Occupational Therapy Assessment of Open-Road Driving Performance: Validity of Directed and Self-Directed Navigational Instructional Components

Kerry Mallon, Joanne M. Wood

OBJECTIVE. The purpose of this study was to validate an assessment tool used by occupational therapists to evaluate on-road driving performance.

METHODS. The driving assessment was conducted over a 15-km route that consisted of a range of traffic situations and contained both directed and self-directed navigational instruction. The driving performance of four groups of drivers of different ages and visual characteristics was assessed independently by an occupational therapist and driving instructor using a range of scoring criteria.

RESULTS. The occupational therapist scores were significantly affected by the drivers' age and visual characteristics (directed navigation, $F(3,133) = 6.05, p = 0.001$; self-directed navigation, $F(3,133) = 5.04, p < 0.002$), and these group differences were greater for self-directed navigational instruction. The occupational therapist scores were highly correlated with the driving instructor's global driver safety rating ($r = 0.76, p < 0.001$).

DISCUSSION. The driving assessment instrument was a valid measure of on-road driving performance relative to an independent global driving safety evaluation. The instrument provided detailed information regarding driving performance and highlighted areas of difficulty, particularly when drivers followed self-navigational instruction.


Occupational therapists employed in rehabilitation settings are increasingly involved in assessing the driving ability of aging drivers and drivers with disabilities, in order to determine their fitness to continue driving or potential for remediation. The responsibility for developing and performing these driving assessments has generally rested with clinically-based occupational therapists rather than researchers. Hence the assessments, while having clinical relevance, lack a substantial research basis. Consequently, decision making regarding fitness to drive is largely based on tests that lack strength and validity (Brooke, Questad, Patterson, & Valois, 1992; Galski, Ehle, & Bruno, 1990), and testing procedures may lack consistency from one clinician to the next (Ranney & Hunt, 1997). It has been suggested that the current methods of open road assessment could be improved by devising standardized assessment protocols that provide quantitative scores of driving performance, as a function of error type and location (Fox, Bowden, & Smith, 1998; Odenheimer et al., 1994; Ranney & Hunt, 1997).

In this study we aimed to validate an open-road assessment tool that contained both directed and self-directed navigational instruction. The choice of driving assessment protocol for this study was considered in the context of previous literature on the assessment of older and disabled drivers, which includes a wide range of techniques with varying outcomes. The Cognitive Behavioural Driver’s Inventory (CBDI) (Engum, Pendergrass, Cron, Lambert, & Hulse, 1988) utilizes a battery of off-road psychological tests followed by on-road evaluation that involves a struc-
tured on-road assessment with specific maneuvers, locations, and error categories, and a subjective evaluation of attitudi-
nal variables. The CBDI has been shown to have a high level of
test retest reliability and validity and was sensitive to dif-
fferences between a control group and the brain injured
groups (Engum, Lambert, & Scott, 1990).

Carr, Jackson, Madden, and Cohen (1992), using the
Miller Road Test in a college campus setting, compared the
driving skills of old and young drivers and reported that the
older drivers made fewer errors and were judged to have
superior driving skills compared to the younger drivers.
However, the validity of these results must be questioned
because testing was not conducted within the complexity of
an open-road environment. More recently, McKnight and
McKnight (1999), using an assessment based on the driv-
ing performance evaluation developed by the California
Department of Motor Vehicles, found that crash-involved
older drivers performed more poorly on intersection visual
search, maintaining a constant speed, positioning the car at
intersections and merges, and navigating correctly.
Examiners in this study were given a 2-day training pro-
gram, however, significant differences across examination
sites, as well as between examiners, were recorded.
Odenheimer et al. (1994) developed an on-road driving
test, which incorporated a range of driving situations and
68 scored driving tasks. They reported that test scores cor-
related highly with the criterion standard of the driving
instructor score, as well as with cognitive ability. The test
was also shown to have high internal reliability.

In the study described here, the driving assessment was
based upon a system already in use in a clinical setting by
some occupational therapists in Australia, which closely
matched that developed by Odenheimer et al. (1994), with
the modification of including a self-directed navigational
component. We aimed to evaluate this assessment tool for
groups of drivers of different ages and visual charac-
teristics and to compare the quantitative scores derived by
this technique with an independent global driver safety
score derived by the driving instructor. It was hypothesized
that the self-directed navigational instruction component
would highlight the driving difficulties experienced by
older drivers and those with visual impairment. The open-
road assessment was part of a larger study investigating age-
related changes in visual function and the effects on driv-
ing performance in the elderly (Wood, 2002; Wood &
Mallon, 2001).

Methods

A cross-sectional study design was used to assess the driving
performance of four groups of participants who varied in
age and visual characteristics. Driving performance was
assessed on one occasion under open road conditions using
a standardized route and assessment tool and was scored
independently by an occupational therapist and driving
instructor to obtain overall as well as specific scores.

Participants

A total of 137 participants were recruited and performed
the on-road assessment of driving performance. All partici-
pants were community-dwelling volunteers who had either
read an article describing the study in a motoring magazine
or had attended presentations by the research team.
Participants were required to be in good general health and
to have a current driving license. Ninety participants had
normal vision and were divided into three age groups: a
group of 30 young (mean = 27.0 ± 5.4 years), 25 middle-
aged (mean = 52.3 ± 5.7 years) and 35 older participants
(mean = 68.9 ± 4.8 years). The remaining 47 older partici-
pants had early visual impairment resulting from an ocular
disease (mean = 70.6 ± 6.2 years). Categorization of the
ocular health of the participants was undertaken by an
optometrist in a clinical examination, which included a
brief case history, biomicroscopy, ophthalmoscopy, and
tonometry. There were no statistically significant differences
in age between the older participants with normal vision
and those with ocular pathology. The study was conducted
in accordance with the requirements of the affiliating uni-
versity ethics committee. All participants were given a full
explanation of the experimental procedures and written
informed consent was obtained, with the option to with-
draw from the study at any time.

On-Road Driving Assessment

The open-road driving assessment was conducted in an
automatic, dual brake vehicle, with the professional driving
instructor seated in the front passenger seat and the occu-
pational therapist seated in the rear of the vehicle. The
occupational therapist (the first author) was highly experi-
enced in driver assessment and had used the same route and
scoring system for the purpose of making recommendations
to driving authorities regarding drivers who had experi-
enced injury or for whom there was some doubt of their
driving safety. Similarly, the driving instructor had extensive
experience in driving assessment, including 12 years assess-
ing a broad age range of drivers, with 5 years specifically
working with older drivers and geriatric rehabilitation.
Neither the driving instructor nor the occupational ther-
pist was aware of the visual characteristics of the partici-
pants and were asked to perform the driving assessments as
they would normally in their own practice, but with the
additional use of the quantitative scoring systems.
Driving Route. The driving route and maneuvers used in this study were devised to provide a standardized procedure for all participants with sufficient duration and complexity to allow assessment of a variety of driving situations and maneuvers, and sufficiently challenging to allow manifestation of visual or cognitive deficits or both (Jones, 1978). A large proportion of intersections and lane changes were also included, as these represent driving situations in which the elderly report increased difficulty (e.g., Kosnik, Sekuler, & Kline, 1990). The route consisted of a 15-km predetermined course on the open road that consisted of city and suburban streets, simple and complex intersections, and included a range of traffic densities and operational maneuvers performed at predesignated locations. The assessment was conducted either in the mid-morning or mid-afternoon to obtain consistency in traffic density and avoid rush hour traffic. The road test was cancelled if it was raining or the road was wet.

This driving route largely replicated the clinical open road assessment in use by occupational therapists of a major rehabilitation center at the time. Participants were given an orientation to the vehicle and vehicle operations, a standard set of instructions that outlined the proposed route, including the self-navigation component, and were instructed to drive as they normally would, obeying all road rules. Participants were also informed that if the driving instructor was required to take control of the vehicle on three or more occasions, then the assessment would be ceased and the instructor would drive the vehicle back to the start point. Participants were given a short warm-up period in which to familiarize themselves with the vehicle operations before commencing the assessment at the set starting point. The time taken to complete the assessment was generally 50 minutes.

Assessment Procedures. Driving performance at 106 sequential locations–maneuvers was recorded by the occupational therapist. The number of locations–maneuvers was selected with the aim of exposing the driver to a sufficient range of driving situations and operations to replicate “real world” driving experiences, and to enable each participants’ performance on specific situations (e.g., intersections) to be evaluated in multiple and diverse traffic conditions. The chosen route also met the professional competency standards for driving assessment routes advocated by the Australian Association of Occupational Therapists—Victoria Inc. (1998). These 106 locations–maneuvers were subdivided into nine categories (Table 1) and at each location, seven different components of driving performance were assessed including general and blind spot observation, indication, braking–acceleration, lane positioning, gap selection, and approach. The type and location of each driving error was recorded.

Table 1. The Categories of Locations–Maneuvers Assessed and Scored for the Occupational Therapist Assessment of Driving.

<table>
<thead>
<tr>
<th>Categories (and Number) of Locations Assessed</th>
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<tbody>
<tr>
<td>Roundabouts (3)</td>
<td></td>
</tr>
<tr>
<td>Merging (2)</td>
<td></td>
</tr>
<tr>
<td>Car parking (5)</td>
<td></td>
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<tr>
<td>Traffic light controlled intersections (20)</td>
<td></td>
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<tr>
<td>Non-traffic light controlled intersections, stop &amp; give way (13)</td>
<td></td>
</tr>
<tr>
<td>Reversing (1)</td>
<td></td>
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<tr>
<td>Emergency brake (1)</td>
<td></td>
</tr>
<tr>
<td>Straight driving (single and dual carriageway) (50)</td>
<td></td>
</tr>
<tr>
<td>Lane changing (11)</td>
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</table>

Failing any aspect of performance resulted in failure of the whole task (for a given location–maneuver), and the occupational therapist justified each task failure by identifying the behavior performed incorrectly. By requiring the occupational therapist to record the types of driving errors made at each location, reliability was increased because the complexity of the task for the occupational therapist was reduced, this approach also maximizes the likelihood of the occupational therapist observing the driver’s performance at the correct moment (Fox et al., 1998). Comparison of driving behavior over a variety of maneuvers–locations also facilitates quantitative analysis of driving errors and makes it possible to pinpoint specific deficiencies in driving actions, which can then be used in driving remediation programs (Fox et al.). Indeed, in a comprehensive review of “on-road” driving assessments, Fox et al. recommended that in order to enhance validity, the on-road assessment should represent the spectrum of situations that drivers would typically encounter when they interact with traffic on a daily basis.

Self-Directed Navigational Instruction. Most of the locations (84%) were assessed when the participant was driving as instructed by the driving instructor, known as directed navigation. For a section of the course (16% of the locations assessed), the participants were asked to find their way to a specific destination, a process known as self-directed navigation. For this component of the course the participants had to use cues from the road system, such as road signs and road markings, to determine the route that they should take. The reason for inclusion of this section was that in self-directed navigation, the driver is actively engaged in multiple tasks involving visual scanning, divided attention, planning and judgment (e.g., scanning for road signs while maintaining lane position and appropriate vehicle speed), and this requires a much higher degree of cognitive and visual ability than simply following directions in the form of single-step commands. Self-directed navigation was thought by the authors to replicate one of the most challenging aspects of “real world” driving, and should be a critical element for inclusion in any assessment of a person’s capacity to drive.
Participants were given an overall score for the number of correct maneuvers out of a total of 106 expressed as a percentage, and as a function of whether the score was for driving with directed or self-directed navigational instruction. The data were further broken down into the number of errors made for each of the nine categories of locations–maneuvers (e.g., roundabouts, straight driving).

**Driving Instructor Assessment** The professional driving instructor was seated in the front seat of the vehicle and gave an overall global driver safety rating, ranging from a score of 1 to 10, for each participant according to current transport licensing standards. A score falling in the range 1–3 indicated that the driving instructor had to take action (e.g., braked, took control of the steering wheel) in order to avoid an incident, or that the driver hit a significant object and that the driver should consider ceasing driving. A score in the range 4–5 indicated poor driving and observation skills, where drivers disobeyed major road signs and road markings and major road rules. A score in the range 6–8 indicated average driving skills but with some bad habits, including the driver slightly disobeying road rules and signs (i.e., 65 km in a 60 km speed zone). Finally a score in the range 9–10 reflected good to excellent driving and observational skills, including obeying and observing all road signs and road rules.

**Cognitive Assessment**

Immediately prior to commencing the open-road assessment, all participants also underwent cognitive screening by the occupational therapist using the Barry Rehabilitation Inpatient Screening of Cognition (BRISC). This instrument was developed to provide a standardized measure of cognition and has been shown to have a high level of validity against other standard tests of cognitive functioning and to have good test-retest reliability (Barry, Clark, Yaguda, Higgins, & Mangel, 1989). The test takes 20–30 minutes to administer and contains many items derived from previously used instruments that have been shown to be useful for the purpose of treatment planning for brain injured persons. The BRISC is divided into eight functional categories, which are designed to test a broad spectrum of cognitive functions within a relatively short time frame. The test categories include reading design copy, verbal concepts, orientation, mental imagery, mental control, initiation, and memory (involving both immediate and delayed recall). The total BRISC score for all eight categories combined was determined for each participant; this was not scored until the on-road assessment had been completed to minimize bias.

**Analysis**

The occupational therapist overall driving performance scores, recorded when participants were driving under directed and self-directed navigational instruction (dependent variables), were analyzed using one-way analysis of variance (ANOVA) to highlight any group differences in performance. The driving performance data were also broken down into the number of errors made at each type of location and a series of one-way ANOVAs used to determine the locations at which drivers made the most errors. The occupational therapist scores were also compared with the overall global safety ratings of the driving instructor to determine the level of interrater agreement using Pearson moment correlation analysis. The correlation between the overall driving performance scores (both those derived by the occupational therapist and the driving instructor) and cognitive test scores (as measured with the BRISC) were also determined.

**Results**

The occupational therapist driving scores for the directed and self-directed navigation instructional components of the on-road assessment are plotted as a function of group assignment in Figure 1. The scores indicate the percentage of locations for each of the navigation types where no errors were made. Figure 1 indicates that all of the participants had a better score when they followed directions from the driving instructor, rather than having to navigate their own way to a particular location. One-way ANOVA indicated that there were significant group differences for both the total directed navigation, \(F(3,133) = 6.05, p = 0.001\), and self-directed navigation scores, \(F(3,133) = 5.04, p = 0.002\). Post hoc Scheffe analysis indicated that these differences were significant when comparing the young and middle-aged participants and the older participants with visual impairment.

In order to further highlight the differences in performance during directed and self-directed navigation instruction, the data were also considered as the total number of errors made, remembering that at each location–maneuver it was possible for a maximum of seven different types of errors to be made. The data were weighted according to the percentage of time that the participants drove under directed (84%) and self-directed (16%) navigation, to allow appropriate comparison between the numbers of errors. Figure 2 represents the weighted number of errors made during directed and self-directed navigation as a function of group assignment. All drivers made more errors under self-directed navigation \(F(3,133) = 37.8, p < 0.001\), and the difference between the number of errors made under directed and self-directed navigation increased significantly with age and visual impairment, \(F(3,133) = 3.7, p < 0.05\), being greatest for the older participants with visual impairment.
The occupational therapist scores can also provide information about whether drivers have more problems at particular types of location, by dividing the total errors into the number of errors made at each category of location–maneuver. Table 2 gives the group mean errors as a function of location–maneuver category and group assignment.

ANOVA demonstrated significant group differences at all locations except emergency braking. The young and middle-aged drivers typically performed better than the older drivers either with or without early visual impairment. Driving performance for the older drivers with visual impairment was also significantly worse than that of the older drivers with normal vision for merging and straight driving.

The scores for overall driving performance as measured by the occupational therapist and the driving instructor global safety rating were significantly positively related using Pearson moment correlation analysis ($r = 0.76, p < 0.001$), demonstrating that 58% of the variance in one score could be predicted by another. The BRISC test scores were significantly positively related to the overall occupational therapy driving assessment score ($r = 0.26, p < 0.01$), and for both the directed ($r = 0.22, p < 0.05$) and self-directed ($r = 0.38, p < 0.001$) components separately using Pearson moment correlation analysis. There was also a significant positive relationship between the BRISC scores and the driving instructor’s safety rating ($r = 0.26, p < 0.01$). However, it is important to note that while all of these correlations were significant, the practical ability to predict one score from another was only in the range of 4.8% (to 14.4%).

### Discussion

The findings indicate that, despite using different assessment and scoring approaches to evaluate driving performance, (i.e., a quantitative score from 106 locations–
maneuvers and a global driving safety rating), there was a significant level of agreement between the occupational therapist and the driving instructor. This finding supports our hypothesis and provides strong support for the current standardized open road assessment techniques, where both parties evaluate separately, then combine their findings in making a decision about fitness to drive. These results are supported by those of Odenheimer et al. (1994) who also found strong correlations between the criterion standard of the driving instructor score and occupational therapist scores using a similar open road based assessment.

The quantitative nature of the occupational therapist scores also allowed more specific investigation of the circumstances under which the drivers had more difficulties and at which locations. All drivers were shown to make proportionally more errors under self-directed compared to directed navigation; however, the difference between directed and self-directed performance was greater for the older drivers and became more obvious when the weighted number of errors was considered. Importantly, inclusion of the self-directed navigation section of the on-road assessment provides an opportunity to evaluate the strategic and tactical aspects of driving, and provides sufficient complexity in driving tasks to challenge the driver cognitively–visually and allow the manifestation of deficits in these areas.

The difficulties encountered in the self-directed component of the assessment are reflected by other research, where older drivers self-report problems finding a particular traffic sign and making an appropriate maneuver in time (Cooper, 1990). Burns (1999) also reported from a questionnaire-based study that way-finding and navigation become more difficult with age and this increased difficulty relates to reduced mobility in the elderly.

The occupational therapist assessment also highlighted the locations at which drivers make most errors. The older drivers made more errors than either the young and middle-aged drivers at all locations, with emergency braking being the only driving situation where these differences did not reach significance. Group differences were most obvious for both non-traffic light and traffic light controlled intersections, roundabouts, merging and lane changing and straight driving. These findings are supported by crash statistics that indicate that older drivers are overrepresented in crashes at intersections and other complex traffic situations including roundabouts, involving failure to give way, turning and changing lanes, disregarding traffic signals or angle collisions (McGwin & Brown, 1999). Crash risk has also been shown to be particularly high for older drivers at both uncontrolled and stop sign controlled locations, as well as when merging and changing lanes (Preusser, Williams, Ferguson, Ulmer, & Weinstein, 1998).

Questionnaire-based studies also support the occupational therapist findings and show that elderly drivers report problems with changing lanes, intersections, night-time driving, other vehicles appearing unexpectedly and reading signs (Cooper, 1990; Kline et al., 1992; Kosnik et al., 1990), as well as judging the speed and changes in speed of other vehicles (Scialfa, Kline, Lyman, & Kosnik, 1987). The occupational therapist data showed a trend for the middle-aged drivers to make fewer errors than any of the other groups, which is also supported by crash statistics that indicate that middle-aged drivers are the safest of all driver cohorts (Stamatiadis & Deacon, 1995).

The driving instructor overall safety rating supports that of the occupational therapist assessment, indicating that all of the older drivers were significantly less safe than the young and middle-aged drivers. This has significant implications for the management of older drivers. In clinical practice, the use of standardized on-road assessment protocols by occupational therapists would enhance the objectivity of driving assessments for older and disabled drivers and provide sufficient detail and justification for the prescription of driving rehabilitation programmers.

Although the scores on the BRISC cognitive test were statistically significantly related to the occupational therapist and driving instructor scores, it is important to note that the correlations were not strong. In practical terms, the BRISC could only predict 6.8% of the overall occupational therapist scores. However, when the scores were broken down into directed and self-directed navigation the relationship was stronger for the self-directed scores. When the driver was required to find his or her way to a particular location, the amount of variance that could be explained in the occupational therapist scores from the BRISC data increased from 4.8% (directed) to 14.4% (self-directed). Nevertheless, the low level of predictability of these scores cannot justify the substitution of cognitive testing for an on-road assessment. These findings concur with those of Brooke et al. (1992), who found that the sum of rated scores of the Trail Making and Tactual Performance Tests (Reitan, & Wolfson, 1985) were significantly related to a global pass–fail on-road assessment rating but not to driving performance scores and concluded that “standardized measures of cognitive function alone do not substantially predict driving performance.” More recently, Stutts, Stewart, and Martell (1998) found that the Trail Making A and B tests were significantly associated with crash risk but that the observed effect was relatively small. Conversely, Odenheimer et al. (1994), found high correlations ($r = 0.72$) between the in-traffic score and the mental state exam, however, it should be noted that in that study participants were recruited from medical and...
dementia clinics and hence had a wide range of mental abilities.

**Clinical Recommendations**

The results of this study suggest that the occupational therapy on-road assessment is a valid measure of driving performance when compared with an independent overall safety rating by a driving instructor, and further that the on-road assessment is able to identify the types and locations of errors made by participants. The standard inclusion of a self-directed driving component in occupational therapy on-road assessment is recommended based on the finding that all drivers made more errors under these conditions, suggesting that self-navigation challenges the driver in a way that directed navigation does not. The route used in this study was designed by the authors to be of significant length and complexity to ensure repeated exposures to specific situations (e.g., intersections) under various levels of traffic density, in order to replicate everyday driving experiences and is recommended for use in clinical practice. Other important benefits of a set route include increased familiarity with the route and hazards by the occupational therapist and driving instructor, so that they are better able to anticipate and observe their client’s performance, allowing increased safety for all participants.

The findings in this study indicated that the on-road assessment used by the occupational therapist was sensitive to the number and types of driving errors, and the locations—maneuvers where these errors occurred. This detailed information can be used to determine the fitness to drive or suitability of the client for a driving rehabilitation program, or both, with specific performance goals that can be measured. For example, a client with repeated lane position errors in more complex road and traffic situations can be prescribed a driving rehabilitation program that focuses on exposure to more complex traffic and gives instruction on technique at the same time. Monitoring of lane position throughout the rehabilitation program yields information on whether the client is able to improve to a safe level, or is unable to progress due to medical or age-related factors.

Overall the use of the standardized on-road assessment with a self-navigation component provides evidence for the clinical evaluation of driving ability, and structure for the use of driving rehabilitation programs. However, while the on-road assessment was quantitative, it only reflected the number and type of errors and not the degree or severity of those errors. Modification of the on-road assessment with a method of scoring the assessment using weighted criteria to denote the degree or severity of driver errors is currently being examined. Further research to examine the predictive validity of the on-road assessment by monitoring crash rates of study participants is also recommended. ▲

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**References**


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