# Visual and Cognitive Deficits Predict Stopping or Restricting Driving: The Salisbury Eye Evaluation Driving Study (SEEDS)

*Lisa Keay,*[1,2] *Beatriz Munoz,*[1] *Kathleen A. Turano,*[3] *Shirin E. Hassan,*[3] *Cynthia A. Munro,*[4] *Donald D. Duncan,*[5] *Kevin Baldwin,*[5] *Srichand Jasti,*[1] *Emily W. Gower,*[1] *and Sheila K. West*[1]

**Purpose.** To determine the visual and other factors that predict stopping or restricting driving in older drivers.

**Methods.** A group of 1425 licensed drivers aged 67 to 87 years, who were residents of greater Salisbury, participated. At 1 year after enrollment, this group was categorized into those who had stopped driving, drove only within their neighborhood, or continued to drive beyond their neighborhood. At baseline, a battery of structured questionnaires, vision, and cognitive tests were administered. Multivariate analysis determined the factors predictive of stopping or restricting driving 12 months later.

**Results.** Of the 1425 enrolled, 1237 (87%) were followed up at 1 year. Excluding those who were already limiting their driving at baseline ($n$ = 35), 1.5% (18/1202) had stopped and 3.4% (41/1202) had restricted their driving. The women (odds ratio [OR], 4.01; 95% confidence interval [CI], 2.05–8.20) and those who prefer to be driven (OR, 3.91; 95% CI, 1.91–8.00) were more likely to stop or restrict driving. Depressive symptoms increased likelihood of restricting or stopping driving (OR, 1.08; 95% CI, 1.009–1.16 per point Geriatric Depression Scale). Slow visual scanning and psychomotor speed (Trail Making Test, Part A: OR, 1.02; 95% CI, 1.01–1.03), poor visuoconstructional skills (Beery-Buktenica Test of Visual Motor Integration: OR, 1.14; 95% CI, 1.05–1.25), and reduced contrast sensitivity (OR, 1.15; 95% CI, 1.03–1.28) predicted stopping or reducing driving. Visual field loss and visual attention were not associated. The effect of vision on changing driving behavior was partially mediated by cognition, depression, and baseline driving preferences.

**Conclusions.** In this cohort, contrast sensitivity and cognitive function were independently associated with incident cessation or restriction of driving space. These data suggest drivers with functional deficits make difficult decisions to restrict or stop driving. (*Invest Ophthalmol Vis Sci.* 2009;50:107–113) DOI:10.1167/iovs.08-2367

Thirty million licensed drivers in the United States are over the age of 65.[1] Surveys among this age group find a strong preference for personal motor vehicle transport, a lack of experience with public transport and limited planning for the possibility of no longer driving.[2] For older drivers, continuing to drive maintains independence and increases participation in out-of-home activities,[3] and many plan to drive into their eighth and ninth decades.[2] We rely on older drivers to limit their driving or stop driving when they are no longer capable of driving confidently and safely. However, it is uncertain exactly how older drivers make this decision: the relevance of functional status, role of personal preferences, and need to continue driving in the decision-making process.

Several studies have demonstrated a link between functional status and stopping or limiting driving exposure. Driving is a visually demanding activity, and studies with comprehensive vision assessment, have shown deficits in vision function influence likelihood of driving cessation.[4–7] In contrast, two studies in which only visual acuity (VA) was measured[8,9] found that decline in general health was the overriding factor; vision was not predictive of driving cessation. The importance of visual function in the decision to limit but continue driving is less controversial.[10–15]

Poor performance on measures of cognition, including processing speed, verbal reasoning, and visuospatial skills have been shown to influence both driving cessation[4,8,12,14,16,17] and driving restriction.[10,12,14,16,17]

Other factors, such as poor physical strength.[8,9,16] poor general health[4,5,8,9,12,18]; reduced activity and older age[17]; limitations in activities of daily living[14]; and specific disease states such as diabetes,[5] neurologic disease,[17] Parkinson's disease,[7] stroke,[4,5,7,14] heart disease,[5,12] and syncope[7] have been shown to increase the likelihood of stopping or limiting driving. Use of multiple medications was found to be greater among nondrivers[8] and use of benzodiazepines was positively associated with driving cessation.[5] Depressive symptoms have been shown to reduce participation in out-of-home activities[18] and driving.[4]

Clearly the decision to change driving behavior is made through consideration of many factors and possibly the interaction among these factors. While literature on stopping or restricting driving is abundant, most analyses are cross-sectional, and there are few longitudinal studies.[4,8,9,11,19] In addition many studies are focused on a particular area of function such as cognition,[8,9] health,[20] or vision.[4,11] We report on a comprehensive analysis of vision, cognition, and general health factors measured in a cohort of older drivers.

From the [1]Dana Center for Preventive Ophthalmology, Wilmer Eye Institute, the [3]Lions Low Vision Center, the [4]Department of Psychiatry and Behavioral Sciences, and the [5]Applied Physics Laboratory, The Johns Hopkins University, Baltimore, Maryland; and the [2]George Institute for International Health, University of Sydney, Sydney, Australia.

Supported by Grant AG23110 from the National Institute on Aging. SKW is the recipient of a Senior Scientific Investigator grant from Research to Prevent Blindness. LK is funded by an Australian National Health and Medical Research Council postdoctoral fellowship.

Submitted for publication June 2, 2008; revised August 16, 2008; accepted October 16, 2008.

Disclosure: **L. Keay**, None; **B. Munoz**, None; **K.A. Turano**, None; **S.E. Hassan**, None; **C.A. Munro**, None; **D.D. Duncan**, None; **K. Baldwin**, None; **S. Jasti**, None; **E.W. Gower**, None; **S.K. West**, None

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Corresponding author: Lisa Keay, Johns Hopkins University, Dana Center for Preventative Ophthalmology, 900, 550 Building, N. Broadway, Baltimore, MD 21205; lkeay1@jhmi.edu.

# METHODS

## Population

The Salisbury Eye Evaluation and Driving Study (SEEDS) is a longitudinal study of vision, cognition, and driving behavior of older drivers living in the greater Salisbury metropolitan area. Wicomico County is located on Maryland's Eastern Shore on a peninsula between the Chesapeake Bay and Atlantic Ocean. Public transport options are limited, and older members of the community rely on private motor vehicles as their primary means of transportation.

All licensed drivers, aged 67 to 87 years, who resided in Wicomico County in 2005, as defined by ZIP codes, were eligible to participate. The method of recruitment has been reported[21] and involved the Maryland Department of Motor Vehicles' (DMV) sending letters to all drivers registered as of May 1, 2005 ($n = 8380$), explaining the study and requesting participation, indicated by return of a postcard. To be eligible for enrollment, the participants were required to have a valid driver's license, and it was confirmed that all were active drivers at the baseline visit. The cohort is not a population-based sample of older drivers because of restrictions in recruitment. We report on baseline data from round 1 (July 2005 to June 2006) and driving changes by round 2 (July 2006 to June 2007).

## Study Design

**Overview.** In round 1, the participants were interviewed in their homes and demographic characteristics, medical comorbidities, and driving behavior were assessed with structured questionnaires. Participants attended the clinic for vision and cognition testing by trained technicians. Each car was outfitted with the Driver Monitoring System (DMS)[22] to monitor driving performance for a period of 5 days. One year after baseline assessment, participants were invited to return to the clinic to have the DMS system installed for a second 5-day period. For this analysis, the odometer reading corrected for driver identification by video camera data and Global Positioning System (GPS) data were used to validate self-report of driving restriction.

In round 2, driving habits or driving cessation were assessed by questionnaire.

The research adhered to the tenets of the Declaration of Helsinki. All participants provided informed consent and the protocol was approved by The Johns Hopkins University Institutional Review Board.

**General Health.** Arthritis, Parkinson's disease, and stroke were considered present if participants reported having received a physician's diagnosis of these disorders. The presence of depressive symptoms was scored using yes/no responses to 30 items on the Geriatric Depression Scale (GDS) questionnaire.[23] Participants were asked to bring all current prescribed and nonprescribed medications for the interviewer to document. Drugs were coded according to the Iowa Drug Information System.[24] The total number of medications and medications that act on the central nervous system (hypnotics and anxiolytics, antipsychotics and antidepressants, yes/no) were determined for each participant.

**Cognition.** A battery of cognitive tests was designed to assess specific aspects of cognition, including attention, visuospatial processing, psychomotor speed/visual scanning and executive function.

The Attentional Visual Field (AVF) was measured out to a 20° radius from fixation by using a computerized divided attention task described in detail elsewhere.[25] In brief, participants were required to verbally report simultaneously presented central and peripheral targets (numbers) and to touch the touch-screen monitor at the location of the peripheral target. The largest visual field (VF) extent at which the participant could locate the peripheral target and identify both the central and peripheral targets defined the AVF threshold. The average AVF extent is the mean of four thresholds, measured at each of four meridians.

Visual motor integration was assessed using the Beery-Buktenica Developmental Test of Visual Motor Integration (VMI),[26] in which a series of 24 figures of increasing complexity were copied by the participant and scored for accuracy. This test was originally designed for developmental assessment in children but was selected for ease of scoring over options such as the Rey Complex Figure Test.[27]

Psychomotor and visual scanning speed were assessed using Part A of the Trail Making Test (TMT),[28] which requires the participant to connect circles numbered 1 to 25. Time to completion in seconds is recorded, with a maximum of 300 seconds permitted. Part B of the TMT requires the participant to connect circles alternating between numbers (1–13) and letters (A–L) as quickly as possible, with a maximum time of 500 seconds permitted.

**Vision.** Vision tests included VA, contrast sensitivity (CS), and VF assessment. For all testing, participants wore their habitual correction; and when required, participants' vision was optically corrected for shorter test distances. Presenting binocular VA was measured with a high-contrast ETDRS acuity chart[29] with standard transillumination, 3-m testing, and a forced-choice protocol. Results were coded as the number of letters seen and scored as logMAR acuity by assigning a value of −0.02 for each letter correctly identified.

Monocular CS was tested for each eye with the Pelli-Robson CS chart with standard illumination at a 1-m test distance. The CS score was the number of letters correctly identified ("O" for "C" was accepted as correct).[30] Bilateral VF was estimated using combined results from the right and left eye Full Field 81 Point tests, with a Quantify-Defects test strategy (Humphrey Field Analyzer II; Carl Zeiss Meditec, Inc., Dublin, CA). This test assesses the static VF over a 60° radius by using a Goldmann III target. For this analysis, results from both eyes were combined to create a binocular VF of 96 points.[31] The number of missed points in the binocular field was tallied.

**Driving Characteristics.** We determined whether the participant preferred to drive or to be driven or use other transportation. Participants were asked hypothetical questions about level of difficulty in securing different types of alternate transportation if they could no longer drive. Difficulty was rated on a scale of 1 to 5, where 1 was not difficult at all and 5 was impossible. The difficulty score was the average of responses.

The residential address of the participants was categorized as either urban or rural, based on the vicinity of services such as shops, pharmacies, banks, post offices, and doctors' offices. The Salisbury Bypass creates a natural border for the urban area of Salisbury; residences within this border were classified as "urban" and all outside as "rural."

## Outcome: Incident Driving Restriction or Cessation

Drivers who were already limiting their driving to within their local neighborhood at baseline were excluded from the analysis. Participants were asked at round 2 if they had stopped driving. If still driving, they were asked whether they had driven beyond their local neighborhood in the previous 12 months. The correlation between self-reported, restricted driving space and other indicators of driving limitation, such as self-reported number of days per week driving and miles per day, were investigated. Validity of self report was compared with the 5-day odometer readings and the GPS data on North–South driving extent.

## Data Analysis

The objective measures of driving exposure and self-reported number of days per week and miles per day and per year were compared between the restricted group and the continued-driving group by the Fisher's exact test or *t*-test, as appropriate, adjusting for baseline values. Descriptive data were produced for the outcome of interest: those who continued driving beyond their neighborhood, those who restricted driving to their neighborhood, and those who stopped driving. The stopped- and restricted-driving groups were collapsed because of small sample sizes. Logistic regression models that included age and sex were used to identify the factors that contribute to the likelihood of stopping or restricting driving. Variables significant at $P < 0.20$ at this stage were included in the multivariate models.

**Table 1.** Baseline Demographic, Medical Characteristics, and Driving Profile of 1202 Participants at Baseline

| Variable | All Participants |
|---|---|
| Age, mean (SD) | 75.0 ± 5.2 |
| Sex (% male) | 614/1202 (51.1) |
| Race (%African American) | 12.3% |
| Rural residence, *n* (%) | 412/1202 (34%) |
| Years of education, mean (SD) | 13.7 ± 5.3 |
| MMSE score, mean (SD) | 28.4 ± 1.7 |
| GDS score, mean (SD) | 3.6 ± 3.4 |
| Medications, mean (SD) | 6.5 ± 4.3 |
| Visual acuity, mean (SD) | −0.01 ± 0.11 |
| Years of driving experience, mean (SD) | 57.3 ± 7.2 |

Each domain—demographic, cognitive, visual, and other factors—included multiple variables and was added to the model in blocks. We acknowledge that risk factors may work together and hypothesized that the impact of functional status may be mediated by the presence other factors including the preference to drive, presence of depressive symptoms, and executive function. The Sobel test of mediation[32] was used to determine whether mediation due to a particular variable was statistically significant ($P < 0.05$) and has been adapted for use with binary outcomes, as required for this analysis.

## Results

Of the 8380 67- to 87-year-old registered drivers in the greater Salisbury area, 4503 (54%) returned the postcards. A small proportion indicated that they were no longer driving (6.0%), 1.6% were deceased, and 2.3% were no longer living in the eligible area. Of the remainder, 42% agreed to participate, and 83% of those were enrolled in the study ($n = 1425$). Men (odds ratio [OR], 1.19; 95% confidence interval [CI], 1.07–1.33) and those 80 to 84 years (OR, 1.31; 95% CI, 1.12–1.52) and over 85 years (OR, 1.46; 95% CI, 1.07–1.98) were more likely to participate than were women and 70- to 75-year-olds. There was no difference in rate of participation by race. Of the 1425 enrolled at baseline, 1237 or 87% were interviewed and/or had the driving assessment at 1 year. Those already limiting their driving at baseline were excluded ($n = 35$).

In general, cognitive function was good, and visual impairment was uncommon (Table 1). Average VA was 20/20+ (logMAR < 0) with SD of 1.1 lines of letters. Few participants' vision was worse than 20/40 at the round 1 assessment (11/1202, 0.9%). The average CS was 35 ± 2 letters, and a small number of drivers (26/1202, 2.2%) correctly identified <30 of 48 letters, a level that can affect performance of tasks of daily living.[33] Most drivers missed no points on their bilateral VF tests (median, 0 points lost) and a very small proportion (13/1202, 1.1%) missed 30 or more points. At baseline, almost all participants (97%) were using at least one medication, and 15% were using 10+ medications. Participants were equally distributed between the men and the women, but the women had approximately 5 years' less driving experience after adjusting for age at the time of the study (59.3 ± 5.9 vs. 55.3 ± 7.9 years; $P < 0.0001$).

### Incident Driving Cessation and Restriction

Eighteen (1.5%) participants reported that they had stopped driving during the 12 months since baseline. Of the 11 who provided reasons, two (2/11) reported being at fault in a previous road crash and decided to stop driving. Two reported feeling unsafe or fearful, and a third (3/11) stopped driving on family advice. The remainder indicated vision problems and health problems.

Forty-one (3.4%) additional participants reported restricted their driving to their local neighborhood.

Self-reported restriction of driving space to their local neighborhood was validated by the other indicators of driving space measured at rounds 1 and 2 in both the 5-day odometer mileage and estimated maximum north–south extent (Table 2). At the 1-year assessment, those who reported restricting their driving space to their local neighborhood registered approximately 5 miles per day, which is consistent with small distances within a local neighborhood. The decrease in mileage from round 1 to round 2 was approximately 40 miles in the group who restricted their driving compared with a reduction of 6 miles in the remaining drivers.

### Factors Predicting Incident Cessation or Restriction of Driving

Women accounted for 88% of the group who restricted driving, but the group that stopped driving completely had approximately an equal number of men and women (Table 3). Adjustment for age and sex showed that all baseline measures of visual function were predictive of stopping or restricting driving 12 months later ($P < 0.05$, Table 3). CS and VA both showed a trend for decline among those continuing, those restricting, and those stopping driving. VF loss was more frequent in those who stopped driving.

**Table 2.** Measures of Driving Extent in Those Who Reduced Driving Area to Their Local Neighborhoods ($n = 41$) and Those Who Continued to Drive Beyond Their Neighborhoods ($n = 1143$)

| Characteristic | Visit | Continued Driving | Driving Restricted to Neighborhood | Age- and Sex-Adjusted *P** |
|---|---|---|---|---|
| 5-Day odometer (miles) | Baseline | 112.7 (103.2) | 66.0 (86.5) | |
| | One year | 107.5 (94.9) | 26.6 (32.1) | |
| | Change | −5.8 (105.9) | −39.9 (95.6) | 0.03, **<0.0001** |
| Max (North-South) GPS | Baseline | 10.4 (13.1) | 4.5 (4.2) | |
| | One year | 10.9 (12.4) | 2.1 (2.6) | |
| | Change | 0.7 (14.8) | −2.0 (5.0) | 0.22, **<0.0001** |
| Self-reported d/wk driving | Baseline | 5.5 (1.7) | 4.1 (2.1) | |
| | One year | 5.4 (1.8) | 3.4 (2.4) | |
| | Change | −0.1 (1.3) | −0.77 (2.3) | 0.0005, **<0.0001** |
| Self reported miles/d | Baseline | 24.9 (30.1) | 15.2 (11.1) | |
| | One year | 22.8 (25.0) | 10.2 (8.3) | |
| | Change | −2.2 (29.5) | −4.4 (10.6) | 0.61, **<0.0001** |

Data are the mean (SD).
* In bold, *P* after adjustment for baseline value.

**Table 3.** Demographic and Functional Characteristics of Those with Incident Driving Restriction or Cessation, Compared with Other Drivers

| | Incident Driving Restriction or Cessation | | | | |
|---|---|---|---|---|---|
| | **Continue ($n$ = 1143)** | **Restrict ($n$ = 41)** | **Stop Driving ($n$ = 18)** | **Unadjusted $P$** | **$P$*** |
| Demographics | | | | | |
| Age, mean (SD) | 74.9 (5.1) | 75.7 (5.6) | 78.6 (4.7) | **0.015** | **0.012†** |
| Women (%) | 47.5 | 87.8 | 50.0 | **<0.001** | **<0.001‡** |
| Blacks (%) | 12.1 | 17.1 | 16.7 | 0.27 | 0.23§ |
| Education, mean years (SD) | 13.7 (5.4) | 12.4 (3.5) | 13.6 (3.6) | **0.02** | **0.02§** |
| General health | | | | | |
| GDS score, mean (SD) | 3.5 (3.4) | 4.9 (3.3) | 6.2 (4.5) | **0.0001** | **0.0009§** |
| Arthritis (%) | 55.7 | 63.4 | 88.9 | **0.02** | 0.10§ |
| Stroke (%) | 9.0 | 9.8 | 11.1 | 0.8 | 0.49§ |
| Parkinson's disease (%) | 0.6 | 2.4 | 0.0 | 0.3 | 0.20§ |
| Medications ($n$) | 6.4 (4.3) | 6.4 (3.4) | 6.8 (3.8) | 0.8 | 0.9§ |
| Using CNS medications (%) | 12.9 | 12.2 | 16.7 | 0.9 | 0.8§ |
| Cognitive function | | | | | |
| Attention | | | | | |
| Visual attention extent, mean deg (SD) | 12.8 (5.1) | 11.8 (5.3) | 8.0 (6.3) | **0.005** | **0.02§** |
| Visuospatial | | | | | |
| Visuomotor integration, mean raw score (SD) | 18.4 (3.4) | 16.5 (3.6) | 16.1 (4.3) | **<0.001** | **<0.001§** |
| Psychomotor speed and visual scanning | | | | | |
| Time TMT Part A in seconds, mean (SD) | 48.5 (21.7) | 60.1 (35.2) | 84.2 (66.5) | **<0.001** | **<0.001§** |
| Executive function | | | | | |
| Time TMT Part B in seconds, mean (SD) | 124.7 (71.9) | 133.7 (76.3) | 170.9 (77.8) | 0.068 | **0.03§** |
| Visual function | | | | | |
| LogMar, mean visual acuity (SD) | −0.01 (0.11) | 0.04 (0.15) | 0.08 (0.014) | **<0.001** | **0.0006§** |
| Contrast sensitivity, better eye mean (SD) | 35.3 (2.2) | 34.4 (2.7) | 32.4 (4.1) | **<0.001** | **<0.001§** |
| Bilateral VF points missing, mean (SD) | 1.98 (5.1) | 1.8 (3.8) | 9.8 (17.1) | **0.007** | **0.001§** |

Bold indicates statistical significance.
* For analysis, those who restricted or stopped driving were combined.
† Adjusted for sex.
‡ Adjusted for age.
§ Adjusted for age and sex.

The baseline measures of cognition also were predictive of stopping or restricting driving, including restricted AVFs, poor visuospatial skills (VMI score), and slow times on the TMTs, which measure psychomotor/visual scanning skills (Parts A and B) and executive skills (Part B).

The number and type of medications and the presence of arthritis, Parkinson's disease, or stroke were not predictive of stopping or restricting driving ($P > 0.05$). The presence of depressive symptoms at baseline was predictive ($P < 0.0001$).

In the group who continued to drive, 94% expressed the preference to be the driver compared with 73% to 78% in the remainder (Table 4). Although not statistically significant, the years of driving experience were greatest in those continuing to drive ($P = 0.1$), and rural drivers were less likely to restrict their driving ($P = 0.17$). The mean ratings for difficulty with alternate transportation were similar across groups and corresponded to a score of 2, or slight difficulty.

In multivariate analyses (Table 5), among the demographic factors, only sex was predictive. The women were four times more likely to stop or restrict their driving than were the men. When the multivariate analysis was repeated for the men and women separately (data not shown), the odds ratios were in the same direction and generally of a magnitude similar to those in the analysis of the whole group. The other major independent predictor was a preference not to drive. When this was taken out of the analysis, the magnitudes of the other risk factors remain similar. GDS, CS, and two measures of cognition also were significantly related to restricting or stopping driving. The magnitude of increased risk due to depression was approximately 10% per unit increase in the GDS score. At baseline, 17% of participants had scores of ≥7 on the GDS, and this group had twice the risk of restricting or stopping driving in the upcoming 12 months (OR, 2.02; 95% CI, 1.09–3.7).

**Table 4.** Driving Characteristics of Those with Incident Driving Restriction or Cessation, Compared with Other Drivers

| | Incident Driving Restriction or Cessation | | | | |
|---|---|---|---|---|---|
| | **Continue ($n$ = 1143)** | **Restrict ($n$ = 41)** | **Stop Driving ($n$ = 18)** | **Unadjusted $P$** | **$P$*** |
| % Preferring to drive themselves | 94.2 | 73.2 | 77.8 | **<0.001** | **<0.001†** |
| Driving experience in years, mean (SD) | 57.4 (7.0) | 56.5 (8.1) | 56.6 (15.3) | 0.4 | 0.1† |
| Difficulty with alternate transport mean (SD) | 2.0 (0.8) | 1.8 (0.8) | 1.9 (0.6) | 0.3 | 0.3† |
| Residents in the urban area (%) | 65.1 | 82.9 | 66.7 | **0.045** | 0.17† |

Bold indicates statistical significance.
* For analysis, those who restricted or stopped driving were combined.
† Adjusted for age and sex.

**Table 5.** Multivariate Analysis of the Factors That Predict Incident Driving Cessation or Restriction and Recommendation to Stop or Restrict Driving

| Factor | Driving Cessation/ Restriction OR (95% CI) |
|---|---|
| Demographics | |
| Age | 1.01 (0.95–1.07) |
| Women | **4.01 (2.05–8.20)** |
| African American | 1.56 (0.64–3.80) |
| Health | |
| Geriatric depression score | **1.08 (1.01–1.16)** |
| Vision | |
| Contrast sensitivity (per letter lost) | **1.15 (1.03–1.28)** |
| Cognition | |
| Psychomotor/vision scanning (Timed TMT Part A, per second) | **1.02 (1.01–1.03)** |
| Visuospatial skills (VMI) | **1.14 (1.05–1.24)** |
| Other factors | |
| Prefer to not drive | **3.91 (1.91–8.00)** |

Bold indicates statistical significance.

We investigated the possibility that functional loss may have resulted in depressive symptoms and preference not to drive and that these are intermediate in the pathway between functional loss and stopping or restricting driving. Of the measures of function, worse CS increased the likelihood that an individual would prefer to be driven (OR, 1.15; 95% CI, 1.04–1.27), with adjustment for age and sex. For depression, several functional factors were associated including points missing on bilateral VF (OR, 1.02; 95% CI, 1.002–1.04 per point missed), slow visual scanning and psychomotor speed (TMT Part A: OR, 1.007; 95% CI, 1.002–1.01 per second) and poor visual motor integration (VMI raw score: OR, 1.03; 95% CI, 1.004–1.07).

Preference to drive acted as a mediator for the way CS influenced the decision to stop or restrict driving (Table 6, $P = 0.04$, 10.8% of effect). Presence of depressive symptoms partially mediated the impact of visual and cognitive functional status on the decision to stop or restrict driving (7%–10%, Table 6). Further, performance on the VMI and TMT Part A tasks partially mediated the impact of poor CS on the likelihood of stopping or restricting driving. Executive function, measured by the TMT Part B, did not mediate the impact of other deficits in function ($P > 0.5$).

## Discussion

Our data suggest that the multifactorial decision to stop or restrict driving is predicted not only by functional deficits in both vision and cognition but also by depression and individual driving preferences. This study supports previous work suggesting drivers who experience deficits in vision[4–7,10–15] or cognition[4,8,10,12,14,16,17] alter driving behavior.

Our finding that decreased contrast sensitivity is associated with stopping or restricting driving corroborates previous research in the Salisbury area[4,11] and other studies that have shown that impaired visual function,[10–15] presence of cataract,[34] and self-reported difficulty seeing in the dark or in glare[5] are associated with modified driving behavior.

VF loss has been shown to be differentially associated with specific types of driving modification such as stopping driving at night.[11] Although we noted a trend between level of VF loss and driving cessation, we do not have sufficient power to fully explore the relationship between VF loss and driving changes, as we have done previously,[4,11] due to the limited number of individuals with significant VF loss (1.1%) and the small sample of individuals who stopped driving (<2%) during the 12-month follow-up period. Previously, we reported a strong influence of cognition on the ability to take a VF test.[35] However, at this time, we do not have sufficient data to evaluate how a decline in cognitive status may influence the relationship between VF loss and a change in driving behavior. The influence of VF loss deserves further exploration.

A strength of this study is the comprehensive battery of tests for both visual and cognitive function. Driving is a visually demanding activity, but also requires integration of visual information and appropriate action in the form of steering, braking, and accelerating. We found independent contributions of poor performance on tests of psychomotor speed and visual scanning and visuomotor integration. These skills are important for safe and confident driving where objects are moving at rapid speeds in relation to each other, and timely and accurate judgments are required. Our findings correspond with other studies on which poor cognitive processing speed[16,8] has been related to stopping driving. The design copy task of the Mini-Mental State Examination (MMSE) has been found to be more influential than memory tasks for continuing to drive,[12] supporting our finding that visual-spatial processing is an important component of driving.

General health status and use of medication did not predict restriction or cessation of driving, contrary to cross-sectional studies in which individuals not driving tend to take more medications.[5,8] The lack of evidence of the importance of physical health and medication use may be reflective of a highly functioning population and a short period of monitoring.

Like other reports in the literature, we found that women were more likely to stop driving than were men with the same level of visual[15] or cognitive[14] impairment. Others have suggested that the differences between the sexes are explainable by differences in lifetime driving experience in which men start driving younger and have higher annual mileage and therefore are more habituated to driving and likely to continue driving longer.[36] The lack of association with years of driving experience in this analysis does not support this claim. How-

**Table 6.** Results of Tests of Mediation

| | GDS | Prefer Not to Drive | Visual Motor Integration | Psychomotor Speed and Visual Scanning |
|---|---|---|---|---|
| Visual motor integration, VMI | 0.01 (9.63) | 0.6 | — | — |
| Psychomotor speed and visual scanning | 0.009 (6.9) | 0.5 | — | — |
| CS | 0.03 (8.8) | 0.038 (10.8) | 0.001 (16.6) | 0.001 (25.5) |

The tests examined whether GDS, preference not to drive, and three measures of cognitive status are mediators for the impact of functional status on the decision to stop or restrict driving. Data are presented as the *P* (Sobel Test) and the amount of mediation (%).

ever, other measures of driving history not captured in our study may explain part of the sex effect.

A personal preference for driving was found to increase the likelihood of continuing driving. Whether preference to drive was an inherent trait or it was in response to functional status is unclear. Driving preference was only partly explained by a deficit in CS, and it is possible that driving preference is both a response to low confidence in vision and a reflection of personal preferences for independent travel. Aspects of personality may contribute to the decision to stop driving, and it would be worthwhile to include this in future research in this area.

Although other studies have shown that loss of driving privileges[37,38] is related to depression, this study provides temporal data to support that depression itself leads to the decision to stop or restrict driving. Further, the effects of visual and cognitive factors on stopping or restricting driving were modestly mediated by depressive symptoms. We showed that part of the role of depression is intermediate in the pathway from functional loss to stopping driving. The association of depression was not explained by the use of psychoactive drugs, although others have found that benzodiazepines are related to stopping driving.[5]

Previous research among frail older drivers has shown that those living in a metropolitan area[14] or in a congregate independent living site[16] are more likely to stop or limit driving, presumably due to availability of local services and facilities. In addition, availability of an alternate driver has been linked to cessation of driving but less to restricted driving.[14] We did not find similar associations in this study; however, our population is fairly homogenous in terms of alternative means of transportation, since public transportation is not currently available in this region. These hypotheses could be explored further in a more diverse population.

Other reports have shown approximately 3% to 5%[4,39] of older drivers stop driving yearly, and a larger proportion of drivers restrict the way they drive in some capacity.[12] Our cohort is a highly functioning group who volunteered to participate in a 3-year study of driving; thus it is not surprising that only a small percentage (<2%) was not driving 12 months into the study. In addition, our criteria for defining "driving restriction" required that they did not drive beyond their neighborhood in the previous 12 months, a severe restriction on driving space. Just 3.4% of the total sample restricted their driving to this extent, driving <5 miles per day on average.

While restriction and stopping are combined for analysis, the trends support the contention that functional deficits are more common in those who restrict driving and most frequent among those who stop driving altogether. Although the results did not show it directly, restricting driving may be an intermediate step before stopping driving altogether.

The factors that lead to restrictions in driving space or stopping driving altogether and the timeliness of the adaptive behavior is of interest. It is reassuring that in this group driving modifications were related to visual and cognitive status and supports the notion that older drivers make decisions in response to decline in functional status. The finding that other factors influence the decision to limit or stop driving, including depressive symptoms, preference to drive, and cognitive status, is helpful in understanding the decision-making process.

## *Acknowledgments*

The authors thank the study participants, the Salisbury Eye Evaluation Study technicians and staff for collecting the data, and Kathleen C. West, RPh, who coded all the medications for this project.

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