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Mild Cognitive Impairment and Everyday Function: An Investigation of Driving Performance

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Abstract

Mild Cognitive Impairment (MCI) involves subtle functional losses that may include decrements in driving skills. We compared 46 participants with MCI to 59 cognitively normal controls on a driving evaluation conducted by a driving rehabilitation specialist who was blinded to participants' MCI classification. Participants with MCI demonstrated significantly lower performance than controls on ratings of global and discrete driving maneuvers, but these differences were not at the level of frank impairments. Rather, performance was simply less than optimal, which to a lesser degree was also characteristic of a subset of the cognitively normal control group. The finding of significantly lower global driving ratings, coupled with the increased incidence of dementia among people with MCI and the known impact of dementia on driving safety, suggests the need for increased vigilance among clinicians, family members, and individuals with MCI for initially benign changes in driving that may become increasingly problematic over time.

Keywords

Mild Cognitive Impairment; Functional Ability; Instrumental Activities of Daily Living; Driving

INTRODUCTION

For many older adults, the ability to drive safely is essential for maintenance of mobility, independence, health, and an active lifestyle[1–3]. Cross-sectional and longitudinal studies indicate that older adults who have given up or reduced their driving report more negative health and psychosocial outcomes than those who have not, such as increased depressive symptoms[4,5], social isolation and diminished participation in out-of-home activities[3], difficulty running their households and reduced access to essential services[5,6], loss of independence and personal mobility[7], and greater likelihood of placement in long-term care[2]. In general, driving restriction is associated with reduction in overall quality of life which, in turn, is associated with increased mortality[8]. Accordingly, research on driving behavior and safety among older adults is becoming increasingly important.

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Due to rapid expansion in the number of licensed drivers over age 65[9] and evidence that risk for dementia and other cognitive disorders increases with age[10,11], the effect of cognitive impairment on driving performance and safety among the elderly is also receiving increased attention in the literature[12,13]. In one of the earliest studies of fitness to drive in Alzheimer's disease (AD), Friedland and colleagues[14] found that about 50% of AD patients had been involved in a crash in the five to six years prior to the study compared to only 10% of control participants. In another retrospective study, examination of driving records revealed that patients with dementia were 2.5 times more likely to have been involved in a motor vehicle collision than demographically-matched controls[15]. Studies that have utilized direct assessment approaches have similarly found impaired driving performance in AD. For example, a longitudinal study of on-road driving performance found that patients with mild AD exhibited a steeper decline in driving safety across assessments than did control participants[16]. The study also included 21 participants with very mild AD (i.e., Clinical Dementia Rating [CDR[17]] of 0.5—a rating acknowledged by the study's authors to be consistent with mild cognitive impairment in the view of some); these participants also declined in driving skills over time, but not as steeply as the mild AD group. In a driving simulator study, Uc and colleagues[18] found that drivers with AD were more likely than controls to experience an at-fault, rear-end collision and to exhibit other unsafe behaviors such as slowing down abruptly or prematurely, or swerving out of the traffic lane. Finally, an evidence-based review concluded that drivers with AD at a severity of CDR 1.0 pose significant safety risks as evidenced by both driving performance and crash measures[19].

Mild cognitive impairment (MCI) often represents an intermediate stage between normal aging and AD[20]. Persons with MCI exhibit cognitive and functional impairments similar to those that characterize AD, albeit of a milder and usually more focal nature[21–23]. MCI is considered a strategic intervention point in the clinical management of AD and its functional sequelae [24].

Based on our review of the literature, there have been four studies of driving performance, assessed either on the road or via crash data, among persons classified as CDR 0.5. Among these studies, two have dubbed this group "very mild DAT [Dementia of the Alzheimer Type]" [16,25], one has termed this group "questionable dementia" [26] and the final study used the term "probable AD at a severity of CDR 0.5" [19]. Although a subset of MCI cases may be assigned a CDR rating of 0.5, this rating does not capture all cases of MCI, many of whom receive CDR ratings of 0.0. Moreover, because persons with AD also may receive CDR 0.5 ratings, a CDR of 0.5 may not be assumed to signal MCI. The MCI designation generally is reserved for patients subjected to additional, multifaceted criteria for case identification[27]. To our knowledge, there have been no empirical studies of driving performance in MCI as defined by Petersen/Mayo criteria[27]. This is a surprising knowledge gap given the heavy reliance of older adults on personal transportation for meeting various needs and the aforementioned associations between dementia status and negative driving outcomes.

In this study, we objectively examined the driving performance of well-characterized samples of cognitively normal older adults and persons with MCI using an on-road driving assessment. We hypothesized that persons with MCI would demonstrate decrements in driving skills and performance relative to cognitively normal controls.

METHOD

Participants

Potential participants were recruited to the Alzheimer's Disease Research Center (ADRC) at the University of Alabama at Birmingham (UAB) through clinical cases presenting to UAB's Memory Disorders Clinic and through community talks and health fairs. Irrespective of

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recruitment source, all ADRC enrollees underwent neurological examination and neuropsychological testing for subsequent consensus determinations of normal, MCI, and other conditions. Medical history and family reports were also provided. Diagnoses were determined in ADRC consensus conferences by neurologists, neuropsychologists, and nursing staff using Petersen/Mayo criteria for MCI[27]. A diagnosis of MCI was not given to any ADRC participant with medical or psychiatric conditions that might account for their cognitive difficulties. Individuals with neurological illness or events such as prior stroke, traumatic brain injury, or brain tumor were excluded. Participants diagnosed with MCI or designated as normal controls via the consensus process were subsequently invited to enroll in the ADRC's Measuring Independent Living in the Elderly Study. The present analyses include baseline data of current drivers from this ongoing longitudinal study.

The MCI group consisted of 46 current drivers (19 women and 27 men; 4 African Americans and 42 European Americans) with a mean age (± SD) of 71.30 (± 7.79); mean education of 14.83 (± 3.06) years; mean far visual acuity score, assessed with corrective lenses if typically worn, of 20/21 Snellen (range 20/36 to 20/13); and mean Dementia Rating Scale, 2nd edition (DRS-2) [28] total score of 132.60 (± 8.49). Three additional study participants with MCI had not driven during the past year (2 women, 1 man), and two additional women with MCI had never driven a car; none of these participants are included in the present analyses. Within the drivers with MCI, 43 were diagnosed with amnestic and 3 with non-amnestic MCI. The amnestic group primarily included persons with memory deficits only; a few had multiple-domain deficits including memory. However, the distinction between single and multi-domain impairment was not a focus of the consensus process. Fifty-nine neurocognitively normal control drivers (36 women and 23 men; 9 African Americans and 50 European Americans) had a mean age of 67.07 (± 6.72), mean education of 15.08 (± 2.60) years, mean far visual acuity score of 20/20 Snellen (range 20/30 to 20/13), and mean DRS-2 total score of 137.48 (± 6.26).

There were no group differences on race, education, or visual acuity (ps > .10). The MCI participant group was significantly older than the control group ($p < .01$), received, as expected, significantly lower DRS-2 total scores ($p < .01$), and had fewer females ($p < .045$). Relevant driving history variables were assessed with self report questionnaires. Twelve MCI drivers and 7 control drivers reported being involved as a driver in an automobile crash during the two years prior to study enrollment. Police were reportedly called to the scene in 7 of the MCI participants' crashes and 6 of the controls' crashes. Eight MCI drivers and 11 control drivers reported being pulled over by the police at least once in the past two years, resulting in traffic citations for 1 MCI participant and 2 controls. MCI drivers reported driving an average of 134.75 miles per week (s.d. 108.27), and control drivers 155.84 (s.d. 160.39), a difference that was not statistically significant ($p > .10$).

Written informed consent was obtained from all participants. The research was conducted in accordance with the Helsinki Declaration, and the UAB Institutional Review Board approved all procedures.

On-Road Driving Assessment

The driving skills of each licensed and currently driving participant were assessed in collaboration with the UAB Driving Assessment Clinic, using a standardized route and rating tool developed for research studies29. This assessment was performed during the study visit under clear weather conditions. Under rainy or inclement weather conditions the evaluation was postponed and conducted in fair weather within two weeks of the study visit. Each drive lasted about 45 minutes and occurred between the hours of 12:30 and 4:00 p.m. Central Standard Time. Each participant drove the clinic's vehicle (1998 Chevrolet Lumina) with dual controls under the supervision and evaluation of a Certified Driving Rehabilitation Specialist

(CDRS) who was also a licensed occupational therapist (OTR/L). The CDRS was blind to participants' group status (i.e., MCI or normal control). Although the present study used only one driving evaluator, previous research using the same route and evaluation tool has reported acceptable inter-rater reliability for global ratings (weighted kappa coefficient = .72) using two raters[29], one of whom conducted all the evaluations in this study. The drive was performed along a predetermined route that included (a) two- and four-lane roads with and without median strips and barriers, (b) highways and interstates, (c) intersections with and without traffic lights, and (d) stop and yield signs. Roads were also of varying traffic density. At multiple pre-established points during the drive, the CDRS coded each participant's performance on specific driving skills such as lane control, gap judgment, turning, maintaining proper speed, stopping distance, signaling, obeying traffic signs, pre and post turn position, spacing, steer steadiness, pre and post crossing position, and proper scanning of driving space. These behaviors were sampled within varying contexts, including crossing intersections, merging, turning at intersections, exiting the interstate, changing lanes, driving on straight stretches, and taking curves.

Coding was done on a 5-point Likert scale: 1 = evaluator took control of car; 2 = unsafe; 3 = unsatisfactory; 4 = not optimal; and 5 = optimal. At the end of the drive, the CDRS also rated the participant's overall driving skills on the same 5-point scale. Examples of behaviors associated with each rating level appear in Table 1.

Statistical Analysis

Because a variety of driving skills were coded, and because coding was performed at multiple time points during the driving evaluation, there were numerous indices of driving behavior that were not necessarily independent observations and therefore did not warrant individual examination. We developed a 2-step data reduction strategy. The first part of this strategy involved *a priori* selection of specific driving skills that were judged to be critical for proper and safe operation of a motor vehicle. These skills were turning (right and left turns were examined separately), lane control, gap judgment, steering steadiness, and maintaining proper speed, as well as the global rating that was assigned at the end of the assessment. The second part of this data reduction strategy involved creating composite variables by averaging each participant's ratings on each of the selected driving skills across the three to five occasions that each skill was assessed. The number of occasions for measurement of each skill did not vary among participants.

We used a threshold of < 0.05 for statistical significance. We did not correct for multiple comparisons because 1) we reduced the data to essential skills in order limit the total number of comparisons, and 2) we were interested *a priori* in discrete driving behaviors in addition to the global driving impression of the CDRS.

An examination of group means on the driving variables of interest (Table 2) revealed a restriction in range, because many participants received ratings at or near ceiling. This non-normal distribution of the variables prohibited the use of parametric tests in our analyses. Therefore, we recoded each participant's average scores on the driving variables, as well as each participant's global rating, as dichotomous variables with 0 indicating "less than optimal driving" (mean score less than 5) and 1 indicating "optimal driving" (mean score of 5). Chi-square analyses were then performed to examine the proportion of MCI versus control participants who were designated as "less than optimal" on each driving variable. Next, logistic regression was used to estimate unadjusted and adjusted (for age and gender) odds ratios (ORs) with 95% confidence intervals (CIs) for less than optimal driving only for those variables on which the $\chi 2$ tests revealed significant group differences. Group, age, and gender were entered sequentially so that potential effects of age and gender on the association between diagnostic classification and driving outcome could be assessed. All analyses were performed using SPSS 12.0 (SPSS Inc., Chicago, IL).

RESULTS

Table 3 displays the results of the χ^2 analyses that were performed to determine the proportion of participants in each group who received less than optimal ratings on the driving variables examined. MCI participants were significantly more likely than controls to receive less than optimal ratings on left-hand turns, lane control, and the global rating. MCI participants also tended to receive less than optimal ratings on maintaining proper speed and gap judgment. There were no group differences for right-hand turns or steering steadiness.

At the lower end of the ratings distributions, mean ratings between 3.0 and 4.0 indicating unsatisfactory performance occurred for 4 MCI participants and 2 control participants in the domains of right and left turns and for 1 control participant in the domain of lane positioning. Mean ratings of 2.0, indicating unsafe performance, occurred for 3 MCI participants and no control participant in the domain of right turns. No instance occurred in this study in which the evaluator was required to take control of the car.

We had an insufficient number of cases with nonamnestic MCI to conduct comparisons of their driving performance to those with amnestic deficits. One of the three nonamestic MCI participants received a global rating of 4; the other two received a rating of 5.

Results of logistic regression models estimating ORs for less than optimal ratings on left turns, lane control, and the global rating appear in Table 4. For left turns, the unadjusted OR indicated that MCI patients were 2.39 times more likely than controls to receive a less than optimal rating. After adjusting for age and gender this OR decreased to 1.93 and was no longer significant ($p > .10$). For lane control, the unadjusted OR indicated that MCI patients were 4.10 times more likely than controls to receive a less than optimal rating. This OR was attenuated to 3.69 but remained significant after adjusting for age and gender. Finally, for global ratings, the unadjusted OR indicated that MCI patients were 3.36 times more likely than controls to receive a less than optimal rating. Adjustment for age and gender resulted in an OR of 4.23, which remained significant. Overall, the association between MCI status and less than optimal driving skills was accounted for by age and gender in one (left-hand turn) but not other (lane control and global rating) driving outcomes.

DISCUSSION

The primary contribution of this study is the finding of subtle functional decrements in discrete and overall driving skills and behaviors in persons with MCI. Conceptualized as an instrumental activity of daily living (IADL)—even as “the ultimate IADL” [30]—driving may be added to the list of IADL domains such as handling finances31 in which the functional performance or efficiency32 of individuals with MCI differs significantly from that of cognitively normal controls.

It is equally important to note that the performance decrements found in this study did not rise to the level of frank driving impairments. Such impairments would have resulted in mean ratings associated with descriptors of “unsatisfactory,” “unsafe,” or “evaluator took control of car.” Instead, mean differences in group ratings were small in magnitude (see Table 2), with both MCI participants and control participants receiving high mean ratings representing performance levels between “optimal” and “not optimal.” As a group, however, it appears that individuals with MCI are less likely than cognitively normal peers to seamlessly perform certain routine driving maneuvers, and they may more often evoke a global impression of less-than-optimal driving performance.

As is apparent in Table 3, there was individual variability in both the MCI and control groups, such that from 14% to 41% of control participants received less than optimal ratings on each of the six discrete driving behaviors, as did 22% to 59% of MCI participants. In both groups, a large proportion of suboptimal ratings occurred in conducting left hand turns and steadiness of steering. Thirty seven and forty one percent of the controls, along with 59% and 52% of the MCI participants, committed minor infractions during left turn and steering maneuvers, respectively. The greatest disparities in proportion of suboptimal ratings between groups occurred in maintaining lane control and negotiating left hand turns; these maneuvers may represent greater demands on cognitive abilities beginning to be affected in MCI, particularly in executive functions needed to coordinate responses under challenging conditions. Although speculative, this interpretation is consistent with recent research demonstrating the importance of executive function to maintenance of IADL function[33].

Relative to the ratings of discrete driving behaviors, the global driving ratings in this study, as in most on-road driving studies, were more subjective, in that they were based on the evaluator's overall impression of the drive. Despite the fact that these ratings were not derived quantitatively from the ratings of discrete behaviors, the evaluator's global impressions were no doubt influenced by her immediately preceding observations, and corresponding ratings, of each driving behavior. It is therefore probable that these global ratings represent a robust index of participants' overall driving performance.

Limitations of this study include the cross-sectional design, which does not allow us to conclude definitively that subtle differences in driving behavior among participants with MCI are due to progressive underlying changes in the brain, although this explanation is plausible. It will be of interest to continue this research over time in the final cohort of this longitudinal study. Another potential limitation is that a restricted range and modest variability were obtained in the driving ratings in this study, emphasizing that the performance of controls and MCI participants was similar and grossly intact. We dichotomized our outcome variables and have interpreted our findings with due caution.

We controlled for the influences of age and gender on driving, and our groups were equivalent on indices of visual acuity. Although our sample did not include individuals with physical disabilities or pain syndromes that would preclude driving, it is possible that unmeasured physical limitations or pain may have affected driving performance. In addition, this study primarily recruited individuals with MCI who presented to a memory disorders clinic and therefore may not be representative of a population-based sample of MCI cases. A related issue is that the large majority of persons with MCI in this analysis were classified with amnestic MCI. At least one report has suggested that amnestic deficits may be no more common than nonamnestic deficits constituting alternate forms of MCI[34]. The driving performance of our MCI sample therefore may not represent all MCI cases, especially those who present with primary nonamnestic deficits. To our knowledge, driving performance among individuals diagnosed with nonamnestic MCI remains to be explored and compared to that of individuals with amnestic MCI; unfortunately, we had insufficient nonamnestic cases to conduct such comparisons.

Strengths of this study include the use of well-characterized samples of MCI and cognitively normal control participants who were consensus-diagnosed using multiple sources of information and following standardized and widely accepted criteria for MCI27. In addition, we used a comprehensive and objective evaluation of driving performance rather than self or informant report of driving competence. Although clinically meaningful, the latter indices are subject to biases associated with recall, diminished awareness, denial of deficits, affective states, and social desirability by cognitively impaired individuals and their proxies35,[36]. Finally, the driving evaluations in this study were conducted by a licensed occupational therapist (Ms. Elgin) who is a certified driving rehabilitation specialist involved in both research and clinical driving evaluations. This rater was, and remains, blind to MCI classification of study participants in this ongoing research.

Clinicians should recognize that a substantial proportion of individuals with MCI might be experiencing subtle changes in driving skills that do not rise to the level of impairments, and in most cases do not warrant driving restriction or cessation, but certainly do warrant monitoring. At the same time, results of this study suggest that a lesser but still fair proportion of cognitively normal older adults also evidence less than optimal driving behaviors, particularly in the performance of left hand turns and steering steadiness. Although individuals with MCI progress to dementia at a much higher rate per year than cognitively intact peers[37], neither MCI nor "normal" cognitive aging are static conditions. Even among cognitively normal older adults who may not progress to either MCI or dementia, subtle driving changes could progressively worsen. Because driver interventions may be more effective when problems are identified early, monitoring for changes in driving among all older adults may be beneficial.

The present finding of significant differences between MCI and controls on global driving ratings extends recent evidence[38] that some but not all drivers with early or very early Alzheimer disease, and relatively fewer normal elders, decline in driving abilities over time to a degree that is potentially hazardous[38]. These findings argue for increased vigilance among clinicians, family members, and individuals with MCI for initially benign changes in driving that may become increasingly problematic over time. Clinicians should become aware of and utilize available resources for on-road driving evaluations in their vicinities, because such referrals can provide a valuable source of objective information regarding driving performance. Finally, given the relationship between complex attention, processing speed, and driving outcomes such as crash risk[39], interventions that improve function in these cognitive domains may hold promise for maintaining driving skills and safety in MCI.

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REFERENCES

1. Fonda SJ, Wallace RB, Herzog AR. Changes in driving patterns and worsening depression symptoms among older adults. J Gerontol B Psychol Sci Soc Sci 2001;56:S343–S351. [PubMed: 11682595]
2. Freeman E, Gange SJ, Munoz B, West SK. Driving status and risk of entry into long-term care in older adults. Am J Public Health 2006;96:1254–1259. [PubMed: 16735633]
3. Marottoli RA, Mendes de Leon CF, Glass TA, Williams CS, Cooney LM, Berkman LF. Consequences of driving cessation: Decreased out-of-home activity levels. J Gerontol B Psychol Sci Soc Sci 2000;55:S334–S340. [PubMed: 11078110]
4. Marottoli RA, Mendes de Leon CF, Glass TA, Williams CS, Cooney LM, Berkman LF, Tinetti ME. Driving cessation and increased depressive symptoms: prospective evidence from the New Haven EPESE. J Am Geriatr Soc 1997;45:202–206. [PubMed: 9033520]
5. Ragland DR, Satariano WA, MacLeod KE. Driving cessation and increased depressive symptoms. J Gerontol A Biol Sci Med Sci 2005;60:399–403. [PubMed: 15860482]

6. Owsley C, McGwin G, Scilley K, Girkin CA, Phillips JM, Searcey K. Perceived barriers to care and attitudes about vision and eye care: Focus groups with older African Americans and eye care providers serving their communities. Invest Ophthalmol Vis Sci 2006;47:2797–2802. [PubMed: 16799016]
7. Carr DB. The older adult driver. Am Fam Physician 2007;61:141–146. 148. [PubMed: 10643955]
8. Burkhardt, J.; Berger, AM.; McGavock, AT. The mobility consequences of the reduction or cessation of driving by older women. In: Rosenbloom, S., editor. Proceedings from the second national conference on women's travel issues. Washington, DC: U.S. Department of Transportation, Federal Highway Administration; 1996. p. 440-454.
9. National Highway Traffic Safety Administration. Countermeasures that work: A highway safety countermeasure guide for state highway safety offices (DOT HS 809 980). Washington, DC: U.S: Department of Transportation; 2006.
10. Gao S, Hendrie HC, Hall KS, Hui S. The relationship between age, sex, and the incidence of dementia and Alzheimer's disease: A meta-analysis. Arch Gen Psychiatry 1998;55:809–815. [PubMed: 9736007]
11. Yamada M, Kasagi F, Sasaki H, Masunari N, Mimori Y, Suzuki G. Association between dementia and midlife risk factors: The Radiation Effects Research Foundation Adult Health Study. J Am Geriatr Soc 2003;51:410–414. [PubMed: 12588587]
12. Carr DB, Duchek JM, Meuser TM, Morris JC. Older adult drivers with cognitive impairment. Am Fam Physician 2007;73:1029–1034. [PubMed: 16570737]
13. Withaar FK, Brouwer WH, van Zomeren AH. Fitness to drive in older drivers with cognitive impairment. J Int Neuropsychol Soc 2000;6:480–490. 14. [PubMed: 10902417]
14. Friedland RP, Koss E, Kumar A, Gaine S, Metzler D, Haxby JV, Moore A. Motor vehicle crashes in dementia of the Alzheimer's type. Ann Neurol 1988;24:782–786. [PubMed: 3207361]
15. Tuokko H, Tallman K, Beattie BL, Cooper P, Weir J. An examination of driving records in a dementia clinic. J Gerontol B Psychol Sci Soc Sci 1995;50:S173–S181. [PubMed: 7767701]
16. Duchek JM, Carr DB, Hunt L, Roe CM, Xiong C, Shah K, Morris JC. Longitudinal driving performance in early-stage dementia of the Alzheimer type. J Am Geriatr Soc 2003;51:1342–1347. [PubMed: 14511152]
17. Morris JC. The Clinical Dementia Rating (CDR): current version and scoring rules. Neurology 1993;43:2412–2414. [PubMed: 8232972]
18. Uc EY, Rizzo M, Anderson SW, Shi Q, Dawson J. Unsafe rear-end collision avoidance in Alzheimer's disease. J Neurol Sci 2006;251:35–43. [PubMed: 17049360]
19. Dubinsky RM, Stein AC, Lyons K. Practice parameter: risk of driving and Alzheimer's disease (an evidence-based review): report of the quality standards subcommittee of the American Academy of Neurology. Neurology 2000;54:2205–2211. [PubMed: 10881240]
20. Petersen RC, Doody R, Kurz A, Mohs RC, Morris JC, Rabins PV, Ritchie K, Rossor M, Thal L, Winblad B. Current concepts in mild cognitive impairment. Arch Neurol 2001;58:1985–1992. [PubMed: 11735772]
21. Okonkwo O, Griffith HR, Belue K, Lanza S, Zamrini E, Harrell LE, Marson DC. Medical decision-making capacity in patients with mild cognitive impairment. Neurology. in press.
22. Tuokko H, Morris C, Ebert P. Mild cognitive impairment and everyday functioning in older adults. Neurocase 2005;11:40–47. [PubMed: 15804923]
23. Wadley VG, Crowe M, Marsiske M, Cook SE, Unverzagt FW, Rosenberg AL, Rexroth D. Changes in everyday function among individuals with psychometrically defined Mild Cognitive Impairment in the Advanced Cognitive Training for Independent and Vital Elderly Study. J Am Geriatr Soc 2007;55:1192–1198. 24. [PubMed: 17661957]
24. Burns A, Zaudig M. Mild cognitive impairment in older people. Lancet 2002;360:1963–1965. [PubMed: 12493278]
25. Carr DB, Duchek JM, Morris JC. Characteristics of motor vehicle crashes of drivers with dementia of the Alzheimer type. J Am Geriatr Soc 2000;48:18–22. [PubMed: 10642016]
26. Whelihan WM, DiCarlo MA, Paul RH. The relationship of neuropsychological functioning to driving competence in older persons with early cognitive decline. Arch Clin Neuropsychol 2005;20:217–228. [PubMed: 15770793]

27. Petersen RC. Mild cognitive impairment as a diagnostic entity. J Intern Med 2004;256:183–194. [PubMed: 15324362]

28. Jurica, PJ.; Leitten, CL.; Mattis, S. Psychological Assessment Resources. 2nd ed.. Lutz, FL: 2001. Dementia Rating Scale.

29. Bowers A, Peli E, Elgin J, McGwin G, Owsley C. On-road driving with moderate visual field loss. Optom Vis Sci 2005;82:657–667. [PubMed: 16127330]

30. Sherman FT. Driving: the ultimate IADL. Geriatrics 2006;61:9–10.

31. Griffith HR, Belue K, Sicola A, Krzywanski S, Zamrini E, Harrell L, Marson DC. Impaired financial abilities in mild cognitive impairment. Neurology 2003;60:449–457. [PubMed: 12578926]

32. Wadley VG, Okonkwo O, Crowe M, Ross-Meadows LA. Mild Cognitive Impairment and everyday function: evidence of reduced speed in performing instrumental activities of daily living. Am J Geriatr Psychiatry. 2008 April; in press.

33. Cahn-Weiner DA, Farias ST, Julian L, Harvey DJ, Kramer JH, Reed BR, Mungas D, Wetzel M, Chui H. Cognitive and neuroimaging predictors of instrumental activities of daily living. J Int Neuropsychol Soc 2007;13:747–757. [PubMed: 17521485]

34. Busse A, Hensel A, Guhne U, Angermeyer MS, Riedel-Heller SG. Mild cognitive impairment: long-term course of four clinical subtypes. Neurology 2006;67:2176–2185. [PubMed: 17190940]

35. Loewenstein DA, Argüelles S, Bravo M, Freeman RQ, Argüelles T, Acevedo A, Eisdorfer C. Caregivers' judgments of the functional abilities of the Alzheimer's disease patient: A comparison of proxy reports and objective measures. J Gerontol B Psychol Sci Soc Sci 2001;56B:P78–P84. [PubMed: 11245361]

36. Wadley VG, Harrell LE, Marson DC. Self- and informant report of financial abilities in patients with Alzheimer's disease: Reliable and valid? J Am Geriatr Soc 2003;51:1621–1626. [PubMed: 14687393]

37. Lopez OZ, Kuller LH, Becker JT, Dulberg C, Sweet RA, Gach HM, Dekosky ST. Incidence of dementia in mild cognitive impairment in the cardiovascular health cognition study. Arch Neurol 2007;64:416–420. [PubMed: 17353386]

38. Ott BR, Heindel WC, Papandonatos GD, Festa EK, Davis JD, Daiello LA, Morris JC. A longitudinal study of drivers with Alzheimer disease. Neurology. 2008 [E-Pub ahead of print].

39. Owsley C, Ball K, McGwin G, Sloane ME, Roenker DL, White MF, Overley ET. Visual processing impairment and risk of motor vehicle crash among older adults. JAMA 1998;279:1083–1088. [PubMed: 9546567]

Table 1

Sample behaviors associated with Below Optimal ratings

Rating	Sample Behaviors
4—Not Optimal	Driving too fast or too slow (5 mph over or under limit)
	Driving too close to center of two-lane road
3—Unsatisfactory	Driving too fast around curve or turn (5 mph over limit)
	Driving on the center line of two-lane road
2—Unsafe	Driving too fast around curve or turn (10 mph over limit)
	Driving across the center line of two-lane road
1—Evaluator took control of car	Speed, lane position, or gap judgment behaviors requiring evaluator to engage dual brake or steering controls

Table 2

Group ratings on driving skills

Variable	Range	Controls, n = 59	MCI, n = 46
Right turn	1–5	4.94 (0.12)	4.75 (0.75)
Left turn	1–5	4.82 (0.28)	4.72 (0.34)
Lane control	1–5	4.94 (0.17)	4.86 (0.22)
Gap judgment	1–5	4.97 (0.05)	4.93 (0.12)
Steer steadiness	1–5	4.92 (0.16)	4.80 (0.30)
Maintaining speed	1–5	4.93 (0.12)	4.85 (0.22)
Global rating	1–5	4.83 (0.38)	4.63 (0.49)

For Range, 1 = evaluator took control of car; 2 = unsafe; 3 = unsatisfactory; 4 = not optimal; and 5 = optimal. Note: No ratings of 1 were given in this study.

Values are mean (SD).

Table 3

Group comparisons on proportion of participants receiving less than optimal ratings

Variable	Controls, n = 59	MCI, n = 46	χ^2	p value
Right turn	12 (20.3)	10 (21.7)	0.03	.861
Left turn	22 (37.3)	27 (58.7)	4.76	.029
Lane control	8 (13.6)	18 (39.1)	9.07	.003
Gap judgment	14 (23.7)	18 (39.1)	2.89	.089
Steer steadiness	24 (40.7)	24 (52.2)	1.38	.241
Maintaining speed	21 (35.6)	24 (52.2)	2.90	.088
Global rating	11 (18.6)	20 (43.5)	7.67	.006

Values are n (%) and represent participants who received less than optimal ratings

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Table 4

Odds Ratios and 95% CIs for Less than Optimal Driving Performance

	Left turn		*Lane control*		*Global rating*	
	Unadjusted, OR (CI)	**Adjusted,† OR (CI)**	**Unadjusted, OR (CI)**	**Adjusted,† OR (CI)**	**Unadjusted, OR (CI)**	**Adjusted,† OR (CI)**
MCI	2.39 (1.09, 5.26)	1.93 (0.82, 4.54)	4.10 (1.58, 10.62)	3.69 (1.30, 10.46)	3.36 (1.40, 8.07)	4.23 (1.47, 12.15)

Controls are the comparison group.

†Adjusted for age and gender