

Supplemental Material

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Subject Characteristics for Primary Studies Included in the Meta-Analysis

Study	N	Mean Age	Mean Education	Sample Characteristics	Driving Measures
Bieliauskas, Roper, Trobe, Green, & Lacy, 1998	18	71.1	14.3	AD and age matched controls who were all driving. Mean MMSE for AD group=19.4.	<u>Road Test</u> : 30-minute road test on a set course on lightly traveled urban streets. NT were correlated with total driving errors, turning errors, & errors other than turning.
Brashear et al., 1998	84	70.5	Not reported	Individuals with dementia and controls. Dementia group CDR \leq 1.0. Corrected vision 20/40 or better and a valid driver's license. Exclusion criteria: professional driving experience, clinical stroke, arthritis sufficient to interfere with driving, use of alcohol or sedating medication.	<u>Non-Road Test</u> : Traffic Sign Recognition test
Carr, LaBarge, Dunnigan, & Storandt, 1998	146	76.8	13.8	AD and controls with a history of driving and a collateral source familiar with the participant's driving history. CDR range = 0.5–2.0 and a mean Short Blessed=12.3 for the AD group. Participants were medically stable and assessed for significant visual or language dysfunction	<u>Non-Road Test</u> : Traffic Sign Naming Test
Cox et al., 1998	50	71.2	14.8	AD and controls older than 55. AD patients were diagnosed for at least 6 months and had no other medical conditions or medications that could affect driving. Patients were recruited from outpatients participating in drug protocols. Patients' mean MMSE=21.2.	<u>Non-Road Test</u> : Atari driving simulator: Participants drove approximately 8 miles on a course that was designed to simulate the demands of a typical grade 2 US highway.

Cushman, 1992	17	75	Not reported	Suspected dementia and controls	<u>Road Test</u> : Parking lot and road tests on a prescribed route, progressing from low-demand to high-demand tasks in moderate to heavy traffic. NT were compared to minimum standard driving scores.
Cushman, 1996	123	Not reported	Not reported	Possible or probable early AD and controls over the age of 55. All had at least 10 years of driving experience and a current state driver's license. Subjects were screened for the presence of disabling medical and neurological conditions	<u>Road Test</u> : Parking lot and road test on a prescribed route with a certified driving evaluator. The exam progressed from low-demand tasks to in-traffic maneuvers in moderate to heavy traffic.
Donnelly, Karlinsky, Young, Ridgley, & Lamble, 1992	12 ^a	70.25 ^a	Not reported	Probable, possible AD and cognitively impaired but non-demented. Although controls were included in the study, the primary authors excluded them from the data that was coded for this meta-analysis. All participants had a valid driving license. Mean MMSE=23.33 in patient group.	<u>Road Test</u> : Weekday, off-peak road test. NT were correlated with a total drive score <u>Non-Road Tests</u> : Written Driving Tests: Rules of the Road, and Road and Traffic Sign Interpretation. Distance Judgment required identifying which of 3 cars was closest to or furthest from the subject while looking through an eyepiece.
Duchek, Hunt, Ball, Buckles, & Morris, 1998	136	Not reported	Not reported	Very mild AD, mild AD, and controls who were all driving at the time of the study, had corrected vision of at least 20/50, and had at least 10 years of driving experience. CDR range=0.5-1. Exclusion criteria: depression, hypertension, reversible dementias, other disorders that could potentially produce cognitive impairment	<u>Road Test</u> : 45-minute parking lot and in-traffic road test along a predetermined route at the same time of day, in good road conditions. NT were compared to a total drive score.

Fitten et al., 1995	83	71.4	14.0	Probable AD, vascular dementia, and 3 control groups (well-controlled diabetes, healthy older subjects, healthy younger subjects). All participants had at least corrected vision of 20/40, and long-standing unrestricted driving licenses. None were taking psychoactive medications or had been professional drivers. Inclusion was restricted in the dementia groups, diabetes control group, and healthy control groups by MMSE \geq 19, 24, and 28, respectively. Exclusion criteria: significant co-morbidities, participation in drug trials, large strokes.	<u>Road Test</u> : A Saturday morning, 2.7 mile course on VA medical center grounds with low-level traffic conditions. Six stages were used to assess specific driving skills. NT were correlated with a total drive score.
Fox, Bowden, Bashford, & Smith, 1997	19	74.3	Not reported	Probable AD. All but one were still driving, and all wanted to continue driving. Mean MMSE=21.3	<u>Road Test</u> : Standardized, daylight route in a suburban area with light to moderate traffic. NT were correlated with the total driving score.
Friedland et al., 1988	24 ^a	67.0	Not reported	Probable AD. No subject took medication that could have affected driving during the reviewed period. Inclusion required that subjects had driven for at least 10 years prior to beginning the study. Although controls were included in the study, the primary authors excluded them from the data that was coded for this meta-analysis.	<u>Caregiver Report</u> : Spouse or first degree relative who had lived with the patient for at least 5 years prior to the onset of illness completed a questionnaire that was developed by the authors.
Gilley et al., 1991	487	72.2	Not reported	Dementia patients with MMSE<24 or MDRS<130. Dementia group's mean MMSE=15.6. Of the sample, 333 participants were licensed to drive at the time of the interview. Exclusion criteria: institutionalization, no primary caregiver with sufficient familiarity with patient's driving history	<u>Caregiver Report</u> : A 15-item questionnaire was used through a structured interview with the patient's primary caregiver.
Harvey et al., 1995	13	63	Not reported	Driving individuals with AD and focal dementia syndromes. Mean MMSE=20.8	<u>Non-Road Test</u> : DRIVAGE simulator consisted of the front half of a car with a large monitor that replaced the windshield. Subjects were instructed to follow a car at a safe distance, controlling the car's brake and gas

					pedals only. NT were compared to driving ratings.
Hunt et al., 1997	123	75.2	14.2	Probable AD and controls who were actively driving and had at least 10 years of driving experience. Inclusion required visual acuity of 20/50. Patients had a CDR of .5 or 1 with mean Short Blessed Test scores of 4.8 and 14.2, respectively.	<u>Road Test:</u> Washington University Road Test consisted of 9.6 km course in various road and traffic conditions with a certified driving instructor. Performance difficulty was distributed evenly throughout the test. Subjects passed a closed-course test in a parking lot before the open road test. Testing was not done in adverse road conditions.
Hunt, Morris, Edwards, & Wilson, 1993	38	73.2	13.3	Probable AD and controls. The AD group had a CDR range from 0.5-1, with a mean Short Blessed test score=7.5. At the time of the study, subjects met the following inclusion criteria: presently driving with at least 10 years experience, no major physical impairment., collateral source familiar with driving history.	<u>Road Test:</u> A 1 hour, predesigned route on urban streets and highways during low-traffic hours and good road conditions. NT were correlated with pass/fail driving scores
Janke & Eberhard, 1998	106	73.6	Not reported	Controls and subjects with dementia or other aging-related medical conditions that resulted in a referral to the DMV. Subjects were at least 55 years old and literate.	<u>Road Tests:</u> Modified Driving Performance Evaluation: A 30- to 45-minute fixed route driving test scored based on errors on structured maneuvers. Area Driving Performance Evaluation: A road test performed in the subject's home neighborhood and scored in a similar way.
Logsdon, Teri, & Larson, 1992	100	74	13	AD patients with a mean MMSE=19.0. Exclusion criteria: never driven or had stopped driving for reasons other than dementia.	<u>Caregiver Report:</u> Caregiver interview using the Record of Independent Living. NT were compared to the item on difficulty while driving
Lucas-Blaustein, Flipp, Dungan, & Tune, 1988	53	71.8	Not reported	Dementia patients with a mean MMSE=17.6.	<u>Caregiver Report:</u> A 20-item screening survey was administered to caregivers or relatives knowledgeable about the patient's driving history. NT were compared to automobile accidents.

Odenheimer et al., 1994	30	72.2	77% had high school or higher	AD, VD and control subjects over 60 with driver's licenses. Dementia group's mean MMSE=14.8. Exclusion criteria: major functional impairments and corrected vision worse than 20/199.	<u>Road Test</u> : A 10 mile, 45 minute road test with both closed course and traffic components. The in-traffic score was correlated with NT.
O'Jile, 1998	50	75.0	13.4	AD and age/education matched controls. All subjects had at least 10 years driving experience with at least one year of driving after onset of symptoms. All but 2 subjects were still driving. AD group's mean MMSE=21.68. Exclusion criteria: drug, alcohol, or physical illness that could compromise cognitive functioning	<u>Caregiver Report</u> : Collateral –reported driving data since the onset of symptoms (or the last 6 years for controls). A Total Driving Index was calculated from the collateral's data and correlated with NT.
O'Neill et al., 1992	57	72.0	Not reported	AD and other dementia patients who continued to drive after the onset of symptoms. Mean MMSE=18.7	<u>Caregiver Report</u> : Caregivers completed a questionnaire regarding the patient's duration of driving, quality of driving, adherence to speed limits, number of accidents, and whether the patient got lost.
Ott et al., 2000	79	74.7	11.6	Probable and possible AD. Mean MMSE=19.6. Attempts to exclude other treatable causes of dementia were made with a battery of lab tests and CTs or MRIs.	<u>Caregiver Report</u> : Caregivers rated subject driving ability on a 4 point scale. Driving score was correlated with NT.
Rebok, Keyl, Bylsma, Blaustein, & Tune, 1994	10 ^a	75.4 ^a	13.3 ^a	Probable AD. Although controls were included in the study, the primary authors excluded them from the data that was coded for this meta-analysis. All subjects had driver's licenses and were driving or had stopped within 6 months of the study. AD group's mean MMSE=22.5.	<u>Non-Road Tests</u> : Driver Performance Test: videotaped presentation of 40 driving situations, each followed by multiple choice questions. Driving Advisement System: a computer-based system with a three pedal floor plate and steering wheel was used to assess 5 driving tasks.

Rizzo et al., 1997	39	71.7	Not reported	AD and control patients. Brain scans were completed on patients to exclude lesions due to cerebrovascular and neoplastic disease. Other exclusion criteria included alcoholism, stroke, depression, vestibular disease, and motion sickness.	<u>Non-Road Test:</u> Iowa Driving Simulator: Participants drove approximately 29 km on a simulated rural 2-lane highway with interactive traffic. Four events associated with potential crashes were interspersed with uneventful driving. Subjects began with a 15- to 20-minute warm-up and training period. Crash was correlated with NT.
Rizzo et al., 2001	30	71.8	Not reported	AD and control patients with current state driver's licenses. Brain scans were completed on patients to exclude lesions due to stroke, neoplasm, or other causes. Other exclusion criteria included alcoholism, stroke, depression, vestibular disease, and motion sickness.	<u>Non-Road Test:</u> Iowa Driving Simulator: Participants drove approximately 15 miles on a simulated rural 2-lane highway with interactive traffic. The scenario culminated with an illegal incursion by another vehicle at an intersection. Subjects began with a 15- to 20-minute warm-up and training period. Crash at intersection was correlated with NT.
Tallman, 1992	54	62.4	12.1	AD, elderly controls, and mid-age controls. All subjects had driven within 1 month of the study. AD group's mean MMSE=23.6. Exclusion criteria: MMSE<20 (AD group), major psychiatric disorder, Parkinson's, disorders interfering with physical mobility, marked vision loss, mental retardation, delirium, or neurological disorders	<u>On-Road:</u> Motor Vehicle Branch Road Test: tested knowledge and abilities to interact with traffic in everyday situations. Hazard Avoidance Task: a closed circuit test in which a trigger switch automatically caused a styrofoam car to move in front of the approaching vehicle. Cone Avoidance Task: tested ability to drive through a course of traffic cones. <u>Non-Road:</u> Computerized Driving Assessment Module: tested simulator brake reaction time and steering accuracy.
Zuin, Ortiz, Boromei,	56 ^a	71.8 ^a	7.0 ^a	Probable AD without focal lesions interpreted as strokes	<u>Caregiver Report:</u> Driving interviews

& Lopez, 2002			<p>on brain scans. This group included patients with cerebrovascular disease, head injury, depression, alcoholism, hypothyroidism, vitamin B12 deficiency, and history of encephalitis. The patient group also included vascular and other dementias. Although controls were included in the study, the primary authors excluded them from the data that was coded for this meta-analysis.</p>	<p>were conducted by neurologists with a reliable informant. Questions regarding specific driving errors were totaled under an “abnormal driving behaviours” score.</p>
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^a Control subjects were excluded by the primary authors in data that was coded in this meta-analysis. Therefore, only the dementia group statistics are reported here.

AD = Alzheimer's disease; IVD = ischemic vascular dementia; LD = learning disability; MMSE = Mini-Mental Status Examination; NT = neuropsychological tests; CDR = Clinical dementia Rating; MDRS = Mattis Dementia Rating Scale; MID=Mult-Infarct Dementia; CVA = cerebral vascular accident; CT = computed tomography; MRI = magnetic resonance imaging

Bibliography of Aging and Driving Literature with the Reason for Exclusion from the Meta-Analysis

Study	Reason for Exclusion
Adler, G., Rottunda, S., Bauer, M., & Kuskowski, M. (2000). Driving cessation and AD: Issues confronting patients and family, <u>American Journal of Alzheimer's Disease</u> , 15, 212-216.	No appropriate data
Adler, G., Rottunda, S., & Dysken, M. W. (1996). The driver with dementia, <u>The American Journal of Geriatric Psychiatry</u> , 4, 110-120.	No appropriate data
Bahro, M., Silber, E., Box, P., & Sunderland, T. (1995). Giving up driving in Alzheimer's disease - An integrative therapeutic approach, <u>International Journal of Geriatric Psychiatry</u> , 10, 871-874.	No appropriate data
Ball, K. (1997). Attentional problems and older drivers, <u>Alzheimer's Disease and Associated Disorders</u> . 11(Suppl. 1), 42-47.	No appropriate data
Ball, K., Owsley, C., Sloane, M. E., Roenker, D. L., & Bruni, J. R. (1993). Visual attention problems as a predictor of vehicle crashes in older drivers, <u>Investigative Ophthalmology & Visual Science</u> , 34, 3110-3123.	No subjects diagnosed with dementia

<p>Bedard, M., Molloy, D. W., & Lever, J. A. (1998). Factors associated with motor vehicle crashes in cognitively impaired adults, <u>Alzheimer's Disease and Associated Disorders</u>, <u>12</u>, 135-139.</p>	<p>No appropriate data</p>
<p>Bloedow, R. A. & Adler, G. (1992). Driving and dementia: Perspectives from an outpatient clinic, <u>Social Work in Health Care</u>, <u>17</u>, 31-43.</p>	<p>No appropriate data</p>
<p>Brouwer, W. H. & Ponds, R. W. H. M. (1994). Driving competence in older persons, <u>Disability and Rehabilitation</u>, <u>16</u>, 149-161.</p>	<p>No appropriate data</p>
<p>Bylsma, F. W. (1997). Simulators for assessing driving skills in demented patients, <u>Alzheimer's Disease and Associated Disorders</u>, <u>11</u>(Suppl. 1), 17-20.</p>	<p>No appropriate data</p>
<p>Cable, G., Reisner, M., Gerges, S., & Thirumavalavan, V. (2000). Knowledge, attitudes, and practices of geriatricians regarding patients with dementia who are potentially automobile drivers: A national survey, <u>Journal of the American Geriatrics Society</u>, <u>48</u>, 14-17.</p>	<p>No appropriate data</p>
<p>Carr, D. B. (1997). Motor vehicle crashes and drivers with DAT, <u>Alzheimer Disease and Associated Disorders</u>, <u>11</u>(Suppl. 1), 38-41.</p>	<p>No appropriate data</p>
<p>Carr, D. B. (2000). Characteristics of motor vehicle crashes of drivers with dementia of the Alzheimer type, <u>Journal of the American Geriatrics Society</u>, <u>48</u>, 18-22.</p>	<p>No appropriate data</p>
<p>Cotrell, V. & Wild, K. (1999). Longitudinal study of self-imposed</p>	<p>No appropriate</p>

driving restrictions and deficit awareness in patients with Alzheimer's disease, <u>Alzheimer Disease and Associated Disorders</u> , 13, 151-156.	data
Crook, T. H., West, R. L., & Larrabee, G. J. (1993). The driving-reaction time test: Assessing age declines in dual-task performance, <u>Developmental Neuropsychology</u> , 9, 31-39.	No subjects diagnosed with dementia
De Raedt, R. & Ponjaert-Kristoffersen, I. (2000). The relationship between cognitive/neuropsychological factors and car driving performance in older adults, <u>Journal of the American Geriatrics Society</u> , 48, 1664-1668.	No subjects diagnosed with dementia
Dobbs, A. R. (1997). Evaluating the driving competence of dementia patients, <u>Alzheimer Disease and Associated Disorders</u> , 11(Suppl. 1), 8-12.	No appropriate data
Drachman, D. A. (1988). Who may drive? Who may not? Who shall decide? <u>Annals of Neurology</u> , 24, 787-788.	No appropriate data
Drachman, D. A. & Swearer, J. M. (1993). Driving and Alzheimer's disease: The risk of crashes, <u>Neurology</u> , 43, 2448-2456.	No subjects diagnosed with dementia
Dubinsky, R. M., Stein, A. C., & Lyons, K. (2000). Practice parameter: Risk of driving and Alzheimer's disease (an evidence-based review), <u>Neurology</u> , 54, 2205-2211.	No appropriate data
Dubinsky, R. M., Williamson, A., Gray, C. S., & Glatt, S. L. (1992). Driving and Alzheimer's disease, <u>Journal of the American</u>	No appropriate data

Geriatrics Society, 40, 1112-1116.

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| Fitten, L. J. (1997). The demented driver: The doctor's dilemma, <u>Alzheimer Disease and Associated Disorders, 11(Suppl. 1), 57-61.</u> | No appropriate data |
| Foley, D. J., Wallace, R. B., & Eberhard, J. (1995). Risk factors for motor vehicle crashes among older drivers in a rural community, <u>Journal of the American Geriatrics Society, 43, 776-781.</u> | No appropriate data |
| Fox, G. K., Withaar, F., & Bashford, G. M. (1996). Dementia and driving: A survey of clinical practice in aged care assessment teams, <u>Australian Journal on Ageing, 15, 111-114.</u> | No appropriate data |
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- Hunt, L. A., Murphy, C. F., Carr, D., Duchek, J. M., Buckles, V., & Morris, J. C. (1997). Environmental cueing may affect performance on a road test for drivers with dementia of the Alzheimer type, Alzheimer Disease and Associated Disorders, *11*(Suppl. 1), 13-16. No appropriate data
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- Johansson, K. & Lundberg, C. (1997). The 1994 international consensus conference on dementia and driving: A brief report, Alzheimer Disease and Associated Disorders, *11*(Suppl. 1), 62-69. No appropriate data

<p>Kapust, L. R. & Weintraub, S. (1992). To drive or not to drive: Preliminary results from road testing of patients with dementia, <u>Journal of Geriatric Psychiatry and Neurology</u>, <i>5</i>, 210-216.</p>	<p>Case studies</p>
<p>Kaszniak, A. W. (1991). Dementia and the older driver, <u>Human Factors</u>, <i>33</i>, 527-537.</p>	<p>No appropriate data</p>
<p>Kolowski, S. J. & Rossiter, J. (2000). Driving in Somerset, <u>Psychiatric Bulletin</u>, <i>24</i>, 304-306.</p>	<p>No appropriate data</p>
<p>Lundberg, C., Hakamies-Blomqvist, L., Almkvist, O., & Johansson, K. (1998). Impairments of some cognitive functions are common in crash-involved older adults, <u>Accident Analysis and Prevention</u>, <i>30</i>, 371-377.</p>	<p>No subjects diagnosed with dementia</p>
<p>Marottoli, R. A. (1997). Crashes: Outcome of choice in assessing driver safety?, <u>Alzheimer Disease and Associated Disorders</u>, <i>11</i>(Suppl. 1), 28-30.</p>	<p>No appropriate data</p>
<p>Marottoli, R. A., Cooney, L. M., Wagner, R., Doucette, J., & Tinetti, M. E. (1994). Predictors of automobile crashes and moving violations among elderly drivers, <u>Annals of Internal Medicine</u>, <i>121</i>, 842-846.</p>	<p>No subjects diagnosed with dementia</p>
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Parasuraman, R. (1991). Attention and driving skills in aging and Alzheimer's disease, <u>Human Factors</u> , 33, 539-557.	No appropriate data
Perryman, K. M. & Fitten, L. J. (1996). Effects of normal aging on the performance of motor-vehicle operational skills, <u>Journal of Geriatric Psychiatry and Neurology</u> , 3, 136-141.	No subjects diagnosed with dementia
Perryman, K. M. & Fitten, L. J. (1994). Impact of attentional deficits on driving performance of the elderly and individuals with mild Alzheimer's disease. In L. J. Fitten (Ed.), <u>Facts and Research in Gerontology</u> (pp. 91-102). New York, NY: Springer.	No appropriate data
Ponds, R. W. H. M., Brouwer, W. H., & van Wolffelaar (1988). Age differences in divided attention in a simulated driving task, <u>Journal of Gerontology</u> , 43, 151-156.	No subjects diagnosed with dementia
Reinach, S. J., Rizzo, M., & McGehee, D. V. (1997). Driving with Alzheimer disease: The anatomy of a crash, <u>Alzheimer Disease and Associated Disorders</u> , 11(Suppl. 1), 21-27.	No appropriate data
Rothke, S. (1989). The relationship between neuropsychological test scores and performance on a driving evaluation, <u>International Journal of Clinical Neuropsychology</u> , 11, 134-136.	No subjects diagnosed with dementia
Sekuler, A. B. & Bennett, P. J. (2000). Effects of aging on the useful	No subjects

field of view, <u>Experimental Aging Research</u> , 26, 103-120.	diagnosed with dementia
Sims, R. V., McGwin, G., Allman, R. M., Ball, K., & Owsley, C. (2000). Exploratory study of incident vehicle crashes among older adults, <u>Journal of Gerontology</u> , 55A, M22-M27.	No subjects diagnosed with dementia
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Trobe, J. D., Waller, P. F., Cook-Flannagan, C. A., Teshima, S. M., Bieliauskas, L. A. (1996). Crashes and violations among drivers with Alzheimer's disease, <u>Archives of Neurology</u> , 53, 411-416.	No appropriate data
Tuokko, H. (1995). Predictors of motor vehicle crashes in a dementia clinic population: The role of gender and arthritis, <u>Journal of the American Geriatrics Society</u> , 43, 1444-1445.	No appropriate data
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Previously Unpublished Data Incorporated into the Meta-Analysis

Predictor Variable	Spearman correlation with crashing at least once in scenarios (Rizzo et al., 1997)		Spearman correlation with crashing at least once at intersection (Rizzo et al., 2001)	
	<u>n</u>	<u>r</u>	<u>n</u>	<u>r</u>
Temporal Orientation	39	-0.539	30	-0.387
WAIS-R Information	39	-0.490	30	-0.344
Controlled Oral Word Association	39	-0.439	30	-0.598
WAIS-R Digit Span	39	-0.500	30	-0.423
Rey-Osterrieth Complex Figure Test	39	-0.607	30	-0.371
Benton-Van Allen Facial Recognition Test	39	-0.605	27	-0.121
WAIS-R Block Design	39	-0.561	29	-0.394
Benton Visual Retention Test	37	-0.437	30	-0.316
Correct Trail Making Test (Part B)	39	-0.592	30	-0.442
Useful Field of Vision Total Loss	38	0.560	30	0.329

Note: Higher scores indicate better cognitive functioning on all tests except Useful Field of Vision. Data submitted with the authors permission.

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