



**AOTA Critically Appraised Topics and Papers Series**  
**Driving and Community Mobility  
for Older Adults**

*\*A product of the American Occupational Therapy Association's  
Evidence-Based Literature Review Project*

**CRITICALLY APPRAISED TOPIC (CAT)**

***Focused Question #3***

**What is the evidence for the effect of automobile-related modifications on the driving ability, performance, and safety of the older adult? Modifications include changes by the industry that enhance or hinder the driving ability, performance, and safety of the older adult.**

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**Clinical Scenario:**

The car occupies an important place in the lifestyle of the older adult. It has been reported that older adults make 85% of trips outside the home either as a passenger or driver of a car (Rosenbloom, 2004). According to Rosenbloom (2004) and Vladeck (2005), a car is convenient and allows the older adult to have easy access to out-of-home occupations and daily activities. Since the car holds a central place in older adult driving and community mobility, it is necessary for the occupational therapist and occupational therapy assistant working in practice, education, and research to understand the evidence related to the car and the implications on occupational performance and ability to participate in the community. As cars become increasingly complex and at the same time more automatic, one needs to be cognizant of the research related to safety and performance features that either may be available commercially or are in development. In addition, it is important to understand if the ability and interest in using these features differ between older and younger drivers. Occupational therapy practitioners can use this information when making recommendations to older adults regarding adaptations to their existing cars or purchase of an appropriate new vehicle. In addition, the results of this review are useful for researchers interested in studying older adult driving.

**Summary of Key Findings:**

Summary of Levels I, II, and III

There were 2 categories of evidence resulting from the systematic review. The first category included 7 studies that examined modifications made to an automobile to determine if they improve visibility and driving. Four were Level I studies and 3 used a

Level II design. The categories are those studies that examined modifications to improve visibility and driving performance as well as studies related to adaptive equipment.

Adaptive equipment includes both lower technology adaptive equipment as well as the higher technology Intelligent Transportation Systems (ITS). ITS includes in-vehicle navigation systems, heads-up displays, visual enhancement systems that enable the driver to see critical hazards, adapted cruise control that adjusts to speed and distance to vehicle ahead set by the driver, and collision avoidance systems that use sensors to monitor vehicle surroundings.

- Older adults need a longer period of time to become familiar with the controls in an unfamiliar vehicle than younger drivers. This extended period of time is needed to become comfortable with regularly and infrequently used controls (Laux, 1991—Level I).
- Older adults can read an instrument panel with larger characters more easily than one with small characters. Brightness of the instrument panel is of importance for older adults only when smaller characters are used (Imbeau et al., 1989—Level II).
- There is good evidence that aftermarket window tinting reduces visibility for older adults (Freedman, Zador, & Staplin, 1993—Level I; LaMotte et al., 2000—Level II).
- There is no benefit of hydrophobic treatments that repel water from windows and outside car mirrors for older and younger drivers (Sayer et al., 1999—Level II).
- There is good evidence from a Level I study (Schumann et al., 1997) that small windshield rake angle and low dashboard reflectance can be helpful to reduce veiling glare from reflected sunlight that can be superimposed on the image of a road scene when driving.

The second category of results included studies related to adaptive equipment. While no studies evaluating lower technology adaptive equipment were located as a result of the search, there were 15 studies that examined the effect of ITS on the driving performance of older adults, including in-vehicle navigation systems, heads-up displays, visual enhancement systems that enable the driver to see critical hazards, adapted cruise control that adjusts to speed and distance to a vehicle ahead, and collision avoidance systems that use sensors to monitor vehicle surroundings. Six of the studies were Level I, 7 were Level II, and 2 had Level III research designs.

- The evidence for the use of ITS is inconclusive. This inconclusiveness has been observed, for example, in studies examining Vision Enhancement Systems (VES) that provide enhanced visual contrast to drivers (Caird, Horrey, & Edwards, 2001 Level I randomized controlled trial; Gish, Staplin, & Perel, 1999 Level II nonrandomized mixed factor design).
- There is evidence that ITS is effective in promoting driving performance of older adults. In studies evaluating the effect of heads-up displays (HUD, a display that presents data without blocking the driver's view), Mollenhauer, Dingus, & Hulse (1995—Level II nonrandomized mixed factor) report more correct turns using HUD. Steinfeld and Green (1995—Level I RCT) report shorter response time using HUD. Research by Wolffsohn et al. (1997—Level II nonrandomized mixed factor) indicates that response time using HUD increases as the cognitive demands of a driving task increase, for example in the difference between day and night driving.

- Older adults report that they would use some ITS equipment. While older adults report, for example, that they would be likely to use driving defense detection equipment (De Waard, Hulst, & Brookhuis, 1999—Level II nonrandomized mixed factor) and adapted cruise control (Fancher et al., 1998—Level II pretest-posttest), other research indicates that older adults would more cautiously accept VES (Gish et al., 1999—nonrandomized mixed factor) and were less likely to use Tetra Star, an advanced-traveler information system, for commuting (Kostyniuk et al., 1997—pretest-posttest).
- Simpler is better than more complex versions of ITS in reducing the cognitive demands of driving. Dingus, McGhee et al. (1997) in a Level II nonrandomized mixed factor design reported, for example, that turn-by-turn information as opposed to full route information is better for older adults using route guidance. Older adults also did better when there was redundancy of information, such as when both auditory and visual information is presented to the driver.

#### Summary of Levels IV and V

Not included in review

#### Contributions of Qualitative Studies:

Not included in review

#### Bottom Line for Occupational Therapy Practice:

The results of the systematic review point to the complex nature of the relationship between the older driver and the car. Visibility, cognitive load, cost, satisfaction, and physical impact of modifications to the car all need to be considered when working with older adult drivers during both the assessment and intervention component of the occupational therapy process.

Occupational therapists and occupational therapy assistants can utilize this information to provide appropriate automobile-related adaptive equipment as necessary to older adults to improve driving performance and safety. In addition, results can be used not only to advocate to payers to provide coverage for automobile-related modifications, but also for occupational therapists and occupational therapy assistants to advocate on state, local, and national levels for appropriate car design for older adults. This advocacy can include working with the car manufacturers to develop cars that meet the needs of older adults.

In addition, occupational therapy educators can include curriculum content on automobile-related modifications, such as the public health impact of driving and community mobility for older adults. Curricula should also include information on adaptive equipment for older adults, the interaction of older adults with selected features of cars, and the impact of that interaction on driving ability, performance, and safety. Content on local, state, and national advocacy for appropriate car design for older adults can also be included in educational curricula.

**Review Process:**

Procedures for the selection and appraisal of articles

**Inclusion Criteria:**

<ul style="list-style-type: none"> <li>• Peer-reviewed journals from 1980 to 2004</li> <li>• Evidence-based reviews (e.g., Cochrane Database of Systematic Reviews)</li> <li>• Published reports (e.g., Transportation Review Board)</li> </ul>	
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**Exclusion Criteria:**

<ul style="list-style-type: none"> <li>• Level IV and Level V studies</li> <li>• Dissertations</li> <li>• Conference proceedings</li> </ul>
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*Search Strategy*

<b>Categories</b>	<b>Key Search Terms</b>
Patient/Client Population	Elderly, Older Driver, Aging, Automobile Driver
Intervention	Automobiles, Traffic Safety, Automotive Engineering, Automobile Driver Simulators, Headlights, Braking, Vision Aids, Glare, Sensory Aids, Instrument Displays
Comparison	Experimental design
Outcomes	Not included in search

<b>Databases and Sites Searched</b>
PubMed (MEDLINE)
TRIS Online
Ergonomics Abstracts
PsycINFO
Society for Automotive Engineers (SAE)
EiCompendex Engineering
EiCompendex Plus
Hand searching of bibliographies of selected articles

### Quality Control/Peer-Review Process:

- Coordinator of project developed search terms in consultation with authors of each question and advisory group.
- A medical research librarian conducted all searches to confirm and improve search strategies.
- Medical librarian and coordinator of project discussed the searches and findings, to ensure that key articles or areas of research had not been overlooked.
- The question author, in conjunction with a graduate student, completed the CAP worksheet for each article that met the inclusion criteria. The coordinator of the project then reviewed the articles and the completed CAPs to look for unanswered questions and discrepancies in interpretation of the results and to ensure that the implications were clear.
- The CAT was written by the author of the question and the coordinator of the project. It was then reviewed by AOTA staff and a content expert in occupational therapy and older drivers and community mobility.

### Results of Search:

#### *Summary of Study Designs of Articles Selected for Appraisal*

Level of Evidence	Study Design/Methodology of Selected Articles	No. of Articles Selected
I	Systematic reviews, meta-analysis, randomized controlled trials	10
II	Two groups, nonrandomized studies (e.g., cohort, case-control)	10
III	One group, nonrandomized (e.g., before and after, pretest, and posttest)	2
IV	Descriptive studies that include analysis of outcomes (e.g., single-subject design, case series)	0
V	Case reports and expert opinion, which include narrative literature reviews and consensus statements	
	Qualitative studies	0
		TOTAL = 22

### Limitations of the Studies Appraised:

Levels I, II, and III

Limitations of the studies in the review include small sample size, lack of control group and randomization as well as limited length of follow-up. In addition, the results of studies conducted in a simulator or other experimental situations may not generalize to on-road conditions, and those studies with healthy participants may not reflect the composition of the older adult population. Also, several studies did not control for extraneous variables in the statistical analysis.

### Articles Selected for Appraisal

Allen, R. W., Stein, A. C., Rosenthal, T. J., Ziedman, D., Torres, J. F., & Halati, A. (1991). A human factors study of driver reaction to in-vehicle navigation systems. *SAE Technical Paper Series* (Paper No. 911680, pp. 83–102).

Burns, N. R., Nettlebeck, R., White, M., & Wilson, J. (1999). Effects of car window tinting on visual performance: A comparison of elderly and young drivers. *Ergonomics*, *42*(3), 428–443.

Caird, J. K., Horrey, W. J., & Edwards, C. J. (2001). Effects of conformal and nonconformal vision enhancement systems on older-driver performance (Report No. 01–0479). *Transportation Research Record*, *1759*, 38–45.

De Waard, D., Hulse, M., & Brookhuis, K. A. (1999). Elderly and young drivers' reaction to an in-car enforcement and tutoring system. *Applied Ergonomics*, *30*, 147–157.

Dingus, T. A., Hulse, M. C., Mollenhauer, M. A., Fleischman, R. N., McGhee, D. V., & Manakkal, N. (1997). Effects of age, system experience, and navigation technique on driving with an advanced traveler information system. *Human Factors*, *39*(2), 177–199.

Dingus, T. A., McGhee, D. V., Manakkal, N., Jahns, S. K., Carney, C., & Hankey, J. M. (1997). Human factors field evaluations of automotive headway maintenance/collision warning devices. *Human Factors*, *39*(2), 216–229.

Fancher, P., Ervin, R., Sayer, J., Hagan, M., Bogard, S., Bareket, Z., Mefford, M., & Haugen, J. (1998). *Intelligent Cruise Control Field Operational Test* (Final Report) (Report No. UMTRI–98–17). Ann Arbor: University of Michigan Transportation Research Institute.

Freedman, M., Zador, P., & Staplin, L. (1993). Effects of reduced transmittance film on automobile rear window visibility. *Human Factors*, *35*(3), 535–550.

Gish, K. W., Staplin, L., & Perel, M. (1999). Human factors issues related to use of vision enhancement systems. *Research on Intelligent Transportation Systems, Human Factors, and Advanced Traveler Information System Design and Effects*. (Transportation Research Record 1694, Paper No. 99-0737, pp. 1–9). Washington, DC: Transportation Research Board

Imbeau, D., Wierwille, W. W., Wolf, L. D., & Chun, G. A. (1989). Effects of instrument panel luminance and chromaticity on reading performance and preference in simulated driving. *Human Factors*, *31*(2), 147–160.

Kostyniuk, L., Eby, D. W., Christoff, C., Hopp, M. L., & Streff, F. M. (1997). *The FAST-TRAC natural use leased-car study: An evaluation of user perceptions and behaviors of Ali-Scout by age and gender* (Report UMTRI-97-09). Ann Arbor: University of Michigan Transportation Research Institute.

LaMotte, J., Ridder, W., III, Yeung, K., & De Land, P. (2000). Effect of aftermarket automobile window tinting films on driver vision. *Human Factors*, 42(2), 327–336.

Laux, L. F. (1991). *Locating vehicle controls and displays: Effects of expectancy and age*. Washington, DC: AAA Foundation for Traffic Safety.

Liu, Y. C., (2001). Comparative study of the effects of auditory, visual and multimodality displays on drivers' performance in advanced traveler information systems. *Ergonomics*, 44(4), 425–442.

McKnight, J. A., & McKnight, A. S. (1992). *The effects of in-vehicle navigation information systems upon driver attention*. Washington, DC: American Automotive Association Foundation for Traffic Safety.

Mollenhauer, M. A., Dingus, T. A., & Hulse, M. C. (1995). *The potential for advanced vehicle systems to increase the mobility of elderly drivers*. Iowa City: University of Iowa Public Policy Center., University of Iowa City, IA.

Pohlmann, S., & Traenkle, U. (1994). Orientation in road traffic. Age-related differences using an in-vehicle navigation system and a conventional map. *Accident Analysis and Prevention*, 26(6), 689–702.

Sayer, J. R., Mefford, M. L., Flannagan, M. J., & Sivak, M. (1999, September). *The effects of hydrophobic treatment of the driver-side window and rearview mirror on distance judgment* (Report No. UMTRI-99-22). Ann Arbor: University of Michigan Transportation Research Institute.

Schumann, J., Flannagan, M. J., Sivak, M., & Traube, E. C. (1997). Daytime veiling glare and driver visual performance: Influence of windshield rake angle and dashboard reflectance. *Journal of Safety Research*, 28(3), 133–146.

Wolffsohn, J. S., McBrien, N. A., Edgar, K., & Stout, T. (1997). The influence of cognition and age on accommodation, detection rate, and response times when using a car head-up display (HUD). *Ophthalmic & Physiological Optics*, 18(3), 243–253.

### **Additional References**

Rosenbloom, S. (2004). Mobility of the elderly: Good news and bad news. In *Conference Proceedings 27—Transportation in an aging society: A decade of experience* (pp. 3–21). Washington, DC: Transportation Research Board.

Steinfeld, A., & Green, P. (1995). *Driver response times to full-windshield heads-up displays for navigation and vision enhancement* (Technical Report UMTRI-95-29). Ann Arbor: University of Michigan Transportation Research Institute.

Tan, A. K., & Lerner, N. D. (1995). *Multiple attribute evaluation of auditory warning signals for in-vehicle crash avoidance systems* (Report DOT HS 808 535). Washington, DC: National Highway Traffic Safety Administration, U.S. Department of Transportation.

Vladeck, B. C. (2005). Economic and policy implication of improving longevity. *Journal of the American Geriatrics Society*, 53, S304–S307.

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CAT format adapted from a template provided by Dr. Annie McCluskey and freely available for use on the OT-CATS website (<http://otcats.com>)

For more information about the Evidence-Based Literature Review Project, contact the American Occupational Therapy Association, 301-652-6611, x 2052.



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