On-road Evaluation: Its Use for the Identification of Impairment and Remediation of Older Drivers

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ABSTRACT. On-road assessment is an essential component of a comprehensive older driver evaluation. However, based on a systematic review of the older driver literature, it appears that the importance of specific elements within an on-road assessment differs depending on the following intended purpose of the evaluation: (a) the detection of impaired drivers; or (b) driver retraining. Moreover, driving rehabilitation specialists identify additional components as important. Directions for future research include the design of an on-road evaluation protocol that incorporates retraining as an integral part of the evaluation process. Through this approach, it may become clear which driving behaviors are amenable to retraining.

KEYWORDS. Driving evaluation, identification of impairment, older adults, driver retraining

INTRODUCTION

Many age-related conditions are associated with decline in cognitive abilities that may compromise one’s ability to drive safely (Anstey, Wood, Lord, & Walker, 2005; Eby, Trombley, Molnar, & Shope, 1998). Most literature related to driving assessment of older adults has focused on detecting unsafe drivers with cognitive impairment. Various groups (e.g., physicians, policy makers) have developed practice guidelines acknowledging the importance of addressing the driving practices of people with disorders that affect cognitive functioning (Dubinsky, Stein, & Lyons, 2000; Johansson & Lundberg, 1997; Patterson et al., 2001; Wang, Kosinski, Schwartzberg, & Shanklin, 2003). However,
medical conditions affecting other aspects of functioning (e.g., sensory/perceptual, physical/motor functions) may also affect driving, but perhaps in different ways.

Given the breadth of disorders that may affect driving, the Canadian Consensus Conference on Driving Evaluation in Older Drivers recommended that referral for a detailed comprehensive driving assessment is appropriate when there is uncertainty about ability to drive safely due to health-related factors (Korner-Bitensky, Gelinhas, Man-Son-Hing, & Marshall, 2005). The consensus group strongly agreed that these referrals for assessment should include, but not be limited to (a) those who have medical conditions that impact functioning (e.g., vision, hearing, musculoskeletal, mental, or neurological health); and (b) specific diagnostic groups in which driving is frequently compromised (e.g., stroke, Parkinson’s disease, mild-to-moderate dementia, cognitive decline, or diabetes with peripheral neuropathy). Regardless of the condition that may be influencing an older adult’s ability to drive safely, the reason for referral for driving assessment is typically to identify unsafe driving and to make decision regarding whether to remove the person from the road.

A less common, but appropriate group for driving assessment is older adults who are either seeking or being referred for driving retraining or remediation. Driving assessments have the potential to provide useful information about the specific driving behaviors that are making the older driver unsafe on the road and how to structure the driver retraining program to target these particular difficulties. Research on older drivers has emphasized the need for interventions to increase older driver safety. A recent systematic review of existing older driver training programs found evidence indicating that educational programs improve driver’s awareness and driving behavior, even though they do not necessarily reduce crash rates (Kua, Korner-Bitensky, Desrosiers, Man-Son-Hing, & Marshall, 2007). It has been suggested that older drivers need educational programs to teach compensatory driving strategies (De Raedt & Ponjaert-Kristoffersen, 2000) and to enhance proactive planning (Marottoli et al., 1998; Rudman, Friedland, Chipman, & Sciortino, 2006). It has been recommended that driver education programs include observations of usual on-road driving prior to and after attending the training sessions. However, few studies have investigated how on-road driving can be incorporated pre- and post-retraining in a comprehensive driver assessment and driver retraining program aimed at improving driver safety.

Given the limited research and growing concern regarding older driver safety, the purpose of this article is to examine on-road driving assessment strategies aimed at identifying (a) unsafe older drivers; and (b) older drivers requiring driver retraining. In addition, literature addressing expert opinion regarding driving assessment and retraining is examined. From the existing research, key elements of on-road evaluation will be articulated that may facilitate the development of procedures to be used to target individuals who may benefit from driver retraining and to target particular driving behaviors as the focus for driver retraining. We will also provide our insights into the usefulness and feasibility of incorporating on-road driving assessment into a comprehensive evaluation and retraining program for older drivers. An evidence-informed approach, such as this one, may prove to be an effective means of improving the safety of older adults.

**METHOD**

A systematic literature review of studies related to on-road driving assessment of older adults was conducted. The literature review focused on the existing research relevant to
on-road driving assessment, including both closed-course and open-road (i.e., in-traffic) methods. Relevant research was identified by searching online databases including Psych Info, Ageline, Medline, the Web of Science, and Transportation Research Information Services (TRIS). An Internet search was used to locate additional scientific literature via Google and Google Scholar and specific transportation research center websites. The following categories of search terms were used: (a) aging terms (e.g., older adults, older drivers, elderly, aged, and seniors); and (b) driving assessment terms (e.g., on-road driving assessment/test/evaluation/examination/track, driving errors/mistakes, fitness to drive, driving performance). The literature search was restricted to research published between 1990 and 2007.

RESULTS

Described below are the key methods and useful components derived from studies on on-road driving assessment strategies aimed at identifying (a) unsafe older drivers; and (b) older drivers requiring driver retraining. We considered the components of the driving assessments to be useful if they could distinguish between specific groups of drivers (e.g., cognitively impaired older adults vs. healthy older adults, drivers who participated in a retraining program vs. those who did not) or were highly correlated with driving task failures. Table 1 summarizes the useful components of the driving assessments that were examined and their reasons for being useful.

Across the studies examined, considerable variability could be seen in: (a) the types of road tests used (e.g., closed route, open/in-traffic route, fixed routes); (b) the components or driving behaviors (e.g., intersections, merging, highway driving) that were assessed; (c) the scoring methods (scoring criteria, evaluators, video) used to evaluate driving behavior; and (d) the groups of drivers being examined (e.g., visually impaired older adults, cognitively impaired older adults). In addition, it is often unclear if and how research has informed the design of these on-road tests.

Driving Evaluations for Identifying Impaired Older Drivers

When on-road tests designed for the identification of impaired older drivers were examined, several key methods used to study on-driving performance of older adults were identified. In some studies, the criteria used for determining whether an older driver failed the driving test were set by comparing the older driver’s performance to unimpaired (i.e., healthy drivers) groups, such as experienced drivers or adults with normal vision. For example, for older drivers to fail the driver’s test designed by Dobbs (2005) and Dobbs, Heller, and Schopflocher (1998), they needed to be making errors that placed them outside the range of competence-defining errors displayed by healthy, normal (experienced) drivers in the same situation. By identifying the attributes of a road course that reveal competence-defining errors of medically impaired drivers, the criteria for “unsafe to drive” met the requirements of the Supreme Court of Canada’s ruling concerning “reasonable road safety.”

In a number of studies, driving courses were designed to increase in complexity from start to finish (e.g., Fitten et al., 1995; Odenheimer et al., 1994). For example, the Spelveda Road Test (Fitten et al., 1995), a 2.7-km fixed route, took place within a hospital internal roadway to ensure low-level traffic conditions and involved six stages of complexity. This type of approach keeps the safety of the driver, the examiner, and
TABLE 1. Summary of On-road Driving Components Found Useful in Studies of Driving Assessment and Training in Older Adults Samples

<table>
<thead>
<tr>
<th>Authors</th>
<th>Useful Components</th>
<th>Comments</th>
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<tbody>
<tr>
<td><strong>Driving Assessment</strong></td>
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<tr>
<td>Dobbs et al. (1998); Dobbs (2005)</td>
<td>• Hazardous • Minor positioning • Turning position • Scanning • Overcautiousness • Signaling errors</td>
<td>Distinguished between healthy and impaired older adults</td>
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<tr>
<td>Carr et al. (1992)</td>
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<tr>
<td>Odenheimer et al. (1994)</td>
<td>• Signaling • Scanning of environment • Anterior/posterior positioning • Speed</td>
<td>Errors performed by older licensed drivers who failed driving tasks</td>
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<tr>
<td>Hunt et al. (1997)</td>
<td>• Complex components • Speed (i.e., slower) • Judgment of distance when making turns • Scanning of the driving environment • Lane control • Awareness of vehicles on road • Braking (i.e., frequent and/or unexpected) • Intersections</td>
<td>Distinguished between healthy and older adults with mild dementia of the Alzheimer disease (AD)</td>
</tr>
<tr>
<td>Fitten et al. (1995)</td>
<td>• Complex stages of course (e.g., streets marked with “do not enter”)</td>
<td>Distinguished between healthy controls (young adult, age-matched diabetes control, age-matched control) and older adults with dementia (e.g., AD, vascular)</td>
</tr>
<tr>
<td>Janke &amp; Eberhard (1998); Janke (2001)</td>
<td>• Concentration errors ○ Didn’t know how to return to the destination ○ Didn’t understand task ○ Proceeded in the wrong direction without awareness of the mistake • M Score = total errors + 2 times critical and hazardous errors • Critical driving errors (striking an object, disobeying a traffic signal, driving well below or above the traffic limit, including hazardous errors) • Hazardous errors (dangerous maneuvers, examiner intervention)</td>
<td>Distinguished between age-matched volunteer drivers and licensed older drivers referred for examination due to difficulties in driving. Only concentration errors distinguished between aged-matched volunteer drivers and those referred drivers with cognitive impairment</td>
</tr>
<tr>
<td>McKnight &amp; McKnight (1999)</td>
<td>• Skill errors (intersection visual search/sharing attention, path through turns, maintaining speed, positioning of car at intersections and merges, navigation) • Overcaution (driving too slowly through turns, on straight sections, and in lane changes, rejecting safe gaps at intersections)</td>
<td>Distinguished between older drivers referred for examination and incident-free older drivers. Examined relations between an automated psychophysical test and a structured road test in incident involving older drivers referred for examination and incident-free older drivers</td>
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### TABLE 1. Summary of On-road Driving Components Found Useful in Studies of Driving Assessment and Training in Older Adults Samples (Continued)

<table>
<thead>
<tr>
<th>Authors</th>
<th>Useful Components</th>
<th>Comments</th>
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| Mallon & Wood (2004) | • Roundabouts  
• Merging  
• Car parking  
• Traffic light  
• Controlled intersections  
• Non-traffic light-controlled intersections, stop & give way  
• Reversing  
• Straight driving (single and dual carriageway)  
• Lane changing | Distinguished between young, middle-aged, and older adults with normal vision and older visually impaired drivers. Older drivers with and without visual impairment differed on merging and straight driving. More errors noted for all drivers under self-directed vs. directed driving conditions. This increased significantly with age and visual impairment. |
| Ashman, Bishu, Foster, & McCoy (1994) | • (a) Search, (b) speed control, and (c) direction control each scored as 1 = satisfactory, 0 = unsatisfactory for each of 5 left turns, 1 right turn, 1 approach to uncontrolled intersection (max = 21 points) | All intervention groups improved significantly on total scores |
| Bedard, Isherwood, Moore, Gibbons, & Lindstrom (2004) | • None | No significant differences between control and treatment groups |
| Marottoli et al. (2007) | • Overall road test score based on a number of driving maneuvers and traffic situations utilized by the Connecticut department of motor vehicles scored 0 = major problems, 1 = minor problem, 2 = no problem (max/best score = 72) | Distinguished between those in a graduated exercise program and controls |
| Ostrow et al. (1992) | • Observing (observing to the rear, the side, the rear quarter, looking back) | Distinguished between those in an 8-week range-of-motion exercise training program and controls |
| Roenker et al. (2003) | • Turning into correct lane  
• Signal use | Showed improvement for simulator-trained group, but not speed of processing training group or low-risk no training reference group |

Other road users in mind because the test can be cut short early when the older driver has difficulty with more basic driving skills.

Other driver assessment programs were designed specifically to include components that older adults are known to have difficulty in completing (Hunt et al., 1997; Mallon & Wood, 2004; Mc Knight & McKnight, 1999). For example, the driving evaluation designed by Mallon and Wood (2004) included many intersections and lane changes as older adults have been found to have difficulty with these situations.

As can be seen in Table 1, a wide variety of components of on-road assessment were found to be useful in identifying impaired older drivers (e.g., hazardous errors, positioning, overcautiousness, concentration, awareness, braking, parking, scanning, signaling, speed, and complex components, such as merging, navigating intersections, left turns, and lane changing). Complex components (e.g., intersections, gap judgments, left turns, lane changes, merges, signaling, and scanning) in on-road assessment seemed to be the most useful for distinguishing between unimpaired and impaired drivers. In addition,
identification of critical, hazardous, and overcaution errors appeared to be useful in this regard. Other components, such as performance on closed-course elements and self-navigational skills, have received mixed support. Although each driving assessment that was reviewed, evaluated a large number of driving behaviors/components, only some of these were shown to be useful when distinguishing unimpaired from impaired drivers.

Driving Evaluation for Driver Retraining/Remediation

The literature examining on-road driving performance in the context of older driver retraining or remediation is far less extensive than that concerning the identification of impaired drivers. It is often implicit, when impaired drivers are identified, that they are no longer fit to drive or that they will not benefit from educational interventions. Yet, unnecessary driving cessation can have detrimental effects for older adults including decreased life satisfaction, isolation, and loneliness (Harrison & Ragland, 2003) and increased prevalence of depression (Ragland, Satariano, & MacLeod, 2005). Since continued driving in later adulthood plays an integral role in maintaining the health, mental health, and quality of life of older adults (e.g., Vance et al., 2006), creating more options for dealing with results of a driving assessment is an important target for future research. Moreover, there is emerging evidence that the older driver can benefit from retraining or remedial interventions.

Some studies have shown post-intervention improvement in on-road driving performance of older drivers. For example, Ostrow, Shaffron, and McPherson (1992) randomly assigned 32 older adults, stratified by gender, to an 8-week range-of-motion exercise training program or a control group that received no intervention. They examined differences between the groups on nine derived variables reduced from a more extensive list of driving tasks posing the greatest difficulties and risks to older drivers. Significant improvement was noted for the intervention group compared with the control group on observing tasks (i.e., observing to the rear, the side, the rear quarter, and looking back).

In another intervention study where on-road performance was used as an outcome measure, Roenker, Cissell, Ball, Wadley, and Edwards (2003) evaluated the on-road driving performance of participants aged 55–86 years before, immediately after, and 18 months after training on speed of processing or a driving simulator. Seventy-seven participants with Useful Field of View (UFOV) reduction of 30% or greater (high risk) were randomly assigned to the two training conditions with twice as many allocated to speed of processing training \( n = 51 \) than to the simulator training \( n = 26 \). Twenty-seven participants with UFOV reduction of less than 30% were randomly assigned to a low-risk reference group. The simulator-trained group improved on two driving measures: turning into the correct lane and proper signal use, but these improvements were no longer evident after 18 months. Similar effects were not observed in the speed-of-processing training group or the low-risk reference group. It was noted, though, that the speed-of-processing training group made fewer dangerous maneuvers (those requiring the evaluator to take control of the car or other vehicles to alter their course) after training relative to the simulator-trained group.

On-road driving evaluation has also been described as an evaluation process (as opposed to the outcome) in rehabilitation studies, in the context of clinical practice in driver rehabilitation. In this clinical setting, on-road driving evaluation may be used to target individuals who may benefit from driver retraining and/or particular driving behaviors as the focus for driver retraining (Fox, Bowden, & Smith, 1998). Many hospitals or rehabilitation centers employ driver rehabilitation specialists
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(DRS), often occupational therapists, who are skilled in physical rehabilitation and vehicle modification to accommodate physical disability. The driving assessments they perform have been developed through clinical judgment and are typically based on subjective criteria. Often the goal of driving assessments conducted in these settings is rehabilitative in nature, focusing on the individual’s driving goals, and assessing driving in situations relevant to these goals. This rehabilitative approach is likely to be of assistance in identifying the driving strengths and weaknesses of the individual and possible driving retraining strategies for that individual. A standardized approach to assessment both pre- and post-driver retraining is generally lacking.

Few detailed descriptions of the approaches adopted in these settings are available. Justiss, Mann, Stav, and Velozo (2006) described, as part of a more comprehensive driver evaluation service, their approach to naturalistic on-road driving evaluation. It began with the client’s transfer into the vehicle and becoming familiar with the vehicle. Then, the evaluation continued on a closed course away from distractions (i.e., parking lot) to allow the driver time to acclimatize to the dual-brake program vehicle. From this off-road area, the course transitioned into a residential or simple driving environment at a low speed of 25–30 mph. The course gradually increased in difficulty onto roads with multiple lanes, traffic signals, and increased traffic flow. A high-speed merge (i.e., 55–70 mph) onto a highway or expressway was also included. Justiss et al. (2006) are one of the few research groups approaching driver evaluation from the rehabilitation perspective to describe the psychometric properties and the clinical utility of their behind-the-wheel evaluation process. Like some of the driving assessments aimed at identifying impaired older drivers, this assessment included components of increasing complexity.

As can be seen from Table 1, the following were the useful components of on-road assessment emerging from studies of driver retraining: searching and speed and direction control when making left turns, right turns and approaching uncontrolled intersections, observing, signaling, and turning into the correct lane. In some cases, overall road-test scores were also useful in distinguishing between intervention groups.

**EXPERT OPINION**

Driver rehabilitation specialists are another useful source of information concerning driving evaluation practices. At workshops of the Association of Driver Educators for the Disabled (ADED) in 1997 \((n = 109)\) and 2003 \((n = 114)\), DRS professional responded to survey questions on the process and structure of driving evaluation practices (Korner-Bitensky, Bitensky, Sofer, Man-Son-Hing, & Gelinas, 2006). Ninety-four percent of respondents indicated that they performed on-road evaluations. Of those reporting use of on-road evaluations, 65% reported using a standardized route in 1997, in contrast to 78% in 2003. Only two respondents used a published (standardized) road test, in both instances the Miller Road Test (Carr, Jackson, Madden, & Cohen, 1992). It was speculated that the cost of standardized approaches may be prohibitive or they may be lacking in terms of practicality or face validity. Ninety-nine percent reported on-road assessment greater than 30 min in length, with 50% reporting length as 30–60 min and 49% indicating greater than 60 min.

Other information from those with knowledge of driving evaluation practices comes from recommendations made by the Canadian Consensus Conference on Driving Evaluation in Older Drivers (Korner-Bitensky et al., 2005) concerning the structure and content of a comprehensive driving examination for individuals over 65 years of age referred for a driving assessment primarily for cognitive reasons (see Table 2). Strong
consensus was reached concerning the observation that, while existing on-road assessments had many different elements, none addressed the entire driving task. There was also strong consensus concerning the statement that a 45–60-min of on-road evaluation generally provides sufficient time to assess various on-road driving maneuvers and behaviors. Moreover, it was agreed that the driver evaluation might need to be cut short if the evaluator or instructor perceives a threat to safety of the individuals in the vehi-

FIGURE 1. Components identified as highly significant from studies of (1) identification of impairment, (2) retraining programs, and (3) expert opinion.
The strong agreement reached at the consensus conference on many of the critical components for on-road assessment provides a basis for a core set of elements for sites to consider when assessing older drivers.

CONCLUSIONS

It appears that the components included in on-road driver evaluations have been varied depending on intended purpose of the evaluation. There is considerable variety across the sources of literature (i.e., driving assessment for the identification of impairment, retraining, and expert opinion) with respect to the components of the on-road assessment that were found to be useful. Figure 1 summarizes the useful components from the on-road assessments that were identified in the studies examined in this review and depicts the overlap in the components that were found to be useful across these three sources of literature.

As can be seen in Figure 1, the only components that were found to be useful across all three sources of literature were lane control and lane positioning. Signaling, observing, and scanning were found to be useful both in the literature examining on-road assessment for identifying impairment and for retraining. Consistent findings also emerged between expert opinion and on-road assessment used in the identification of impaired older drivers (e.g., intersections, merging, roundabouts, left turns, reversing, stopping, yielding, and speed). Future research will need to continue to identify the most useful behaviors to evaluate during on-road driving assessments, while eliminating those behaviors that show limited promise (i.e., for identifying impaired drivers and/or as behaviors for targeting in on-road driver retraining programs). One limitation of this research is that some assessment procedures involved observation of restricted sets of driving behaviors, while others were more inclusive.

In the past, driving assessments used for retraining were developed through clinical judgment and were based on subjective criteria. Only recently, steps have been taken toward formalizing these processes. Over 15 years ago, Brouwer and Van Zomeren (1992) suggested incorporating retraining as an integral component of on-road driver evaluation. They suggested that when impaired drivers are identified, training in strategic (e.g., route planning) and tactical-level (i.e., maneuvers) compensatory behaviors should proceed until training goals are reached or a preset maximum number of lessons are exceeded. In this context, unsafe driving would be defined as the inability to reach the criterion as a safe driver within the limits of available training and technical adaptations. This approach has the advantage of “building in” retraining to the driving assessment procedure so that the driver is given every opportunity to improve. However, to date, little published research has been available to guide the implementation of such a program.

Literature investigating the most appropriate components and scoring methods to be included in a driver assessment, especially one that incorporates a driver-retraining component, is lacking. Future research focused on driving assessment in the context of retraining might incorporate the recommendations from the Canadian Consensus Conference on older driver safety and include the most useful components identified in the above-mentioned literature (see Table 2). Focusing on distinguishing between those driving maneuvers/components that are amenable to driver retraining and those that are not would provide useful information that is not currently available. This information could be used to guide practice recommendations (e.g., retraining where probable success is high, driving cessation when retraining is unlikely to be successful).
In addition, it will be important to determine the amount of retraining (e.g., number of sessions) within which significant and clinically meaningful change in the key driving behaviors is likely to be achieved. Those individuals who do not respond to retraining on critical key driving behaviors in this amount of time could then be recommended for driving cessation.

In conclusion, the material reviewed here suggests that key elements for on-road evaluation can be articulated that may facilitate the development of procedure to be used to target individuals who may benefit from driver retraining and to target particular driving behaviors as the focus for driver retraining. This may represent one efficient way to improve the safety of older drivers, by helping those individuals who may still be fit to remain driving on the road safely for as long as possible, while also identifying those individuals and behaviors that may not be amenable to driver retraining.

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**REFERENCES**


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