Poor Sense of Direction Is Associated With Constricted Driving Space in Older Drivers

Kathleen A. Turano,1 Beatrix Munoz,1,2 Shirin E. Hassan,3 Donald D. Duncan,4 Emily W. Gower,1,2 Karen B. Roche,5 Lisa Keay,2,6 Cynthia A. Munro,7 and Sheila K. West1,2

The aims of this study were to determine whether perceived sense of direction was associated with the driving space of older drivers and whether the association was different between genders. Participants (1,425 drivers aged 67–87 years) underwent a battery of visual and cognitive tests and completed various questionnaires. Sense of direction was assessed using the Santa Barbara Sense of Direction (SBSOD) scale. Driving space was assessed by both the driving space component of the Driving Habits Questionnaire and log maximum area driven. Analyses were performed using generalized linear models. The SBSOD score was lower in women than in men and significantly associated with log driving area in women but not in men. The SBSOD score also showed a significant association with women’s self-reported driving restriction. The findings emphasize the need to explore the role of psychological factors, and include gender, in driving studies and models.

Key Words: Drivers—Driving restriction—Driving space—Gender—Navigational ability—Sense of direction.

Older drivers have reported voluntarily reducing their driving either by stopping altogether or by restricting their driving to shorter distances, familiar areas, low-traffic areas, or to daytime and good weather conditions (Charlton, Oxley, Fildes, & Les, 2001; Hakamies-Blomqvist & Wahlström, 1998; Marottoli et al., 1993; Unsworth, Wells, Browning, Thomas, & Kendig, 2007). Some investigators have proposed that older drivers reduce their driving to compensate for the loss of function or increased stress and difficulty of driving (Bäckman & Dixon, 1992; Charlton et al., 2001; Hakamies-Blomqvist & Wahlström, 1998; Marottoli et al., 1993). In fact, studies have shown significant associations between self-report of driving reduction and decreased sensory function, cognitive function, or physical function (Anstey, Windsor, Luszcz, & Andrews, 2006; Ball et al., 1998; Brabyn, Schnee, Lott & Haegerstrom-Portnoy, 2005; Campbell, Bush, & Hale, 1993; Edwards et al., 2008; Freeman, Munoz, Turano, & West, 2005; 2006; Jette & Branch, 1992; Marottoli et al., 1993; Sims, Ahmed, Sawyer, & Allman, 2007).

Largely unexplored is any association between driving reduction and psychological traits (Lindstrom-Forneri, Tuokko, & Rhodes, 2007), which may be more closely associated with driving reduction than decreased physical function (Anstey et al., 2006). One such trait is perceived navigational ability. Persons who report a poor sense of direction are more likely to report that they worry about becoming lost (Bryant, 1982) and feel more anxious when lost compared with those who report a good sense of direction (Kozlowski & Bryan, 1977).

Thus, it is likely that wayfinding problems cause stress to the driver, and particularly older drivers, who perceive wayfinding to be more difficult than do younger drivers (Burns, 1998). In a focus group of older drivers, navigation difficulties were the most commonly reported problem (Sixsmith, 1990). In another study, older participants identified navigating in unfamiliar areas as the most challenging driving situation (Vrkljan & Polgar, 2007).

Given the negative emotions and difficulties associated with orienting and wayfinding in persons with a poor sense of direction, it is reasonable to expect that they would limit their travel more than persons with a good sense of direction. Indeed, some people with vision loss report limiting independent travel to known routes to avoid the stress of becoming disoriented or lost (Golledge, 1993). In those persons who already have a poor sense of direction, the potential stress is likely to be even more pronounced. However, driving cessation and reduction are associated with increased risks of mental and physical health problems (Fonda, Wallace, & Herzog, 2001; Marottoli et al., 1997). Those who cease driving are more likely than others of similar age, gender, mental, and physical functioning to be admitted to long-term care (Freeman, Gane, Muñoz, & West, 2006). Therefore, understanding the factors that affect driving reduction can be used to effectively counsel older adults regarding driving decisions and to design interventions that have the potential to balance mobility and safety in older adults.

One aim of this study was to evaluate whether perceived sense of direction is a predictor of driving restriction in...
older drivers. And because women are known to have higher navigational anxiety, uncertainty, and difficulty than do men (Burns, 1998; Kozlowski & Bryant, 1977; Lawton, Charleston, & Zieles, 1996), a second aim was to evaluate whether the association between perceived sense of direction and driving restriction is different between genders.

We hypothesized that perceived sense of direction is a predictor of driving restriction in older drivers and that the association between sense of direction and driving restriction is stronger in women compared with men. To test these hypotheses, we analyzed the association between the scores from the Santa Barbara Sense of Direction Questionnaire (SBSOD) and estimates of driving space, determined from the scores of the driving space component of the Driving Habits Questionnaire (Owsley, Stalvey, Wells, & Sloane, 1999), and the actual maximum area driven in driving episodes occurring during a 5-day period using data from older drivers in the Salisbury Eye Evaluation Driving Study (SEEDS). We performed gender-specific analyses.

**METHODS**

**Population**

SEEDS is a longitudinal study of vision, cognition, and driving behavior of older drivers living in the greater Salisbury metropolitan area. Salisbury is a semirural city on Maryland’s Eastern Shore, with a major freeway running north and south. The Eastern Shore itself is bounded on three sides by water. Leaving the area requires substantial driving in a north–south direction.

Postcards were mailed from the Maryland Department of Motor Vehicles to all registered drivers aged 67–87 years as of May 1, 2005, residing in the Greater Salisbury Metropolitan Area of Wicomico County to invite them to participate. Details on the sample and respondents were described previously (Zhang et al., 2007). In short, we were allowed to enroll those who responded affirmatively, a total of 1,425 older drivers. Data for this report were collected in Round 1 of the study (July 2005–June 2006).

The research followed the tenets of the Declaration of Helsinki, and informed consent was obtained from subjects. The Johns Hopkins Medical Institutions’ review board approved the research.

**Procedure**

Participants underwent a battery of cognitive and vision tests administered by trained technicians. For the purpose of this study, only the results of cognitive status in the general, attention, working memory, psychomotor speed, and visual search domains are reported.

**Demographic information.**—Basic demographic data such as age, gender, race, level of education, and current medication use were obtained using questionnaires administered at the participants’ homes. Information about specific comorbidities was derived through medical history questionnaires and the Geriatric Depression Scale (GDS) questionnaire (Yesavage et al., 1983). The GDS is a 30-item self-report questionnaire used to identify the presence of depressive symptoms. The higher the GDS score, the greater the number of self-reported depressive symptoms. Participants also were asked about current use of medications for arthritis pain and the feeling of pain in the knees, hips, legs, or feet. A pain score was created counting the number of positive answers to these questions (scale 0–5, with 0 being no pain).

**Cognitive measures.**—General cognitive status was assessed using the standardized Mini-Mental State Examination (MMSE). Lower MMSE scores indicate lower levels of cognition. The Brief Test of Attention (BTA) (Schretlen, Brandt, & Bobholz, 1996) was used to assess participants’ executive function, attention, and working memory. In this task, participants were required to focus their attention on a specified stimulus set and use their working memory to maintain it while withstanding distraction. Only the first 10 trials were administered; thus, the maximum score for this test was 10. Higher BTA scores indicate better performance on the divided attention test.

The Trail-making Test, Part B (Bowie & Harvey, 2006), was used to assess psychomotor speed, visual–spatial attention, and visual search. The time required to consecutively connect labeled circles that alternated between numbers (1–13) and letters (A–L) was recorded (maximum time-out score of 500 s). Longer times to complete the task indicate poorer performance.

The attentional visual field (AVF) was assessed using a divided attention task (Hassan et al., 2008). Participants were required to verbally report a simultaneously presented central and peripheral target (number) 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. Higher thresholds indicate larger AVFs.

**Vision function measures.**—Visual function was assessed using participants’ habitual spectacle or contact lens prescription. Binocular visual acuity (VA) was measured using a high contrast Early Treatment Diabetic Retinopathy Study (ETDRS) acuity chart (Ferris, Kassoff, Bresnick, & Bailey, 1982) with standard transillumination and 3-m testing. Binocular threshold VA was scored by assigning each correctly identified letter a value of −0.02 log minimum angle of resolution (MAR). The lower the log MAR value, the better the VA.

Monocular contrast sensitivity (CS) was assessed using the Pelli–Robson letter CS chart (Pelli, Robson, & Wilkens, 1982) with standard transillumination and 3-m testing. Monocular threshold CS was scored by assigning each correctly identified letter a value of −0.02 log minimum angle of resolution (MAR). The lower the log MAR value, the better the VA.
1988), 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).

Monocular VFs in both eyes were measured using the 81-point, quantify defect test strategy on the Humphrey Field Analyzer. This test assesses the static VF over a 60° radius VF using a Goldmann III target. For this analysis, the results from the two eyes were combined to create a binocular VF of 96 points. The number of missed points in the binocular field was tallied and used for analyses.

**Self-reported sense of direction.**—In the present paper, the SBSOD (Hegarty, Richardson, Montello, Lovelace, & Subbiaha, 2002) was used to assess participants’ perceived sense of direction. The measure consists of statements about spatial and navigational abilities, preferences, and experiences in which participants rate their level of agreement on a 7-point scale (“strongly agree” to “strongly disagree”). The instrument was designed in response to the need for a standardized measure of sense of direction. Earlier measures had shown substantial variability in their association with the ability to find one’s way in the environment and to learn the layout of a large-scale space, skills referred to as environmental spatial ability (Hegarty et al., 2002). The instrument was designed with 27 items derived from previous instruments and statements made in a pilot study. A factor analysis of the results revealed 15 items associated with the item “My sense of direction is very good.” Those items were retained for the final 15-item instrument. Internal consistency, α, for the 15-item instrument was 0.88, and test–retest reliability, assessed by two administrations of the questionnaire 40 days apart, was 0.91 (Hegarty et al., 2002). Construct validity was demonstrated by significant correlations between the SBSOD scores and wayfinding performance; SBSOD scores were correlated with pointing errors in updating one’s location in space while moving in the environment ($r = -.40$) and with pointing errors to unseen landmarks ($r = -.44$) (Hegarty et al., 2002).

Half the items in the questionnaire are stated positively and the other half negatively. Therefore, prior to analysis, the scoring of the positively stated items was reversed so that higher ratings indicated a higher sense of direction for all items. Interval measures of sense of direction were estimated from the ordinal ratings of the agreement ratings by performing Rasch analysis (Wright & Masters, 1982) on the matrix of the 15-item ratings using Winsteps (Chicago, IL) (Linacre & Wright, 1997). With these models, a “person logit” can be defined as the difference between each person’s perceived sense of direction and the mean item measure. If the person logit is positive, the person’s perceived sense of direction is greater than the average sense of direction for the 15 items.

**Self-reported driving space.**—Self-reported driving space was determined from the participants’ yes/no responses to whether they had driven to each of five specified regions in the past year, where each region is a certain distance (or spatial extent) from home: “outside the Mid-Atlantic Region,” outside the Eastern Shore, distant towns within the Eastern Shore, neighboring towns, or neighborhood only. Questions were adapted for the Maryland Eastern Shore from questions 29 and 31–34 on the Driving Habit Questionnaire (Owens et al., 1999). Participants were categorized into the farthest region they had reported driving to.

**Maximum area driven.**—Participants had their driving behaviors monitored for five consecutive days in their own vehicle using our novel Driving Monitor System (DMS), described previously (Baldwin, Duncan, & West, 2004). The DMS includes a Global Positioning System (GPS 18 LVC) unit (Garmin, Olathe, KS) that tracks the driver’s route during each driving segment, defined as when the car turns on to when it turns off. As an objective indicator of driving space, we used maximum area driven, computed as the area of an ellipse whose axes were the maximum miles driven in the north–south and east–west directions, as determined by the GPS. For some participants, DMS data are not available because the GPS failed to activate or the driving segments were so short that the estimate of miles driven was too small relative to the odometer reading.

**Data Analyses**

The $t$ and chi-square tests were used to determine the characteristics that differed between the men and the women. Linear regression was used to determine the characteristics associated with sense of direction. Smoothed scatter plots (Lowess function in S) were used to examine the assumption of a linear relationship between continuous/interval predictors and the outcomes of interest (perceived sense of direction, maximum area driven). We modeled perceived sense of direction as a function of age, race, gender, education, MMSE, years of driving experience, and AVF.

To determine whether sense of direction was associated with driving space, we used regression models to evaluate two measures of driving space. Each regression was stratified by gender and controlled for AVF and years of driving experience, age, race, education, depression, pain, Trail-Making Test, (Part B), and MMSE. First, the logarithm of the maximum area driven was evaluated as a function of perceived sense of direction using linear regression. Second, self-reported driving space was evaluated as a function of perceived sense of direction using multinomial logistic regression. This analysis calculates factors by which the odds of having driven to each region relative to having driven to the farthest region (outside the Mid-Atlantic region) are multiplied across levels of predictor variables. The two categories for the closest regions (“immediate neighborhood” and “neighboring towns”) were collapsed into one category due to the small sample size in the immediate neighborhood category. The likelihood ratio test was used to...

---

TURANO ET AL.
test for significance of the global effect of individual covariates on the model.

**Results**

Of the 1,425 participants, 50% (712) were men. Men had lower scores on the GDS compared with women, but men had lower cognitive function, with lower MMSE and BTA scores, and longer times on Trail-making Test, Part B (Table 1). Men also had better VA but slightly poorer VFs. There was no gender difference in the score for the AVF. Men had more years of driving experience, higher SBSOD scores, and a larger difference in the score for the AVF. Men had more years of education, higher MMSE scores, and a larger difference in the score for the AVF. Men had more years of driving experience, higher SBSOD scores, and a larger difference in the score for the AVF.

**Sense of Direction Scores**

The shape of the distributions of the SBSOD scores was similar for men and women; however, the SBSOD logit scores for the men are significantly higher than for the women (p < .001). The median SBSOD logit scores were 0.44 and 0.17 for the men and women, respectively.

In a linear regression model adjusting for age, race, education, MMSE, years of driving experience, and AVF, being a man was associated with a 0.31 increase in the SBSOD logit score compared with being a woman (p < .0001; Table 2). Participants who were younger, and had more years of driving, more education, higher MMSE scores, and larger AVF had higher SBSOD scores.

**Maximum Area Driven**

Linear regression analyses of driving space (measured as log maximum area driven) as a function of SBSOD showed similar associations by gender (Table 3). For both men and women, driving space decreased with increasing age. Maximum area driven decreased an average of about 1.0 square mile each year of age. For men, driving space increased with increasing years of driving experience. Among men, the relationship between SBSOD and driving space was not statistically significant, but among women, for every 0.5-logit increase in the SBSOD score, maximum area driven increased by 0.213 log units ($p = .0001$). This is equivalent to an estimated 53% increase in the square miles area of driving space per logit SBSOD increase. The overall results were essentially unchanged when the analysis was restricted to persons who reported they were the primary drivers or when driving space was defined as the maximum driving extent along the north–south meridians.

**Self-Reported Driving Space**

The characteristics of participants with small to large self-reported driving space are shown in Table 4. Participants who severely limited their driving space tended to be older, and men and women to have more vision and cognitive deficits compared with those who drove more widely.

Table 5 shows gender-specific adjusted odds ratios (ORs) of having driven to each region relative to having driven...
outside the Mid-Atlantic region (largest driving space) as a function of SBSOD. For men, associations were in the expected directions for most variables, suggesting restriction with increased age, lesser education, and more depressive symptoms. The global association with sense of direction did not reach statistical significance, but there was notable indication of association with restriction of driving to the neighborhood/near towns, with the odds of such a severe restriction decreasing (odds of 0.67, confidence interval [CI] = 0.46–0.96) for each 0.5-logit increase in the SBSOD score. Trends for association between the SBSOD score and restricting driving to distant towns and the Eastern Shore were in the expected direction, with decreasing odds of 0.79 (CI = 0.57–1.10) and 0.86 (CI = 0.71–1.04), respectively. Associations with age and depressive symptoms were strongest for restricting driving to the neighborhood/near towns, with ORs of 1.26 (per year; CI = 1.15–1.39) and 1.12 (per symptom; CI = 1.03–1.21), respectively. The number of years of driving experience showed decreasing odds of 0.89 (CI = 0.83–0.96) for restricting to the neighborhoods/near towns, for each year of driving, but increasing odds (not significant) of 1.12 (CI = 1.01–1.24) for restricting to the distant towns.

Among women, associations with self-reported driving space, again, were in the expected directions for most variables, suggesting restriction with increased age, lesser education, smaller AVFs, and poorer sense of direction. The global association with race did not reach statistical significance, but there was notable indication of association with restriction of driving to the neighborhood/near towns, with increasing odds of 2.42 (CI = 1.20–4.87) for Black women. Unlike the men, women’s self-reported driving space was not globally associated with depression symptoms or driving experience. As expected, restricting driving to neighborhood/near towns, distant towns, and the Eastern Shore was associated with lower SBSOD scores (Table 5). The association with increasing education was strongest for restricting driving to the neighborhood/near towns with protective OR of 0.80 (per year; CI = 0.72–0.89).

**DISCUSSION**

This study aimed to evaluate the association between perceived sense of direction and driving restriction in older drivers and to determine whether the association differed between women and men. Our results showed that even after accounting for cognitive and other predictors, perceived sense of direction was still a significant predictor of driving space in older female drivers. A poorer sense of direction was significantly associated with restricting driving space among older female drivers for both measures of driving space (maximum area driven and self-report). The strong association between sense of direction and driving space in older women suggests that perceived spatial/navigational ability plays an important role in their driving restrictions. Older persons who report a poor sense of direction may find driving stressful, particularly in unfamiliar areas and/or in the presence of decreased sensory function. As a result they might restrict their driving to familiar areas, those closer to home.

Sense of direction has been shown to correlate (small to moderate correlations) with performance on wayfinding tasks, such as accuracy of pointing to unseen landmarks, accuracy of path choices, and speed at performing shortcuts (Cornell, Sorenson, & Mio, 2003). Whether sense of direction correlates with actual driving ability in older female drivers is open for future research. A positive correlation between the two factors would indicate that older female drivers make wise decisions regarding driving reduction. A lack of association between the two factors could suggest that decisions about driving reduction might be premature and done to reduce stress rather than compensate for poor driving.

Among men, the association between the SBSOD score and driving space was not as straightforward. The SBSOD score did not show a significant or appreciable association with (log) maximum area driven, but it did show a significant association with self-reported driving space in the most restricted areas, neighborhood/near towns. The discrepancy between the association of the SBSOD score and the two driving space measures may be due to differences in measurement between the two. The maximum area driven may have been underestimated because first, it represents 5 days of driving only, and second, we confined it to a single segment rather than trying to link driving segments and derive an absolute

### Table 2. Association of Demographic and Cognitive Factors With SBSOD Score in a Multivariate Linear Regression Model

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>β</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (per year)</td>
<td>−0.011**</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Blacks</td>
<td>−0.025</td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>0.31***</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Education (per year)</td>
<td>0.029**</td>
<td>&lt; .01</td>
</tr>
<tr>
<td>MMSE (per 1 increase)</td>
<td>0.029**</td>
<td>&lt; .01</td>
</tr>
<tr>
<td>Years of driving experience (per year)</td>
<td>0.005*</td>
<td>&lt; .05</td>
</tr>
<tr>
<td>AVF per degree</td>
<td>0.008**</td>
<td>&lt; .001</td>
</tr>
</tbody>
</table>

Notes: AVF = attentional visual field; MMSE = Mini-Mental State Examination; and SBSOD = Santa Barbara Sense of Direction Questionnaire.

* p <.05; ** p <.01; *** p <.001.

### Table 3. Association of SBSOD With Driving Space Measured as the Log Maximum Area Driven, Controlling for Demographic and Cognitive Factors in Multivariate Models, Stratified by Gender

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Men, β</th>
<th>p</th>
<th>Women, β</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (per yr)</td>
<td>−0.089**</td>
<td>&lt; .001</td>
<td>−0.060***</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Blacks</td>
<td>−0.143</td>
<td></td>
<td>0.110</td>
<td></td>
</tr>
<tr>
<td>Education (per yr)</td>
<td>0.043</td>
<td></td>
<td>−0.037</td>
<td></td>
</tr>
<tr>
<td>GDS score (per unit)</td>
<td>−0.026</td>
<td></td>
<td>−0.011</td>
<td></td>
</tr>
<tr>
<td>Pain (0–5) per unit increase</td>
<td>−0.065</td>
<td></td>
<td>0.101</td>
<td></td>
</tr>
<tr>
<td>Trails B (per 10 seconds)</td>
<td>−0.009</td>
<td></td>
<td>−0.024</td>
<td></td>
</tr>
<tr>
<td>Years of driving experience (per yr)</td>
<td>0.057*</td>
<td>&lt; .05</td>
<td>0.016</td>
<td></td>
</tr>
<tr>
<td>SBSOD score (per 0.5-logit increase)</td>
<td>0.028</td>
<td></td>
<td>0.215**</td>
<td></td>
</tr>
<tr>
<td>AVF per deg</td>
<td>−0.004</td>
<td></td>
<td>−0.001</td>
<td></td>
</tr>
</tbody>
</table>

Notes: AVF = attentional visual field; GDS = Geriatric Depression Scale; SBSOD = Santa Barbara Sense of Direction Questionnaire.

* p <.05; ** p <.01; *** p <.001.
extent over an entire episode. Although there may be some misclassification, we feel that potential underestimation of driving space alone is unlikely to account for the discrepancy between driving space measures. A more likely possibility is the difference between the two measures in regard to the timescale of response. The self-reported driving space instrument queries a participant’s driving extent over the last year, whereas the driving space estimates driving extent from a 5-day sample. The abbreviated time sample may have been too short to capture long-distance trips. This explanation is plausible given that we told participants to drive their usual patterns during the week the device was installed; participants may have postponed longer trips to mimic usual driving habits. Also, the data show that men tended on average to drive longer distances. An alternative explanation is that the men inflated their reported sense of direction. However,

Table 5. Association of SBSOD With Reported Driving Space, Controlling for Demographic and Cognitive Factors in Multivariate Models

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Neighborhood and Near Towns, OR (95% CI)</th>
<th>Distant Towns, OR (95% CI)</th>
<th>Eastern Shore, OR (95% CI)</th>
<th>( \chi^2 ) (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (per year)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>1.26 (1.15–1.39)</td>
<td>0.98 (0.87–1.10)</td>
<td>1.07 (1.00–1.15)</td>
<td>27.98***</td>
</tr>
<tr>
<td>Women</td>
<td>1.20 (1.13–1.27)</td>
<td>1.14 (1.08–1.22)</td>
<td>1.10 (1.03–1.16)</td>
<td>38.34***</td>
</tr>
<tr>
<td>Blacks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>0.55 (0.20–1.52)</td>
<td>0.76 (0.32–1.94)</td>
<td>0.91 (0.48–1.73)</td>
<td>1.41</td>
</tr>
<tr>
<td>Women</td>
<td>2.42 (1.20–4.87)</td>
<td>2.06 (0.98–4.31)</td>
<td>1.54 (0.75–3.16)</td>
<td>6.64</td>
</tr>
<tr>
<td>Education (per year)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>0.86 (0.77–0.95)</td>
<td>0.80 (0.72–0.88)</td>
<td>0.88 (0.82–0.95)</td>
<td>25.27***</td>
</tr>
<tr>
<td>Women</td>
<td>0.80 (0.72–0.89)</td>
<td>0.92 (0.82–1.02)</td>
<td>0.93 (0.84–1.03)</td>
<td>14.99***</td>
</tr>
<tr>
<td>GDS score (per unit)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>1.12 (1.03–1.21)</td>
<td>1.08 (1.00–1.17)</td>
<td>1.03 (0.97–1.11)</td>
<td>2.23 (2.2)</td>
</tr>
<tr>
<td>Women</td>
<td>1.05 (0.98–1.12)</td>
<td>1.03 (0.97–1.11)</td>
<td>0.98 (0.91–1.05)</td>
<td>4.94</td>
</tr>
<tr>
<td>Pain (0–5) per unit increase</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>0.80 (0.45–1.43)</td>
<td>0.77 (0.44–1.34)</td>
<td>0.83 (0.57–1.20)</td>
<td>1.57</td>
</tr>
<tr>
<td>Women</td>
<td>1.27 (0.81–2.02)</td>
<td>0.99 (0.61–1.59)</td>
<td>0.74 (0.47–1.16)</td>
<td>5.68</td>
</tr>
<tr>
<td>Trails part B (per 10 s. increase)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>1.03 (0.99–1.06)</td>
<td>1.01 (0.97–1.04)</td>
<td>1.00 (0.97–1.02)</td>
<td>2.72</td>
</tr>
<tr>
<td>Women</td>
<td>1.04 (1.00–1.09)</td>
<td>1.03 (0.98–1.08)</td>
<td>1.02 (0.97–1.07)</td>
<td>4.20</td>
</tr>
<tr>
<td>Years of driving experience (per year)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>0.89 (0.83–0.96)</td>
<td>1.12 (1.01–1.24)</td>
<td>0.99 (0.95–1.03)</td>
<td>18.01***</td>
</tr>
<tr>
<td>Women</td>
<td>0.97 (0.93–1.01)</td>
<td>1.00 (0.96–1.05)</td>
<td>1.00 (0.96–1.04)</td>
<td>5.75</td>
</tr>
<tr>
<td>SBSOD score (per 0.5-logit increase)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>0.67 (0.46–0.96)</td>
<td>0.79 (0.57–1.10)</td>
<td>0.86 (0.71–1.04)</td>
<td>6.85</td>
</tr>
<tr>
<td>Women</td>
<td>0.43 (0.32–0.58)</td>
<td>0.58 (0.43–0.78)</td>
<td>0.72 (0.56–0.92)</td>
<td>30.81***</td>
</tr>
<tr>
<td>AVF per degree</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>0.97 (0.91–1.03)</td>
<td>0.95 (0.90–1.01)</td>
<td>0.99 (0.95–1.03)</td>
<td>3.19</td>
</tr>
<tr>
<td>Women</td>
<td>0.93 (0.88–0.98)</td>
<td>0.96 (0.90–1.01)</td>
<td>0.96 (0.91–1.02)</td>
<td>14.57**</td>
</tr>
</tbody>
</table>

Notes: Reference Mid-Atlantic region, number in reference category: men = 373; women = 186. AVF = attentional visual field; GDS = Geriatric Depression Scale; CI, confidence interval; OR = odds ratio; and SBSOD = Santa Barbara Sense of Direction Questionnaire.

*p < .05; **p < .01; ***p < .001.
several studies have shown that men compared with women actually have good spatial/navigational ability (Bryant, 1982; Cornell et al., 2003; Lawton et al., 1996; Montello, Lovelace, Golledge, & Self, 1999).

The finding that men had higher SBSOD scores than women is consistent with previous literature (Kozlowski & Bryant, 1977) and with findings that men have higher spatial confidence (Lunneborg, 1984) and lower spatial anxiety (Lawton et al., 1996) than women. If it is the case that older men have little difficulty or stress with navigation, then it is conceivable that sense of direction does not play as important a role in decisions about driving reduction for them as it does for women. This could explain the gender difference in the strength of association between sense of direction and driving space restriction.

The finding that women restrict their driving space to a greater extent than do men is consistent with the finding that women have a more limited life space, that is, travel distance from home (Peel et al., 2005), than do men. A recent longitudinal study showed that a severely constricted life space was associated with an increase in the mortality and frailty of older women and that even a slightly constricted life space was associated with a higher risk of becoming frail (Xue, Fried, Glass, Laffan, & Chaves, 2007). Factors associated with driving reduction in older adults include a perceived loss of independence (Buys & Carpenter, 2002), decrease in community activity participation (Marottoli et al., 2000), increased risk of isolation and depression (Fonda et al., 2001; Marottoli et al., 1997; Ragland, Satariano, & MacLeod, 2005), and increased risk of entering a long-term care institution (Freeman, Gange et al., 2006). The increased risk of health problems associated with limited travel highlights the need for intervention strategies aimed at reducing navigational stress and difficulty, particularly for women. Effective strategies may prevent older drivers from prematurely restricting their driving space just to reduce stress.

Navigational difficulty might be alleviated through the use of Intelligent Transportation Systems. Systems such as in-vehicle navigation systems have received positive responses from older adults in focus groups (Kostyniuk, Streff, & Eby, 1997; Oxley & Mitchell, 1995). In one focus group, participants found the systems useful and indicated their willingness to pay substantial prices for the devices (Oxley & Mitchell, 1995). They did point out the need to have prior hands-on training with the devices before using them on their own (Kostyniuk et al., 1997). Although these responses are promising, the devices that best afford safe driving will likely be those that are designed with age-related limitations in mind, particularly the loss of ability to divide attention, a known predictor of crash risk. Further research is needed to determine whether such devices can reduce the stress associated with navigating while driving and whether their use affects decisions about driving reduction.

The data in this study were derived from a population of older drivers located in a semirural city, where one has to drive a distance in the north–south direction to leave the area. Further research is needed to determine whether the findings generalize to older drivers who live in other geographic areas and terrain.

The findings in this study indicate that future driving studies with older adults should take into consideration the role that psychological factors play. Perceived ability can influence driving decisions, sometimes more strongly than physical or cognitive factors. The findings highlight strong gender differences with regard to driving restriction and perceived sense of direction and emphasize the need to include gender in driving studies and models.

FUNDING
The research was funded by a National Institutes of Health/National Institute on Aging grant (AG23110) to SKW; an Research to Prevent Blindness Althouse Special Scholars award to EWG; and an Australian National Health and Medical Research Council Postdoctoral Fellowship grant to LK.

Correspondence
Address correspondence to Kathleen A. Turano, PhD, The Johns Hopkins University School of Medicine, 600 North Wolfe Street, Wilmer Room 129, Baltimore, MD 21205. Email: kturano1@jhmi.edu

References


Received April 4, 2008
Accepted January 11, 2009
Decision Editor: Rosemary Blieszner, PhD