. (2005) Older drivers with adequate flexibility to turn their head to look over their shoulder (study involved backing maneuver only) often rely on a mirror check only, indicating a need for education on the proper procedures for backing (findings could translate for merge maneuver).	General consensus that it makes sense to provide education, even if it isn't adequate; people will be people, and it may work for some and not others. Education (theory) alone may never be enough; may need to be coupled with skills training.

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: KNOWLEDGE		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Driver safety education (Theory + BTW)	Marottoli (2007): AAA Safe Driving for Mature Operators presented in 2, 4-hour sessions with supplemental topics (including search strategies for intersections), plus 2, 1-hour on-road driving sessions focused on common errors made by older persons. On road performance assessed at baseline and 8 weeks post-intervention included 31 T-type intersections and 32 crossing intersections. There were 15 right turns, 12 merges, and several opportunities for right turns on red. Post-test scores were significantly higher than baseline, translating to 9.5% decrease in crash risk over 2-year period. The items showing the most improvement included scanning to the rear, lane selection, right turns, and judgment. Bedard et al. (2008): Significant improvement in knowledge, but no change in driving performance for the category of signal violations/right of way/inattention.	General consensus that it makes sense to provide education, even if it isn't adequate; people will be people, and it may work for some and not others. Education (theory) alone may never be enough; may need to be coupled with skills training.
Driver safety education (Interactive/computer-based)		Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)		Panelists state that vehicles have safety features but many need to be adjusted, and older drivers don't know how to do this. Education about driving aids is a positive theme to staying on the road longer. Countermeasure merits further research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.
Pre-trip planning		Countermeasure suggested by panelists as meriting further research

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: PHYSICAL/PSYCHOMOTOR

SPECIFIC DEFICIT: HEAD/NECK/TRUCK RANGE OF MOTION

Associated Driver Performance Errors

- Difficulty turning head to left to look for gap in approaching traffic (and failure to detect potential conflict vehicles, or detect them at safe maneuvering distance).
- Impaired ability to turn head to check over shoulder significantly predicted at-fault crashes in 20-month follow up period (Staplin et al., 2003).
- Limited range of motion of neck is significantly associated with adverse driving events (self reported, prior 5 years) (Marottoli et al., 1998).
- Range of motion significantly associated with pass/fail performance on road test (McCarthy & Mann, 2006).
- Decision time to make a go/no go response to turn at a simulated T-intersection increased with age and level of impairment in range of neck movement (Hunter-Zaworski, 1990).
- Crash-involved older drivers were 1.25 times more likely to have medical diagnosis of joint/spine disorders in 2-yr period prior to crash than non-crash-involved controls (Cui, 2001).
- Self-reported health symptoms relating to spine and lower body (limited strength or movement, lack of feeling or sensation, involuntary movement, chronic pain) related to self reported driving difficulties, and lack of physical activity related to difficulty with shoulder checking (Tuokko et al., 2007).
- Panelists indicated a deficit in head/neck trunk range of motion could be associated with the following critical driver performance errors: #1 failure to visually detect potential conflicts, hazards, or traffic control information; #4 slowed vehicle control response.

Included Behavioral Countermeasures

- Training in compensatory head/eye movements, scanning strategies
- Physical aerobic/activity training
- Strength and flexibility exercises
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)
- Collision warning systems
- After-market, non-planar, driver-side mirror
- Medical management (incl. pharmacy review)

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: HEAD/NECK/TRUNK RANGE OF MOTION		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Training in compensatory head/eye movements, scanning strategies		Panelists agreed that this is an appropriate countermeasure, but candidates must be cognitively intact. This type of training has been used for telescopic and amorphic-lens drivers ("search and destroy" method) and has been effective in improving peripheral visual detection.
Physical aerobic/activity training	May be research from Art Kramer at the University of Illinois looking at physical exercise programs and driving (simulator).	Merits further research.
Strength and flexibility exercises	Ostrow et al. (1992). Exercise program consisting of chin flexion/extension, neck rotations, head side bending, chin tucks, rotating shoulders backward, and trunk rotations. Sig. improvements in trunk rotation and shoulder flexibility across experimental subjects' 3 testing sessions (baseline, 8 and 11 weeks). Subjects in experimental group showed improvements in field-based assessment of driving skill: looked more frequently to the sides and rear of their vehicle than control drivers who did not participate in program. Marottoli et al. (2007) 12 week, in-home exercises 15 minutes daily, 7 days/week, with weekly in-home visit by physical therapist. Exercises focused on axial/extremity condition, upper extremity coordination/dexterity, and gait abnormalities. On-road driving performance was measured at baseline and post-intervention for treatment and control group. Significant improvement for treatment group compared to control group translated to 8 to 16 percent lower crash occurrence over 2 year period. Intervention group also made 37% fewer critical errors (inattention, turning or changing lanes w/o looking, and disobeying signs or signals) than control group at follow up. McCoy et al. (1993): Home-based exercises designed to improve posture, trunk rotation, neck flexibility, shoulder flexibility. 1-hour training session followed by 8 weeks of exercise, 4 times per week. Post intervention On-road drive test performance improved by 6.8 percentage points (significant), and when physical therapy was combined with driver education, improvement increased by 8.7 percent.	Panelists agreed that this is an appropriate countermeasure
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)		Panelists state all 3 types of education may be useful for deficits in head/neck/trunk range of motion; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: HEAD/NECK/TRUNK RANGE OF MOTION		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)		Panelists state that vehicles have safety features but many need to be adjusted, and older drivers don't know how to do this. Education about driving aids is a positive theme to staying on the road longer. Concern about liability for re- aiming mirrors for drivers during CarFit; OTs put the mirrors back to their original position when the drivers arrive at the evaluation. Countermeasure merits further research.
Collision warning systems	Oxley and Mitchell (1995): collision warning system tested in a simulator was effective in preventing older drivers from turning across traffic through gaps that were dangerously short.	Suggested by panelists as countermeasure that merits further research. Need forward as well as side-collision warning. Would be helpful if it caused the vehicle to brake, in addition to providing a warning.
After-market, non-planar, driver-side mirror	No research on "bulls eye" convex mirror affixed to standard planar mirror, however Staplin et al. (1998) found that approx 13% of older driver sample in laboratory simulator study made unsafe gap acceptance judgments to change lanes in front of an adjacent-lane vehicle overtaking at 25 mi/h differential while using full-sized non-planar mirrors. Also one-third of sample indicated sole reliance on mirror when changing lanes. De Vos (2000): older drivers look over their shoulders less frequently than younger drivers when changing lanes. Drivers accept smaller gaps when using non-planar mirrors, due to image minification.	Panelist OTs concerned that the recommendation could be a liability, but merits further research. Even aiming mirrors for drivers during CarFit is a liability and OTs put the mirrors back to their original position when the drivers arrived at the evaluation. Non-planar mirrors would require optical distortion training, and there is currently no standard of care.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients. Impairments in psychomotor functioning may result from musculoskeletal disease leading to weakening, frailty, and/or restricted range of motion. Medical management of arthritis is important.

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: PHYSICAL/PSYCHOMOTOR

SPECIFIC DEFICIT: ARM STRENGTH/RANGE OF MOTION/SPEED OF MOVEMENT

Associated Driver Performance Errors

- Older women with difficulty extending arms above their shoulders had increased crash risk (Hu et al., 1998).
- Difficulty reaching out was significantly associated with crashes in prior 6 years (Sims et al., 1998). Crash type not specified in research studies.
- Range of motion significantly associated with pass/fail performance on road test (McCarthy & Mann, 2006).
- Panelists indicated a deficit in arm strength/range of motion/speed of movement could be associated with slowed vehicle control response (critical driver performance error #4) .

Included Behavioral Countermeasures

- Physical aerobic/activity training
- Strength and flexibility exercises
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)
- Medical management (incl. pharmacy review)

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: ARM STRENGTH/RANGE OF MOTION/SPEED OF MOVEMENT		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Physical aerobic activity/training	May be research from Art Kramer at the University of Illinois looking at physical exercise programs and driving (simulator).	Merits further research.
Strength and flexibility exercises	Marottoli et al. (2007) 12 week, in-home exercises directed by physical therapist focusing on axial/extremity condition, upper extremity coordination/dexterity, and gait abnormalities. On-road driving performance was measured at baseline and post-intervention for treatment and control group. Significant improvement for treatment group compared to control group translated to 8 to 16 percent lower crash occurrence over 2 year period. Intervention group also made 37% fewer critical errors (inattention, turning or changing lanes w/o looking, and disobeying signs or signals) than control group at follow up.	Panelists agreed that this is an appropriate countermeasure
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)		Panelists state all 3 types of education may be useful for deficits in arm strength/range of motion/speed of motion; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)		Panelists state that vehicles have safety features but many need to be adjusted, and older drivers don't know how to do this. Education about driving aids is a positive theme to staying on the road longer. Countermeasure merits further research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients. Impairments in psychomotor functioning may result from musculoskeletal disease leading to weakening, frailty, and/or restricted range of motion. Medical management of arthritis is important.

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: PHYSICAL/PSYCHOMOTOR

SPECIFIC DEFICIT: LEG STRENGTH/RANGE OF MOTION/SPEED OF MOVEMENT

Associated Driver Performance Errors

- Slow accelerating into through lanes, resulting in shorter time to collision with approaching vehicle.
- Poor performance on rapid pace walk is associated with adverse driving events (Crashes, violations) (Marottoli et al., 1994; Staplin et al., 2003), and pass/fail performance on road test (McCarthy & Mann, 2006).
- Range of motion significantly associated with pass/fail performance on road test (McCarthy & Mann, 2006).
- Older drivers reporting pain in the feet, hips, legs, or current treatment for arthritis had significantly slower brake reaction speeds (both initial reaction and physical response speed) than drivers with no complaints of pain in these areas (Zhang et al., 2007).
- Panelists indicated a deficit in leg strength/range of motion/speed of movement could be associated with slowed vehicle control response (critical driver performance error #4) .

Included Behavioral Countermeasures

- Physical aerobic/activity training
- Strength and flexibility exercises
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)
- Medical management (incl. pharmacy review)

CRASH TYPE 4: Merge at yield sign onto limited access highway.

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: LEG STRENGTH/RANGE OF MOTION/SPEED OF MOVEMENT		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Physical aerobic activity/training	May be research from Art Kramer at the University of Illinois looking at physical exercise programs and driving (simulator).	Merits further research.
Strength and flexibility exercises	Marottoli et al. (2007) 12 week, in-home exercises directed by physical therapist focusing on axial/extremity condition, upper extremity coordination/dexterity, and gait abnormalities. On-road driving performance was measured at baseline and post-intervention for treatment and control group. Significant improvement for treatment group compared to control group translated to 8 to 16 percent lower crash occurrence over 2 year period. Intervention group also made 37% fewer critical errors (inattention, turning or changing lanes w/o looking, and disobeying signs or signals) than control group at follow up.	Panelists agreed that this is an appropriate countermeasure
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)		Panelists state all 3 types of education may be useful for deficits in arm strength/range of motion/speed of motion; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)		Panelists state that vehicles have safety features but many need to be adjusted, and older drivers don't know how to do this. Education about driving aids is a positive theme to staying on the road longer. Countermeasure merits further research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients. Impairments in psychomotor functioning may result from musculoskeletal disease leading to weakening, frailty, and/or restricted range of motion. Medical management of arthritis is important.

CRASH TYPE 5: Lane change on multilane (4+) roadway.

FUNCTIONAL DEFICITS THAT MAY INFLUENCE CRASH RISK

SENSORY/PERCEPTUAL (VISION)

- Contrast Sensitivity
- Visual Fields
- Depth and Motion Perception (Angular Motion Sensitivity)
- Dark Adaptation and Glare Recovery

ATTENTION/COGNITION

- Speed of Processing
- Selective Attention
- Divided Attention
- Working Memory
- Executive Function (Judgment and Decision Making)
- Spatial Abilities
- Knowledge (Rules of the Road and Safe Driving Strategies)

PHYSICAL/PSYCHOMOTOR

- Head/Neck/Trunk Range of Motion
- Arm Strength/Range of Motion/Speed of Movement
- Leg Strength/Range of Motion/Speed of Movement

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION)

SPECIFIC DEFICIT: CONTRAST SENSITIVITY

Associated Driver Performance Errors

- Could contribute to a failure to visually detect a potential threat.
- Has been correlated with poor driving performance (Wood, 2002; Baldock et al., 2007) and increased crash risk in prior 5-year period (Owsley, Stalvey, Wells, Sloane, & McGwin, 2001).
- Contrast sensitivity along with visual spatial memory and 2 measures of visual attention RT explained 35% of the variance in driving ability demonstrated in on-road test (Baldock, Mathias, McLean & Berndt, 2007).

Included Behavioral Countermeasures

- Refractive correction (incl. Wavefront technology)
- Cataract surgery
- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Central vision enhancement systems (bioptic telescopic lenses, implantable telescopes)
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Collision warning systems
- Medical management (incl. pharmacy review)

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: CONTRAST SENSITIVITY		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Refractive correction (incl. Wavefront technology)	Haddrill (2007): Ophthonix founder A. Dreher reports that iZon lenses (wavefront lenses) provide higher definition vision in the daytime and significantly improve night driving responses when compared with conventional lenses. Night vision improved a driver's ability to identify pedestrians by an average of 330 ms (30 ft sooner at 55 mi/h) when compared to conventional lenses. www.allaboutvision.com/lenses/wavefront-lenses.htm; http://ophthonix.izonlens.com/globals/faqs.asp; www.allaboutvision.com/whatsnew/lenses1.htm.	A panel member (vision specialist) recommended inclusion of Wavefront technology as part of refractive correction. Wavefront technology diagnoses higher-order vision errors represented by the way the eye refracts or focuses light; such aberrations defocus images even with 20/40 acuity. Wavefront guided lenses can reduce certain higher-order aberrations, which potentially can improve low light image quality during activities such as driving at night. Panelist notes research on effectiveness for driving is currently limited to that conducted by lens manufacturer (see Haddrill 2007 description of Ophthonix iZon wavefront guided lenses). Another caution noted by the panelist regarding the lens company research is that improvements in vision with the wavefront lenses were compared to patients' vision as they appeared for the study. But it is well known that many patients especially over age 60 haven't had regular eye check-ups or new prescriptions.
Cataract surgery	• Monestam and Wachtmeister (1997): Self reported problems with distance judgment declined from 37% to 6% of sample following cataract surgery. • McGwin et al. (2003): contrast sensitivity improved significantly in the sample that underwent surgery, and day and night driving scores on Activities of Daily Vision Scale significantly improved post-operatively in surgery group. • Owsley et al. (2002):Patients with a cataract who underwent surgery and IOL implantation had half the crash rate of drivers with cataract who did not undergo surgery (4.74 crashes per million miles of travel vs. 8.95). • Wood and Carberry (2006): Bilateral cataract surgery resulted in significant improvements in on-road performance, related to improvements in CS.	Panelists agree this is a relatively inexpensive treatment and improvements result in crash reduction. Cataracts are often the only medical condition affecting driving performance. Even if crash reduction benefit is small, cataract surgery may provide a large public health benefit because of the large number of people affected by cataracts.
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	• Gallo, Rebok, and Lesikar (1999). Self-reported vision impairment was related to avoidance of challenging driving situations, but not to self-reported citations or crashes in prior 2 years. Authors conclude that vision impaired drivers who self restrict are less likely to crash. Vision impairment categories: no trouble seeing; a little trouble, a lot of trouble (i.e., may not be specific to CS). • Ball, Owsley, Stalvey, Roenker, Sloane, and Graves (1998): No relationship between avoidance score and crashes in subsequent 3 year period. • De Raedt and Ponjaert-Kristoffersen (2000): poor performers on a road test but were free of (self-reported) at-fault crashes (prior 12 mo) used significantly more strategic compensation tactics (avoidance of challenging situations) than poor performers with a history of at-fault crashes. • Hennessy (1995): older drivers with poor CS and who (sometimes of often) avoided heavy traffic had a reduced crash risk compared to those with poor CS who did not avoid heavy traffic. Avoidance brought risk equal to that of drivers with good CS.	Panelists indicate this may or may not be effective; "we don't know if this works." People try to self-regulate when there are alternative transportation options, but there are times when they "must" drive even if they'd rather not (e.g., winter when it gets dark earlier, or no other driver to take them). Making people aware of deficits is the first step in getting people to self restrict, if they will self restrict.

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: CONTRAST SENSITIVITY		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Central vision enhancement systems (bioptic telescopic lenses, implantable telescopes)	Janke and Kazarian (1983): Crash rate in users is 1.5 times higher than population rate, but less than the crash rate of drivers licensed with other medical conditions. Clark (1996): Crash rates for BTL users 1.9 times higher than comparison group, but citation rates 0.7 of that for comparison group. Szlyk et al. (2000): Training in the use of BTL lenses (both lab and on-road) significantly increased performance in recognition, peripheral identification, and scanning compared to performance of non-trained BTL users.	Panelists in agreement with countermeasure if accompanied by training and assessment of driving safety after training. Recommend licensing with restrictions after low-driving program/rehab. Use lens only for spotting (5-10% of time). Training curriculum and design of lenses needs to be "nailed down." Training curriculum needs to be developed by Occupational Therapists. Countermeasure appropriate if no cognitive deficit.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for contrast sensitivity deficit; raises awareness of deficit so they can self restrict. Also provide education to physicians and eyecare specialists so they can educate their patients. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Collision warning systems	Oxley and Mitchell (1995): collision warning system tested in a simulator was effective in preventing older drivers from turning across traffic through gaps that were dangerously short.	Suggested by panelists as countermeasure that merits further research. Need forward as well as side-collision warning. Would be helpful if it caused the vehicle to brake, in addition to providing a warning.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION)

SPECIFIC DEFICIT: VISUAL FIELDS

Associated Driver Performance Errors

- Could contribute to a failure to visually detect a potential threat.
- Impaired detection capability for stimuli in the affected parts of the visual field (Lovsund, Hedin, & Tornros, 1991).
- Correlated with crashes (Ball et al., 1993; Johnson & Keltner, 1983; Ruben et al., 2007; Szlyk et al., 1991).
- Drivers with Glaucoma (McGwin, Owsley, & Ball, 1998; Hu et al., 1998) and macular degeneration (Owsley et al., 1998) have higher crash rate than those without, and these conditions can restrict visual field.
- Significant relationship between right visual field size and driving performance (on-road test included 2 right-turn intersections) (Tarawneh et al., 1993).
- Combination of peripheral vision deficit and restricted head movement increases the difficulty of bringing an approaching vehicle on a perpendicular roadway into central vision, and may explain why older drivers have higher rates of intersection crashes that result in injury or death (Isler, Parsonson & Hansson, 1997).

Included Behavioral Countermeasures

- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Central vision enhancement systems (bioptic telescopic lenses, implantable telescopes)
- Visual field expansion systems (prism, bioptic amorphic lenses, video feeds)
- Training in Compensatory Head/Eye Movements, Scanning Strategies
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Education about driving aids (Car Fit, features/adaptive equipment, shoes, etc.)
- Medical management (incl. pharmacy review)

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: VISUAL FIELDS		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	Hennessy (1995): poorer visual field ability (modified Synemed perimeter) was significantly associated with greater avoidance of driving at night, rain, dusk, dawn, and making left turns, but the predictive value of visual fields performance on crash rate (prior 3 yrs) was mediated only for avoidance of left turns; But avoidance did not reduce risk, it increased it (inadequate compensation).	Panelists indicate this may or may not be effective; "we don't know if this works." People try to self-regulate when there are alternative transportation options, but there are times when they "must" drive even if they'd rather not (e.g., winter when it gets dark earlier, or no other driver to take them). Making people aware of deficits is the first step in getting people to self restrict, if they will self restrict.
Central vision enhancement systems (bioptic telescopic lenses, implantable telescopes)	Janke and Kazarian (1983): Crash rate in users is 1.5 times higher than population rate, but less than the crash rate of drivers licensed with other medical conditions. Clark (1996): Crash rates for BTL users 1.9 times higher than comparison group, but citation rates 0.7 of that for comparison group. Szlyk et al. (2000): Training in the use of BTL lenses (both lab and on-road) significantly increased performance in recognition, peripheral identification, and scanning compared to performance of non-trained BTL users.	Panelists in agreement with countermeasure if accompanied by training and assessment of driving safety after training. Recommend licensing with restrictions after low-driving program/rehab. Use lens only for spotting (5-10% of time). Training curriculum and design of lenses needs to be "nailed down." Training curriculum needs to be developed by Occupational Therapists. Countermeasure appropriate if no cognitive deficit.
Visual field expansion systems (prisms, bioptic amorphic lenses, video feeds)	Szlyk et al. (1998): Following training with the lenses (lab and on-road), patients showed improvements in all visual skill categories, including peripheral detection and selecting appropriate gaps. Authors note further research necessary to determine safety while driving.	Panelist states that 100 degree binocular field is a good minimum standard; if < 100 degrees and adamant about driving, a driver should be offered these systems to see if he/she can adapt to it (should be the standard of care). Target audience would be a driver with 50 degree binocular fields in a State with no visual field requirement, and prisms (ref Eli Peli) could be used to expand the field to 100 degrees to make driving safer. Video feed may be better than amorphic lenses.

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: VISUAL FIELDS		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Training in compensatory head and eye movements, scanning strategies	Coeckelbergh et al. (2001): Training in compensatory viewing strategies, particularly on-road training, improved viewing behavior for persons with central or peripheral visual field constriction, and increased the number of subjects who passed a road test who previously failed. Ss had visual field defects due to ocular pathology; those with severe cognitive impairments were excluded from participation. Dynavision apparatus has been used in office rehab settings to train compensatory scanning strategies for visual inattention and visual field deficit in persons with intact attentional mechanisms. Klavora et al. (1995) found that Dynavision training with 10 older (age 46-73) post-CVA individuals resulted in significantly improved behind-the-wheel driving performance when compared with expected outcomes. All failed their first BTW assessment pre-Dynavision training. Training involved three 40-minute Dynavision Training sessions per week for 6 weeks. On the second BTW assessment, 6 of the 10 subjects earned a "safe to resume driving and/or receive on-road driving lessons." Laderman, Szlyk, Kelsch, and Seiple (2000): 4-week training on a task in a rehab center setting to teach peripheral detection, scanning, and tracking where the clients sat close to a screen and detected slide images in the periphery using amorphic lenses, then turning their heads toward the object to identify it more clearly through the carrier. 8-week training in-vehicle on closed course with driving instructor to practice skills. Before-after training results indicated 39% improvement in tasks involving peripheral detection, and 27% improvement in scanning tasks. Authors note further research is needed to define standards and evaluation methods for training curricula.	Panelists agreed that this is an appropriate countermeasure, but candidates must be cognitively intact. This type of training has been used for telescopic and amorphic-lens drivers ("search and destroy" method referred to by panelist, described by Laderman et al., 2000) and has been effective in improving peripheral visual detection. One panelist mentioned a book that may be useful in this training older adults to scan effectively by Ken Mills "Disciplined Attention: How to Improve Your Visual Attention When You Drive." The book (directed toward young driver training) is not a countermeasure that's ready to go, but it's one ready to be researched.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for visual field deficits; raises awareness of deficit so they can self restrict. Also provide education to physicians and eyecare specialists so they can educate their patients. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills education. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Education about driving aids (CarFit, features/adaptive equipment, shoes, etc.)		Panelists state that vehicles have safety features but many need to be adjusted, and older drivers don't know how to do this. Education about driving aids is a positive theme to staying on the road longer. Countermeasure merits further research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION)

SPECIFIC DEFICIT: DEPTH AND MOTION PERCEPTION

Associated Driver Performance Errors

- Gap judgment error: driver changes lanes in front of approaching vehicle into too short a gap, and approaching vehicle must slow or make erratic lane change maneuver to avoid a crash.
- Older drivers (especially females) rely on distance instead of integrating speed and distance, especially for higher-speed roads (Yan, Radwan, & Guo, 2007; Andersen & Enriquez, 2006; Scialfa et al., 1991; Dazentas, McDowell, & Cooper, 1980; Braitman et al., 2007; De Raedt & Ponjaert-Kristoffersen, 2000).
- Impairments in stereoacuity are related to retrospective crashes (Owsley, McGwin, & Ball, 1998; Ivers et al., 1999; Staplin et al., 1998).
- Poor structure from motion performance is related to simulator crashes (Rizzo et al., 1997 and at-fault safety errors on the road (Uc et al., 2005).
- Central motion sensitivity related to on road driving performance (Wood, 2002).
- Panelists indicated that a deficit in depth and motion perception could be associated with inability to predict development of future conflicts (critical performance error #3), in addition to gap judgment errors (#2).

Included Behavioral Countermeasures

- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Education about driving aids (Car Fit, features/adaptive equipment, shoes, etc.)
- Medical management (incl. pharmacy review)

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: DEPTH AND MOTION PERCEPTION		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	Ball, Owsley, Stalvey, Roenker, Sloane, and Graves (1998): No relationship between avoidance score and crashes in subsequent 3 year period. De Raedt and Ponjaert-Kristoffersen (2000): drivers who performed poorly on a road test but were free of (self-reported) at-fault crashes in the prior 12-mo period used significantly more strategic compensation tactics (avoidance of challenging situations) than poor-performing drivers with a history of at-fault crashes.	Panelists indicated that drivers could choose the route that has a protected turn.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for depth and motion perception deficits; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Education about driving aids (CarFit, features/adaptive equipment, shoes, etc.)		Panelists state that vehicles have safety features but many need to be adjusted, and older drivers don't know how to do this. Education about driving aids is a positive theme to staying on the road longer. Countermeasure merits further research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION)

SPECIFIC DEFICIT: DARK ADAPTATION AND GLARE RECOVERY

Associated Driver Performance Errors

- Disability glare would result in difficulty determining what lane an approaching vehicle is in when making gap judgment.
- Older drivers with 3+ letters lost in the presence of glare on Peli-Robson Chart were 2.32 times more likely to crash in 4-year follow-up period (after adjusting for age, race, sex, cognitive performance, education, comorbidities, depression, and living alone. But no relationship found between disability glare and crashes in 3-year follow-up period (Owsley et al. ,1998).
- Panelists indicated this deficit could be associated with a failure to detect potential conflicts, hazards, or traffic control information (Driver Performance Error #1).

Included Behavioral Countermeasures

- Cataract surgery
- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Education about driving aids (CarFit, features/adaptive equipment, shoes, etc.)
- Medical management (incl. pharmacy review).

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: SENSORY/PERCEPTUAL (VISION) SPECIFIC DEFICIT: DARK ADAPTATION AND GLARE RECOVERY		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Cataract surgery	McGwin et al. (2003): disability glare improved significantly post surgery in group of patients with cataract. First surgery eye improvement in acuity significantly related to change in overall activities of daily vision scale and night driving and glare disability subscales. Change in disability glare in second surgery eye significantly assoc. w/change in ADVS score as well as change scores in night driving, near vision, and disability glare subscales.	Panelists agree this is a relatively inexpensive treatment and improvements result in crash reduction. Cataracts are often the only medical condition affecting driving performance. Even if crash reduction benefit is small, cataract surgery may provide a large public health benefit because of the large number of people affected by cataracts.
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	Ball, Owsley, Stalvey, Roenker, Sloane, and Graves (1998): No relationship between avoidance score and crashes in subsequent 3 year period. De Raedt and Ponjaert-Kristoffersen (2000): drivers who performed poorly on a road test but were free of (self-reported) at-fault crashes in the prior 12-mo period used significantly more strategic compensation tactics (avoidance of challenging situations) than poor-performing drivers with a history of at-fault crashes.	Panelists indicate this may or may not be effective; "we don't know if this works." People try to self-regulate when there are alternative transportation options, but there are times when they "must" drive even if they'd rather not (e.g., winter when it gets dark earlier, or no other driver to take them). Making people aware of deficits is the first step in getting people to self restrict, if they will self restrict.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be dark adaptation/glare recovery deficits; raises awareness of deficit so they can self restrict. Also provide education to physicians and eyecare specialists so they can educate their patients. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills education. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Education about driving aids (CarFit, features/adaptive equipment, shoes, etc.)		Panelists state that vehicles have safety features but many need to be adjusted, and older drivers don't know how to do this. Education about driving aids is a positive theme to staying on the road longer. Countermeasure merits further research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: SPEED OF PROCESSING

Associated Driver Performance Errors

- Effect of slowed speed of processing (SOP) may be slowing of retrieval of knowledge of right-of-way rules, and slowed reasoning and decision-making about appropriate visual search and vehicle control.
- SOP deficits (UFOV subtest 1) accounted for 4.1% of the variance in crash involvement (prior 3-years) for drivers age 70+ (type not specified) adjusting for age, gender, and driving exposure (Hennessy, 1995).
- Older drivers who performed poorly on the Trails A test had significantly more retrospective crashes (Stutts, Stewart, & Martell, 1996, 1998; Goode, Ball, Sloane, Roenker, Roth, Myers, & Owsley, 1998) and prospective crashes (Lesikar, Gallo, Rebok, & Keyl, 2002) than drivers who performed well on this SOP measure. Crash type not specified in these studies.
- Older crash-involved drivers with licenses suspended for failure to yield the right of way performed significantly worse on Trails A than subjects w/o suspended licenses (Lundberg, Hakamies-Blomqvist, Almkvist, & Johannson, 1998).
- Panelists indicated that a speed of processing deficit could be associated with the following critical driver performance errors: #2 gap judgment errors; #3 inability to predict development of future conflicts; #4 slowed vehicle control response; #5 inadequate visual search/improper lookout; and #6 slowed decision making.

Included Behavioral Countermeasures

- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Speed of processing training
- Physical aerobic activity/training
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Collision warning systems
- Medical management (incl. pharmacy review)

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: SPEED OF PROCESSING		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	• Ball, Owsley, Stalvey, Roenker, Sloane, and Graves (1998): No relationship between avoidance score and crashes (prior 3 yrs). • Hennessy (1995): poorer SOP ability was significantly associated with greater avoidance of driving at night, rain, dusk, dawn, alone, left turns, and heavy traffic, but the predictive value of the SOP subtask on crash rate (prior 3 yrs) was mediated only for avoidance of left turns; But avoidance did not reduce risk, it increased it (inadequate compensation). • De Raedt and Ponjaert-Kristoffersen (2000): poor performers on a road test who were free of (self-reported) at-fault crashes in the prior 12-mo period used significantly more strategic compensation tactics (avoidance of challenging situations) than poor performers with history of at-fault crashes.	Panelists indicate this may or may not be effective; "we don't know if this works." People try to self-regulate when there are alternative transportation options, but there are times when they "must" drive even if they'd rather not (e.g., winter when it gets dark earlier, or no other driver to take them). Making people aware of deficits is the first step in getting people to self restrict, if they will self restrict.
Speed of processing training	Roenker et al. (2003): Speed of processing training using all 3 subtests of UFOV compared to Doron simulator training and untrained reference group. Global ratings of on-road driving performance improved for both training groups, but only SOP group maintained performance at 18 mo. For "dangerous maneuvers" component, both training groups showed improvements, but only SOP training maintained improvement at 18 mo. Dangerous maneuvers included 6 opportunities for unprotected turns across traffic and 9 left-turn entrances to a high-traffic road.	Panelists agreed this may be a viable countermeasure, but there is a need to establish the link between training on task and transfer to driving.
Physical aerobic activity/training	Marmeleira, Godinho, and Fernandes (2008) found that a 12-week exercise program with 3, 60-min sessions per week improved visual attention in speed of processing and divided attention (using the UFOV protocol) at 12 weeks follow-up in adults ages 60 to 81. The intervention incorporated perceptual and cognitive tasks (problem solving and responding to challenging situations) with aerobic activity. Examples are: walking while listening for auditory cues to perform fast and specific psychomotor responses). At 12 weeks, speed of processing and divided attention were significantly improved compared to baseline for the exercise group; at baseline, there was no difference between groups. Actual driving performance was not studied, and there was no exercise-only group to determine the contribution of physical activity alone on speed of processing or divided attention.	Research article provided by panelist following meeting; panelists did not get to comment on countermeasure for deficit. Merits further research
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for speed of processing deficits; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Collision warning systems	Oxley and Mitchell (1995): collision warning system tested in a simulator was effective in preventing older drivers from turning across traffic through gaps that were dangerously short.	Suggested by panelists as countermeasure that merits further research. Need forward as well as side-collision warning. Would be helpful if it caused the vehicle to brake, in addition to providing a warning.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: SELECTIVE ATTENTION

Associated Driver Performance Errors

- Older drivers with selective attention deficits had shorter time to collision values, took longer to cross the road, and had shorter safety cushions (on-road study) than drivers with no impairment in selective attention ability (Pietras et al., 2006).
- Poor visual attention (number cancellation test) related to poor on-road driving performance, specifically lane changing, exiting, merging, monitoring speed, following at a safe distance, and judging distances appropriately (Richardson & Marottoli, 2003).
- Selective attention with visual search correlated significantly with global road test score, accounting for 19% of the variance (De Raedt & Ponjaert-Kristoffersen, 2000). It also correlated significantly w/visual behavior and communication (r= -.43) and perception and reaction to signals (r=-.37).
- Poor scores on Brief Test of Attention and on Trails A were related to slower perception-reaction times and slower brake movement times during a computerized test of simple RT (Zhang et al., 2007).
- Panelists indicated that a selective attention deficit could be associated with the following critical driver performance errors: #2 gap judgment errors; #3 inability to predict development of future conflicts; #4 slowed vehicle control response; #5 inadequate visual search/improper lookout; and #6 slowed decision making

Included Behavioral Countermeasures

- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Speed of processing training
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Collision warning systems
- Medical management (incl. pharmacy review)
- Cognitive rehab (incl. memory training) for normally aging population
- Compensatory cognitive/memory training for impaired/MCI population

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: SELECTIVE ATTENTION		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	Ball, Owsley, Stalvey, Roenker, Sloane, and Graves (1998): No relationship between avoidance score and crashes in subsequent 3 year period. De Raedt and Ponjaert-Kristoffersen (2000): drivers who performed poorly on a road test but were free of (self-reported) at-fault crashes in the prior 12-mo period used significantly more strategic compensation tactics (avoidance of challenging situations) than poor-performing drivers with a history of at-fault crashes.	Panelists indicate this may or may not be effective; "we don't know if this works." People try to self-regulate when there are alternative transportation options, but there are times when they "must" drive even if they'd rather not (e.g., winter when it gets dark earlier, or no other driver to take them). Making people aware of deficits is the first step in getting people to self restrict, if they will self restrict.
Speed of processing training	Roenker et al. (2003): Speed of processing training using all 3 subtests of UFOV compared to Doron simulator training and untrained reference group. Global ratings of on-road driving performance improved for both training groups, but only SOP group maintained performance at 18 mo. Lane change performance of SOP group remained constant from baseline to both post tests; simulator group's lane change performance fell from baseline to 18-mo follow-up, reference group's lane change performance fell at immediate post test but returned to baseline level at 18-mo follow-up. No difference between 3 groups on lane change performance at baseline.	Panelists agreed this may be a viable countermeasure, but there is a need to establish the link between training on task and transfer to driving.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for selective attention deficits; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Collision warning systems	Oxley and Mitchell (1995): collision warning system tested in a simulator was effective in preventing older drivers from turning across traffic through gaps that were dangerously short.	Suggested by panelists as countermeasure that merits further research. Need forward as well as side-collision warning. Would be helpful if it caused the vehicle to brake, in addition to providing a warning.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.
Cognitive rehab (including memory training) for normally aging population	One panelist noted that reasoning training conducted as part of the ACTIVE trial described by Ball, Berch, Helmers, Jobe, Leveck, et al. (2002) showed an effect on decreased driving difficulty in the 6 years following enrollment in the study. These findings were presented at the 2008 GSA meeting, but not published as of the date of this report.	Panelists indicate this is building subskills for the driving task. An OT panelist noted that you cannot just do a lot of the cognitive retraining tasks and assume that it will generalize to driving. You need to make that part of the therapy program. Countermeasure has tremendous promise but it is just in its infancy for developing the training protocols, and making sure it is appropriate. There is a real need for good research to make sure that we use this appropriately.
Compensatory cognitive/memory training for impaired/MCI population		Panelists were cautious about recommending cognitive interventions for people with early stage dementia, and indicated that strategies must be compensatory rather than restorative for this group.

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: DIVIDED ATTENTION

Associated Driver Performance Errors

- Maneuver requires looking into rear-view and sideview mirrors to detect adjacent-lane vehicles, turning head over shoulder to verify blind spot is clear and make gap judgment decision, maintain lane position while making indirect and direct looks away from the road, maintaining adequate following distance if there is a vehicle ahead, and performing lane change maneuver.
- Drivers with UFOV divided attention deficit had a significantly higher odds of crashing (prospectively) than drivers with normal divided attn performance (crash type not specified) (Rubin et al., 2007; Staplin et al., 2003; Edwards et al., 2008).
- Divided attention deficit associated with prospective crashes, the majority of which were failure-to-yield the right of way (Owsley et al., 1998).
- Panelists indicated that a divided attention deficit could be associated with the following critical driver performance errors: #2 gap judgment errors; #3 inability to predict development of future conflicts; #4 slowed vehicle control response; #5 inadequate visual search/improper lookout; and #6 slowed decision making

Included Behavioral Countermeasures

- Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)
- Speed of processing training
- Physical aerobic/activity training
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Collision warning systems
- Medical management (incl. pharmacy review)
- Cognitive rehab (incl. memory training) for normally aging population
- Compensatory cognitive/memory training for impaired/MCI population

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: DIVIDED ATTENTION		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Avoidance of challenging driving situations (self- or DRS-initiated, or license restrictions)	Ball, Owsley, Stalvey, Roenker, Sloane, and Graves (1998): No relationship between avoidance score and crashes in subsequent 3 yrs. Hennessy (1995): poorer divided attention ability was significantly associated with greater avoidance of driving at night, rain, dusk, dawn, alone, left turns, and heavy traffic, but the predictive value of the divided attention subtask of UFOV on crash rate (prior 3 yrs) was not mediated by any of the forms of self restriction. De Raedt and Ponjaert-Kristoffersen (2000): poor performers on a road test who were free of (self-reported) at-fault crashes in the prior 12-mo period used significantly more strategic compensation tactics (avoidance of challenging situations) than poor performers with a history of at-fault crashes. Owsley et al. (1998) found that older drivers with UFOV reduction of 40% or more and who reported driving fewer than 7 days per week had a 45% decreased crash risk compared to older drivers with a 40% or more reduction in UFOV who reported driving 7 days/week.	Panelists indicate this may or may not be effective; "we don't know if this works." People try to self-regulate when there are alternative transportation options, but there are times when they "must" drive even if they'd rather not (e.g., winter when it gets dark earlier, or no other driver to take them). Making people aware of deficits is the first step in getting people to self restrict, if they will self restrict.
Speed of processing training	Roenker et al. (2003): Speed of processing training using all 3 subtests of UFOV compared to Doron simulator training and untrained reference group. Global ratings of on-road driving performance improved for both training groups, but only SOP group maintained performance at 18 mo. Lane change performance of SOP group remained constant from baseline to both post tests; simulator group's lane change performance fell from baseline to 18-mo follow-up, reference group's lane change performance fell at immediate post test but returned to baseline level at 18-mo follow-up. No difference between 3 groups on lane change performance at baseline.	Panelists agreed this may be a viable countermeasure, but there is a need to establish the link between training on task and transfer to driving.
Physical aerobic activity/training	Marmeleira, Godinho, and Fernandes (2008) found that a 12-week exercise program with 3, 60-min sessions per week improved visual attention in speed of processing and divided attention (using the UFOV protocol) at 12 weeks follow-up in adults ages 60 to 81. The intervention incorporated perceptual and cognitive tasks (problem solving and responding to challenging situations) with aerobic activity. Examples are: walking while listening for auditory cues to perform fast and specific psychomotor responses). At 12 weeks, speed of processing and divided attention were significantly improved compared to baseline for the exercise group; at baseline, there was no difference between groups. Actual driving performance was not studied, and there was no exercise-only group to determine the contribution of physical activity alone on speed of processing or divided attention.	Research article provided by panelist following meeting; panelists did not get to comment on countermeasure for deficit. Merits further research.

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: DIVIDED ATTENTION		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) found no difference in crash rate during 2 year follow up period for drivers with 40% or more reduction in UFOV or a visual acuity deficit (20/30 to 20/60) in an educational intervention group ("Knowledge Enhances Your Safety") who reduced their overall exposure and avoided driving at night, in the rain, in rush hour, and made right turns around the block to avoid left turns across traffic. Avoidance and exposure were self-reported, so social desirability may have been operative; or restriction was not frequent enough to be protective. Also, crash type was not restricted to at-fault in the study.	Panelists state all 3 types of education may be useful for divided attention deficits; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Collision warning systems	To avoid hitting leading vehicle while looking for gap in traffic approaching from behind on mainline. Maltz et al. (2004): older drivers benefited from use of headway and detection alerting device.	Suggested by panelists as countermeasure that merits further research. Need forward as well as side-collision warning. Would be helpful if it caused the vehicle to brake, in addition to providing a warning. Concern is with complete reliance on the technology to detect hazards (especially for backing up) where older drivers back up without doing head/shoulder checks and have backed into (and killed) pedestrians. Also elderly people may be more distracted rather than assisted by some of the advanced technologies. And, most rehab center's adapted cars are not high-end/high tech, so it would be difficult for OTs to train people in the use of the technologies.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.
Cognitive rehab (including memory training) for normally aging population	OTs noted that there are protocols and treatments for retraining attention, but cognitive rehab literature shows efficacy of attentional therapy in the broader rehab area ("Society for Cognitive Rehab"). It doesn't directly address driving, but builds subskills for the driving task.	Panelists indicate this is building subskills for the driving task. An OT panelist noted that you cannot just do a lot of the cognitive retraining tasks and assume that it will generalize to driving. You need to make that part of the therapy program. Countermeasure has tremendous promise but it is just in its infancy for developing the training protocols, and making sure it is appropriate. There is a real need for good research to make sure that we use this appropriately.
Compensatory cognitive/memory training for impaired/MCI population	Klavora et al. (1995) conducted a before-after study with 10 stroke patients with visual and attentional difficulties and rated unsafe to drive. Following training with a Dynavision apparatus, 6 of 10 participants earned a rating of "safe to resume driving and/or to receive on-road driving lessons."	Panelists were cautious about recommending cognitive interventions for people with early stage dementia, and indicated that strategies must be compensatory rather than restorative for this group.

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: WORKING MEMORY

Associated Driver Performance Errors

- Better working memory performance (5 sets of additions, where each set included 3, 2-digit numbers) was associated with larger gaps selected, in a simulator study of left turns across oncoming traffic (Guerrier et al., 1999).
- Lee, Lee, Cameron, and Li-Tsang (2005) found that poor performance on a working memory task by older drivers (ages 60-88) during simulated driving was significantly associated with self-reported crashes in the prior 1-year period.
- Hunt, Morris, Edwards, and Wilson (1993) found a significant correlation between pass/fail outcome on a road test and performance on the Logical memory subscale of the Wechsler Memory Scale (assessing immediate and delayed recall).
- Szlyk, Myers, Zhang, Wetzel, and Shapirio (2002) found that older drivers with poor performance on several measures of working memory had poorer performance in a driving simulator (drove at slower speed, and had more lane boundary crossings) than drivers with better performance on the working memory tasks.
- Panelists indicated a working memory deficit could be associated with the following critical driver performance errors: #2 gap judgment errors; #3 inability to predict the development of future conflicts from current traffic and contextual information.

Included Behavioral Countermeasures

- Physical aerobic/activity training
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Medical management (incl. pharmacy review)
- Cognitive rehab (incl. memory training) for normally aging population
- Compensatory cognitive/memory training for impaired/MCI population
- Pre-trip planning

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: WORKING MEMORY		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Physical aerobic activity/training		Panelists indicated this countermeasure merits further research for remediation of working memory deficits, stating a large body of research showing aerobic exercise results in alertness--hippocampul regeneration.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)		Panelists state all 3 types of education may be useful for working memory deficits; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.
Cognitive rehab (including memory training) for normally aging population	OTs noted that there are protocols and treatments for retraining attention, but cognitive rehab literature shows efficacy of attentional therapy in the broader rehab area ("Society for Cognitive Rehab"). It doesn't directly address driving, but builds subskills for the driving task. Laderman, Szlyk, Kelsch, and Seiple (2000) found improvement in visual memory (remembering store names subjects had walked past) after practice in the laboratory recalling sequences of numbers, letters, and shapes presented briefly on 35-mm slides.	Panelists indicate this is building subskills for the driving task. An OT panelist noted that you cannot just do a lot of the cognitive retraining tasks and assume that it will generalize to driving. You need to make that part of the therapy program. Countermeasure has tremendous promise but it is just in its infancy for developing the training protocols, and making sure it is appropriate. There is a real need for good research to make sure that we use this appropriately.
Compensatory cognitive/memory training for impaired/MCI population		Panelists were cautious about recommending cognitive interventions for people with early stage dementia, and indicated that strategies must be compensatory rather than restorative for this group.
Pre-trip planning		Countermeasure suggested by panelists as meriting further research

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: EXECUTIVE FUNCTION (JUDGMENT/DECISION-MAKING)

Associated Driver Performance Errors

- Age-related declines in executive control function include planning, scheduling, working memory, inhibitory processes, and multi-tasking.
- Association between poor performance on Trails B Test (a measure of executive function) and retrospective (Stutts et al., 1998; Goode et al., 1998; Daigneault et al., 2002) and prospective state-recorded crashes (Staplin et al., 2003) and poor simulator (Rizzo et al., 1997; Szlyk et al., 2002)) and on-road performance (Tarawneh et al., 1993), although type of crash not specified.
- Poor performance on a maze test (also measures executive functioning) was correlated with road test failure (Snellgrove, 2005; Ott et al., 2008).
- Panelists indicated that an executive function deficit could be associated with the following critical driver performance errors: #2 gap judgment errors; #3 inability to predict development of future conflicts; #4 slowed vehicle control response; #5 inadequate visual search; and #6 slowed decision making.

Included Behavioral Countermeasures

- Physical aerobic/activity training
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Medical management (incl. pharmacy review)
- Cognitive rehab (incl. memory training) for normally aging population
- Compensatory cognitive/memory training for impaired/MCI population
- Pre-trip planning

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: EXECUTIVE FUNCTION (JUDGMENT/DECISION-MAKING)		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Physical aerobic activity/training	No studies on improvement in driving, however, Colcombe and Kramer (2003) found the largest positive effects of fitness training and cognitive functioning in older (non-demented) adults was on executive control processes. Programs combining aerobic training with strength and flexibility training had the largest effects. Conflicting evidence was found by Marmeleira, Godinho, and Fernandes (2008); an exercise program incorporating walking with cognitive and perceptual tasks resulted in no improvement on tests of executive function (Stroop or Trails B) from baseline to 12-weeks post intervention.	Panelists indicated this may be an appropriate countermeasure for deficits in executive function, but requires further research. A panelist mentioned that the literature in the area of exercise and cognitive function is mixed, with some studies showing improvement and others showing no effect. One problem with the research may be that the exercise interventions are too brief to result in an improvement.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)	Marottoli (2007): AAA Safe Driving for Mature Operators presented in 2, 4-hour sessions with supplemental topics (including search strategies for intersections), plus 2, 1-hour on-road driving sessions focused on common errors made by older persons. On road performance assessed at baseline and 8 weeks post-intervention included 31 T-type intersections and 32 crossing intersections. There were 15 right turns, 12 merges, and several opportunities for right turns on red. Post-test scores were significantly higher than baseline, translating to 9.5% decrease in crash risk over 2-year period. The items showing the most improvement included scanning to the rear, lane selection, right turns, and judgment. Eby, Molnar, Shope, Vivoda, and Fordyce (2003). Driving Decisions Workbook (a self assessment tool) was effective in increasing older drivers' awareness of changes in driving abilities related to aging, and effects of changes on driving. Participants stated they would seek 2nd tier assessment and change driving habits. Skufca (2008): AARP DSP participants indicated course encouraged them to change certain driving behaviors (20% indicated avoiding left turns as a new behavior).	Panelists state all 3 types of education may be useful for deficits in executive functioning; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.
Cognitive rehab (including memory training) for normally aging population		Panelists indicate this is building subskills for the driving task. An OT panelist noted that you cannot just do a lot of the cognitive retraining tasks and assume that it will generalize to driving. You need to make that part of the therapy program. Countermeasure has tremendous promise but it is just in its infancy for developing the training protocols, and making sure it is appropriate. There is a real need for good research to make sure that we use this appropriately.
Compensatory cognitive/memory training for impaired/MCI population		Panelists were cautious about recommending cognitive interventions for people with early stage dementia, and indicated that strategies must be compensatory rather than restorative for this group.
Pre-trip planning		Countermeasure suggested by panelists as meriting further research.

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: SPATIAL ABILITIES

Associated Driver Performance Errors

- Errors in distance judgment and difficulty predicting the development of traffic situations (Johansson & Lundberg, 1997).
- Poor performance on clock-drawing test (a measure of visuospatial functioning) accounted for 38% of the variance in road test performance in sample referred for fitness to drive assessment (excluded persons suspected of dementia or cognitive decline); Specific errors not described in correlational analysis (De Raedt & Ponjaert-Kristoffersen, 2001).
- Impaired pentagon copying performance was associated with adverse driving events (crashes, violations), but type not specified (Marottoli et al., 1994). Poor performance on the MVPT Visual Closure subscore was associated with crashes (type not specified) in 20-month follow-up period (Staplin et al., 2003), and on poor road test performance (Tarawneh et al., 1993).
- Older, crash-involved subjects with suspended licenses performed worse on tests of visuospatial abilities than older non-crash-involved drivers with suspended licenses, and older drivers with clean records. A main violation type leading to crashes and suspensions included failure to yield the right of way (Lundberg et al., 1998).
- Poor performance on tests of spatial ability (Rey-Osterreith Complex Figures and Wechsler Memory Scale) discriminated crash-involved from crash-free drivers in prior 5-year period (Goode et al., 1998).
- Panelists indicated that a deficit in spatial abilities could be associated with the following critical driver performance errors: #2 gap judgment errors; #3 inability to predict the development of future conflicts; #5 inadequate visual search/improper lookout; and #6 slowed decision making

Included Behavioral Countermeasures

- Visual perceptual therapy
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Medical management (incl. pharmacy review)

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: SPATIAL ABILITIES		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Visual perceptual therapy	McCoy et al. (1993): Evaluated workbook exercises to improve visual perception in 5 areas: spatial relationships, visual discrimination, figure ground, visual closure, and visual memory. Before-after on-road driving performance (DPM technique) improved by 7.7 percentage points, compared to no improvement in control group.	Panelists indicated this countermeasure merits further research for remediation of deficits in spatial abilities.
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)		Panelists state all 3 types of education may be useful for deficits in spatial abilities; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. OTs note that if there is a serious deficit, driving should be ruled out. Spatial abilities deficits manifest themselves in lane control difficulty. They will start with easy situations and progress to more difficult situations if there is improvement. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: ATTENTION/COGNITION

SPECIFIC DEFICIT: KNOWLEDGE

Associated Driver Performance Errors

- Lack of knowledge about how to aim mirrors to eliminate blind spot, lack of awareness of importance of using head turns to verify presence/absence of approaching traffic, and for gap judgment.
- Panelists indicated a knowledge deficit could be associated with the following critical driver performance errors: #3 inability to predict the development of future conflicts; #8 lack of understanding or failure to apply safe driving practices.

Included Behavioral Countermeasures

- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)
- Medical management (incl. pharmacy review)
- Pre-trip planning

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: KNOWLEDGE		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Driver safety education (Theory/Classroom)	Skufca (2008): AARP DSP participants indicated course encouraged them to change certain driving behaviors, specifically: always checking blind spots (74%) , paying more attention when exiting or entering highways (49%), yielding the right of way (44%), and limiting travel on freeways (18%) as a consequence of information learned. Kutner (2006): No difference in crash rate (self reported) in prior 12-month period for AARP Driver Safety program participants and comparison group of not-AARP DSP participants. Bedard et al. (2004). Canadian Safety council adaptation of AARP DSP evaluated for treatment and comparison group using an on-road evaluation at baseline and post-treatment. On-road evaluation scores improved significantly for treatment and control group from baseline to post-intervention; no significant difference between treatment and comparison group on mean change score from the first to second evaluation. Janke (1994). Completion of Mature Driver Improvement Program was associated with more total fatal injury crashes and fewer citations compared with group who did not attend course. Eby, Molnar, Shope, Vivoda, and Fordyce (2003). Driving Decisions Workbook (a self assessment tool) was effective in increasing older drivers' awareness of changes in driving abilities related to aging, and effects of changes on driving. participants stated they would seek 2nd tier assessment and change driving habits; no evaluation on whether drivers followed through on these plans. McCoy et al. (1993). Completion of AAA Safe Driving for Mature Operators was associated with a significant increase in on-road driving performance (baseline and post intervention road test using DPM technique) of 3.7 percentage points. Education plus physical therapy increased score by 8.7 percentage points; education plus perceptual therapy increased score by 13.9 percentage points. Nasvadi and Vavrik (2007). Evaluation of British Columbia Safety Council adaptation of AARP DSP comparing police-reported at-fault crash and violation rate for participants vs. non-participants in prior 2-year period, to determine whether self-selection bias exists for those who attend remedial safety courses. Significantly more participants than controls had crashed, but there was no difference in violation rate. A follow-up comparison of crash rate for subsequent 2-year period for attendees and controls with matched pre-course crash rate showed that more attendees had crashes than non-attendees, but the difference was not significant. However, when stratifying by age group and gender, males age 75+ who attended the course were 3.8 times more likely to be involved in a crash than controls who did not attend class. No difference in crash rate for men ages 55-74 or women ages 55-74 and those 75+. Porter et al. (2005) Older drivers with adequate flexibility to turn their head to look over their shoulder (study involved backing maneuver only) often rely on a mirror check only, indicating a need for education on the proper procedures for backing (findings could translate for lane change maneuver).	General consensus that it makes sense to provide education, even if it isn't adequate; people will be people, and it may work for some and not others. Education (theory) alone may never be enough; may need to be coupled with skills training.

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: KNOWLEDGE		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Driver safety education (Theory + BTW)	Marottoli (2007): AAA Safe Driving for Mature Operators presented in 2, 4-hour sessions with supplemental topics (including lane change strategies, blindspots, mirrors, head checks, and signaling), plus 2, 1-hour on-road driving sessions focused on common errors made by older persons. On road performance assessed at baseline and 8 weeks post-intervention. Post-test scores were significantly higher than baseline, translating to 9.5% decrease in crash risk over 2-year period. The items showing the most improvement included scanning to the rear, lane selection, right turns, and judgment. Bedard et al. (2008): Significant improvement in knowledge, and significantly fewer instances of failing to check traffic when changing lanes for the intervention group, compared to the control group.	General consensus that it makes sense to provide education, even if it isn't adequate; people will be people, and it may work for some and not others. Education (theory) alone may never be enough; may need to be coupled with skills training.
Driver safety education (Interactive/computer-based)		Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)		Panelists state that vehicles have safety features but many need to be adjusted, and older drivers don't know how to do this. Education about driving aids is a positive theme to staying on the road longer. Countermeasure merits further research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients.
Pre-trip planning		Countermeasure suggested by panelists as meriting further research

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: PHYSICAL/PSYCHOMOTOR

SPECIFIC DEFICIT: HEAD/NECK/TRUCK RANGE OF MOTION

Associated Driver Performance Errors

- Difficulty turning head to left to look for gap in approaching traffic (and failure to detect potential conflict vehicles, or to detect them at safe maneuvering distance).
- Impaired ability to turn head to check over shoulder significantly predicted at-fault crashes in 20-month follow up period (Staplin et al., 2003).
- Limited range of motion of neck is significantly associated with adverse driving events (self reported, prior 5 years) (Marottoli et al., 1998).
- Range of motion significantly associated with pass/fail performance on road test (McCarthy & Mann, 2006).
- Crash-involved older drivers were 1.25 times more likely to have medical diagnosis of joint/spine disorders in 2-yr period prior to crash than non-crash-involved controls (Cui, 2001).
- Self-reported health symptoms relating to spine and lower body (limited strength or movement, lack of feeling or sensation, involuntary movement, chronic pain) related to self reported driving difficulties, and lack of physical activity related to difficulty with shoulder checking (Tuokko et al., 2007).
- Panelists indicated a deficit in head/neck trunk range of motion could be associated with the following critical driver performance errors: #1 failure to visually detect potential conflicts, hazards, or traffic control information; #4 slowed vehicle control response.

Included Behavioral Countermeasures

- Training in compensatory head/eye movements, scanning strategies
- Physical aerobic/activity training
- Strength and flexibility exercises
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)
- Collision warning systems
- After-market, non-planar driver-side mirror
- Medical management (incl. pharmacy review)

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: HEAD/NECK/TRUNK RANGE OF MOTION		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Training in compensatory head/eye movements, scanning strategies		Panelists agreed that this is an appropriate countermeasure, but candidates must be cognitively intact. This type of training has been used for telescopic and amorphic-lens drivers ("search and destroy" method) and has been effective in improving peripheral visual detection.
Physical aerobic/activity training	May be research from Art Kramer at the University of Illinois looking at physical exercise programs and driving (simulator).	Merits further research.
Strength and flexibility exercises	Ostrow et al. (1992). 8-wk exercise program: chin flexion/extension, neck rotations, head side bending, chin tucks, rotating shoulders backward, trunk rotations. Significant .improvements in trunk rotation and shoulder flexibility across experimental subjects' 3 testing sessions (baseline, 8 and 11 weeks). Subjects in experimental group showed improvements in field-based assessment of driving skill: looked more frequently to the sides and rear of their vehicle than control drivers who did not participate in program. Marottoli et al. (2007) 12 week, in-home exercises 15 minutes daily, 7 days/week, with weekly in-home visit by physical therapist. Exercises focused on axial/extremity condition, upper extremity coordination/dexterity, and gait abnormalities. On-road driving performance measured at baseline and post-intervention for treatment and control group. Significant improvement for treatment group compared to control group translated to 8 to 16 percent lower crash occurrence over 2 year period. Intervention group also made 37% fewer critical errors (inattention, turning or changing lanes w/o looking, disobeying signs/signals) than control group at follow up. McCoy et al. (1993): Home-based exercises designed to improve posture, trunk rotation, neck flexibility, shoulder flexibility. 1-hour training session followed by 8 weeks of exercise, 4 times per week. Post intervention On-road drive test performance improved by 6.8 percentage points (significant), and when physical therapy was combined with driver education, improvement increased by 8.7 percent.	Panelists agreed that this is an appropriate countermeasure
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)		Panelists state all 3 types of education may be useful for deficits in head/neck/trunk range of motion; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: HEAD/NECK/TRUNK RANGE OF MOTION		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)		Panelists state that vehicles have safety features but many need to be adjusted, and older drivers don't know how to do this. Education about driving aids is a positive theme to staying on the road longer. Concern about liability for re- aiming mirrors for drivers during CarFit; OTs put the mirrors back to their original position when the drivers arrive at the evaluation. Countermeasure merits further research.
Collision warning systems	Oxley and Mitchell (1995): collision warning system tested in a simulator was effective in preventing older drivers from turning across traffic through gaps that were dangerously short.	Suggested by panelists as countermeasure that merits further research. Need forward as well as side-collision warning. Would be helpful if it caused the vehicle to brake, in addition to providing a warning.
After-market, non-planar driver-side mirror	No research on "bulls eye" convex mirror affixed to standard planar mirror, however Staplin et al. (1998) found that approx 13% of older driver sample in laboratory simulator study made unsafe gap acceptance judgments to change lanes in front of an adjacent-lane vehicle overtaking at 25 mi/h differential while using full-sized non-planar mirrors. Also one-third of sample indicated sole reliance on mirror when changing lanes. De Vos (2000): older drivers look over their shoulders less frequently than younger drivers when changing lanes. Drivers accept smaller gaps when using non-planar mirrors, due to image minification.	Panelist OTs concerned that the recommendation could be a liability, but merits further research. Even aiming mirrors for drivers during CarFit is a liability and OTs put the mirrors back to their original position when the drivers arrived at the evaluation. Non-planar mirrors would require optical distortion training, and there is currently no standard of care.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients. Impairments in psychomotor functioning may result from musculoskeletal disease leading to weakening, frailty, and/or restricted range of motion. Medical management of arthritis is important.

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: PHYSICAL/PSYCHOMOTOR

SPECIFIC DEFICIT: ARM STRENGTH/RANGE OF MOTION/SPEED OF MOVEMENT

Associated Driver Performance Errors

- Older women with difficulty extending arms above their shoulders had increased crash risk (Hu et al., 1998).
- Difficulty reaching out was significantly associated with crashes in prior 6 years (Sims et al., 1998). Crash type not specified in research studies.
- Range of motion significantly associated with pass/fail performance on road test (McCarthy & Mann, 2006).
- Panelists indicated a deficit in arm strength/range of motion/speed of movement could be associated with slowed vehicle control response (critical driver performance error #4).

Included Behavioral Countermeasures

- Physical aerobic/activity training
- Strength and flexibility exercises
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)
- Medical management (incl. pharmacy review)

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: ARM STRENGTH/RANGE OF MOTION/SPEED OF MOVEMENT		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Physical aerobic activity/training	May be research from Art Kramer at the University of Illinois looking at physical exercise programs and driving (simulator).	Merits further research.
Strength and flexibility exercises	Marottoli et al. (2007) 12 week, in-home exercises directed by physical therapist focusing on axial/extremity condition, upper extremity coordination/dexterity, and gait abnormalities. On-road driving performance was measured at baseline and post-intervention for treatment and control group. Significant improvement for treatment group compared to control group translated to 8 to 16 percent lower crash occurrence over 2 year period. Intervention group also made 37% fewer critical errors (inattention, turning or changing lanes w/o looking, and disobeying signs or signals) than control group at follow up.	Panelists agreed that this is an appropriate countermeasure
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)		Panelists state all 3 types of education may be useful for deficits in arm strength/range of motion/speed of motion; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)		Panelists state that vehicles have safety features but many need to be adjusted, and older drivers don't know how to do this. Education about driving aids is a positive theme to staying on the road longer. Countermeasure merits further research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients. Impairments in psychomotor functioning may result from musculoskeletal disease leading to weakening, frailty, and/or restricted range of motion. Medical management of arthritis is important.

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: PHYSICAL/PSYCHOMOTOR

SPECIFIC DEFICIT: LEG STRENGTH/RANGE OF MOTION/SPEED OF MOVEMENT

Associated Driver Performance Errors

- Slow acceleration or failure to maintain speed when changing lanes, resulting in shorter time to collision with approaching vehicle.
- Poor performance on rapid pace walk is associated with adverse driving events (Crashes, violations) (Marottoli et al., 1994; Staplin et al., 2003), and pass/fail performance on road test (McCarthy & Mann, 2006).
- Range of motion significantly associated with pass/fail performance on road test (McCarthy & Mann, 2006).
- Older drivers reporting pain in the feet, hips, legs, or current treatment for arthritis had significantly slower brake reaction speeds (both initial reaction and physical response speed) than drivers with no complaints of pain in these areas (Zhang et al., 2007).
- Panelists indicated a deficit in leg strength/range of motion/speed of movement could be associated with slowed vehicle control response (critical driver performance error #4).

Included Behavioral Countermeasures

- Physical aerobic/activity training
- Strength and flexibility exercises
- Driver safety education (theory/classroom)
- Driver safety education (theory + BTW)
- Driver safety education (interactive/computer-based)
- Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)
- Medical management (incl. pharmacy review)

CRASH TYPE 5: Lane change on multilane (4+) roadway.

GENERAL DEFICIT: ATTENTION/COGNITION SPECIFIC DEFICIT: LEG STRENGTH/RANGE OF MOTION/SPEED OF MOVEMENT		
Behavioral Countermeasure	**Countermeasure Evaluation(s)?**	**Commentary**
Physical aerobic activity/training	May be research from Art Kramer at the University of Illinois looking at physical exercise programs and driving (simulator).	Merits further research.
Strength and flexibility exercises	Marottoli et al. (2007) 12 week, in-home exercises directed by physical therapist focusing on axial/extremity condition, upper extremity coordination/dexterity, and gait abnormalities. On-road driving performance was measured at baseline and post-intervention for treatment and control group. Significant improvement for treatment group compared to control group translated to 8 to 16 percent lower crash occurrence over 2 year period. Intervention group also made 37% fewer critical errors (inattention, turning or changing lanes w/o looking, and disobeying signs or signals) than control group at follow up.	Panelists agreed that this is an appropriate countermeasure
• Driver safety education (Theory/Classroom) • Driver safety education (Theory + BTW) • Driver safety education (Interactive/computer-based)		Panelists state all 3 types of education may be useful for deficits in arm strength/range of motion/speed of motion; raises awareness of deficit so they can self restrict. Education by OT may be a reimbursable intervention. Education alone may never be enough; may need to be coupled with skills training. OTs use commentary driving and building skills through progressively more challenging situations. Interactive/computer-based driver education was added by panelists as an outgrowth of the discussions on classroom/theory driver education and on-road/behind the wheel driver training. It is an emerging application that needs more research.
Education about driving aids (CarFit, features/adaptive equipment, shoes, etc)		Panelists state that vehicles have safety features but many need to be adjusted, and older drivers don't know how to do this. Education about driving aids is a positive theme to staying on the road longer. Countermeasure merits further research.
Medical management (incl. pharmacy review)		Suggested by panelists. Leads to early detection of impairments and remediation. Provide education to physicians, pharmacists, and eyecare specialists linking medical conditions to functional impairments and driving risk so they can educate their patients. Impairments in psychomotor functioning may result from musculoskeletal disease leading to weakening, frailty, and/or restricted range of motion. Medical management of arthritis is important.

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