Divided Visual Attention as a Predictor of Bumping while Walking: The Salisbury Eye Evaluation

Aimee Teo Broman,[1] *Sheila K. West,*[1] *Beatriz Muñoz,*[1] *Karen Bandeen-Roche,*[2] *Gary S. Rubin,*[3] *and Kathleen A. Turano*[1]

Purpose. The purpose of this study was to determine the association between bumping while walking and divided visual attention, as measured by the useful field of view (UFOV).

Methods. The Salisbury Eye Evaluation is a population-based study of community-dwelling adults, aged 72 to 92 at the third round of data collection. Participants walked a circuitous 32.8-m course, seeded with obstacles, and the number of bumps made while traversing the course was counted. UFOV divided attention score was based on processing speed: the time taken to identify a central target, and the location of a peripheral target simultaneously. Association between number of bumps and UFOV score was assessed in a generalized linear model, with adjustment for vision and attention measures that might explain the UFOV score.

Results. Of the 1504 participants in this study, 10.1% did not attempt the mobility course. In a model adjusting for demographic, physical, cognitive and attention, and vision measures, a decrease of 50 ms in processing speed for the divided-attention task was associated with a 4.9% increase ($P = 0.004$) in number of bumps made over the course. Receiver operating characteristic curves were created for the UFOV and visual field tests, to determine accuracy in detecting those with a high number of bumps. The visual field test had slightly higher area under the curve, but positive predictive value for both tests was low.

Conclusions. The UFOV test of divided attention, as measured by processing speed, independently predicted bumping while walking. These data suggest that poor visual attention is a significant risk factor for bumping while walking. (*Invest Ophthalmol Vis Sci.* 2004;45:2955–2960) DOI:10.1167/iovs.04-0219

Safe navigation while walking is important, particularly for older persons who must avoid falls and reduce their risk of accidents. Falling and lower levels of mobility or physical activity have been shown to be risk factors for entering a nursing home, higher morbidity, and higher mortality in older persons.[1–5] Avoiding stumbling and bumping into objects are critical components of safe navigation, and therefore determining risk factors for bumping while walking is important in helping to prevent bumps and potential subsequent falls.

Failure to avoid obstacles in one's path bears a similarity to vehicle crashes, although the latter clearly involves other complex functions, such as navigating an automobile and moving at a higher speed. A significant predictor of crashes is worse score on a test of the useful field of view (UFOV), and in particular, the divided-attention component of the UFOV.[6–9]

The divided-attention component of the UFOV can be measured by visual field extent or by processing time in which peripheral visual information can be detected and localized at the same time that a target in the central visual field can be identified.[10] Although UFOV divided attention, measured by visual field extent, has been shown to be a good predictor of motor vehicle crashes in an older adult population,[9] there are no studies on the predictive properties of the UFOV divided-attention test measured by processing speed. In this study, we used processing speed of the UFOV divided-attention test to predict "crashes" in a closer, more personal space, and hypothesized that diminished UFOV divided attention would predict risk of bumping while walking an obstacle course.

The purpose of this study is to determine the association between the number of bumps made while walking a mobility course and divided visual attention, adjusting for other factors that might explain the UFOV divided-attention score. We also compared the predictive properties of the divided visual attention test with a conventional visual field test in identifying those who are at risk of bumping objects while walking.

Methods

Population

The Salisbury Eye Evaluation (SEE) is a longitudinal population-based study of vision and visual function in a random sample of community-dwelling residents of Salisbury, Maryland. Participants in the first round of data collection (1993–1995) were 65 to 84 years old and were required to have a mini-mental state examination (MMSE) score of 18 or higher. Details on this population are described extensively elsewhere.[11]

Data for this analysis were taken from the third round (1999–2001) of data collection, 6 years after baseline. Two thousand five hundred twenty (65% of eligible individuals [$n = 34$]) participants were in the baseline study. Of these, 1504 remained in the study for the third round of data collection. Loss over time was predominantly due to death (48.5%), refusal (31.5%), or move to a residence out of the area (18.3%). Continuing participants were younger (by 2 years, on average) and had higher MMSE scores (by 1.2 points, on average) than participants who were alive but did not participate. All subjects participating in round 3 were interviewed and examined in a standardized fashion at a central examination site by trained technicians.

The Institutional Review Board of the Johns Hopkins Medical Institutions approved all procedures for the study, and written, informed consent was obtained from each participant, according to the tenets of the Helsinki Accord.

From the Departments of [1]Ophthalmology and [2]Biostatistics, The Johns Hopkins University, Baltimore, Maryland; and the [3]Institute of Ophthalmology, University College London, London, United Kingdom.

Supported by Grant AG16294 from the National Institute of Aging. SKW is a Research to Prevent Blindness Senior Scientific investigator.

Submitted for publication February 27, 2004; revised May 10, 2004; accepted May 27, 2004.

Disclosure: **A.T. Broman**, None; **S.K. West**, None; **B. Muñoz**, None; **K. Bandeen-Roche**, None; **G.S. Rubin**, None; **K.A. Turano**, None

The publication costs of this article were defrayed in part by page charge payment. This article must therefore be marked "*advertisement*" in accordance with 18 U.S.C. §1734 solely to indicate this fact.

Corresponding author: Aimee Teo Broman, Dana Center for Preventive Ophthalmology, Wilmer Suite 129, 600 North Wolfe Street, Baltimore, MD 21287; aibroman@jhmi.edu.

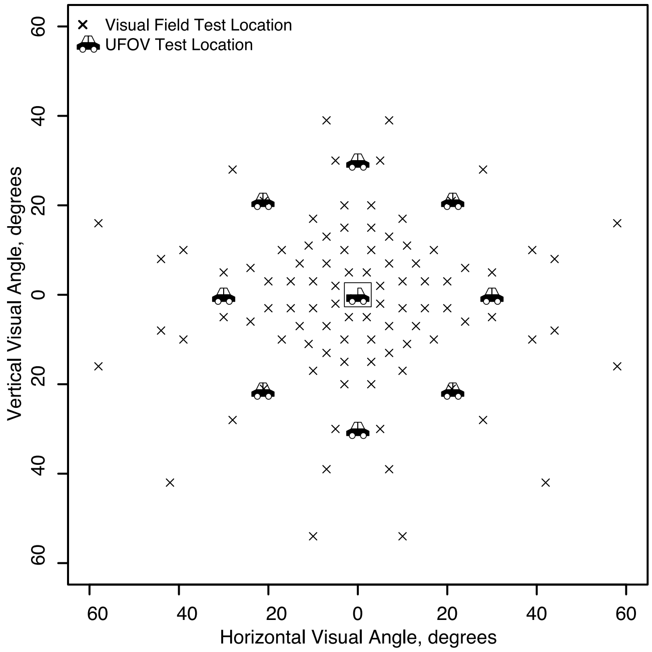

FIGURE 1. UFOV and visual field test locations.

Clinic Measures

A computer version of the UFOV test was used (Visual Resources, Inc., Bowling Green, KY). In this version, the divided-attention test measured processing speed for a divided attention task. A 17-in. touch-sensitive monitor was used to view the images, and participants were seated 18 to 24 in. from the screen. The targets presented were approximately 2 × 2 cm. The central target (silhouette of a car or truck) was presented on a black background in a fixation box on the screen. A peripheral target (silhouette of a car) was simultaneously presented at one of eight locations near the edge of the screen (at approximately a 30° visual angle), along the cardinal and oblique axes (Fig. 1). The participant was asked to identify the centrally presented object and locate the direction of the peripheral target. The targets were presented at decreasing exposure durations, ranging from 16 to 500 ms. The outcome from this test was the exposure duration at which a participant could correctly identify the central and peripheral targets 75% of the time, using a double-staircase method[12] (Edwards JD et al., manuscript in preparation). If a subject was unable to judge correctly the central and peripheral objects at the longest duration of 500 ms, a score of 500 was assigned. Participants whose visual acuity was worse than 20/100 did not take this test.

Acuity was measured binocularly with the Early Treatment of Diabetic Retinopathy Study (ETDRS) charts, using strict forced-choice testing procedures and the participant's habitual distance correction (hereafter referred to as presenting acuity). The number of letters read correctly was converted to log10 (logarithm of the minimum angle of resolution; logMAR) based on the methods of Bailey et al.[13]

Visual field was tested in each eye using the 81-point, single-intensity screening test strategy on a field perimeter (Humphrey Field Analyzer; Carl Zeiss Meditec, Dublin, CA). This strategy tests points over a 60° (radius) field with a single-target intensity of 24 dB. The test is a variation on the functional test developed by Esterman.[14] Similar to the Esterman study, we used test targets of single intensity and size. However, Esterman differentially weighted regions of the visual field based on their presumed usefulness; our study gives equal weight to all points in the visual field. We combined the fields from the left and right eyes to create a binocular visual field, made up of 96 points (Fig. 1).[15] A point in the field was counted as missed if the participant could not see that point in both the left and the right eye.

The Brief Test of Attention (BTA)[16] provided a measure of nonvisual, sustained, divided attention. In this test, the examiner recited a sequence of letters and numbers, and the participant was asked to count the number of letters in the sequence. Participants were not allowed to use their hands to visually help them keep track of the letters, and so the ability of the participant to count letters is thought to be a measure of selective attention in the presence of distracters, as well as sustained attention. The score ranges from 1 to 10 and is a count of the number of sequences in which the participant was correctly able to determine the number of letters. Participants who could not hear the recitation were excused from this test (n = 16).

The mobility course used to measure amount of bumping while walking has been described previously.[17] Briefly, the course was 32.8-m long and was seeded with obstacles, including hanging plants, wastebaskets, and wooden life–size figures of people. A technician conducted a detailed explanation of the course to the participant and how he or she was to navigate it. The participant was asked to walk as quickly and safely as possible while avoiding all obstacles in his or her path. A trained observer followed the participant through the course and marked on a map where the participant made physical contact with an object along the course. In the first half of the course, participants walked at a normal speed with normal room lighting. In the second half of the course, participants wore dark glasses to simulate a low-luminance situation. The number of physical contacts (bumps) was summed over the entire length of the course.

Questionnaire items provided basic demographic measures on age, gender, and race (white or African American). Cognitive status was assessed using the MMSE.[18] Depressive symptoms were assessed through the General Health Questionnaire, using the subscale on depressive symptoms (seven items).[19,20] Trained technicians measured a participant's height and weight, from which we calculated body mass index (BMI) , as described previously.[21]

Balance was measured using three 30-second timed stands.[3,22] Participants began with a stance of medium difficulty (semitandem: heel of one foot placed at the heel of the first metatarsal phalangeal joint of the other foot), and if they were unable to hold the stance for 30 seconds, they tried a stance of less difficulty (side-by-side: feet next to each other). If they were able to hold the semitandem stance for 30 seconds, they attempted the tandem stance (heel of one foot placed at the tip of the first toe of the other foot). Ability to hold the increasingly difficult stances resulted in higher balance scores.

Grip strength was measured using a hand dynamometer (Jamar) and the result was used as a measure of frailty in this sample.

Statistical Analysis

We were interested in predicting number of bumps per course using the UFOV score of divided attention, adjusted for demographic and physical factors associated with mobility. A second question of interest was whether other attention and vision measures we collected (BTA, visual acuity, and visual field) explained the relationship of divided visual attention and bumping. We hypothesized that the visual component of the UFOV test could be explained by distance visual acuity (to identify the central image) and visual field (to identify the position of the peripheral image). The outcome measure was a count of the number of bumps over the course. Thus, we used generalized linear regression models to describe the (log) course-wide bump rate. Poisson regression is a model commonly used for this purpose; however, our data exhibited appreciable extra-Poisson variability. To accommodate this, we specified negative binomial models for the distribution of counts. Regression models fit bumps as a function of divided-attention score, adjusting for age, gender, race, depression, MMSE score, number of comorbid conditions, BMI, and height. BTA score and vision measures were also added to the model to observe their role in explaining the relationship of divided attention and bumping. This generalized linear model uses a log link, and thus, estimates from the model can be raised to the e power, to produce a "rate ratio." This statistic is similar to an odds ratio, except that the rate ratio estimates a difference in rate

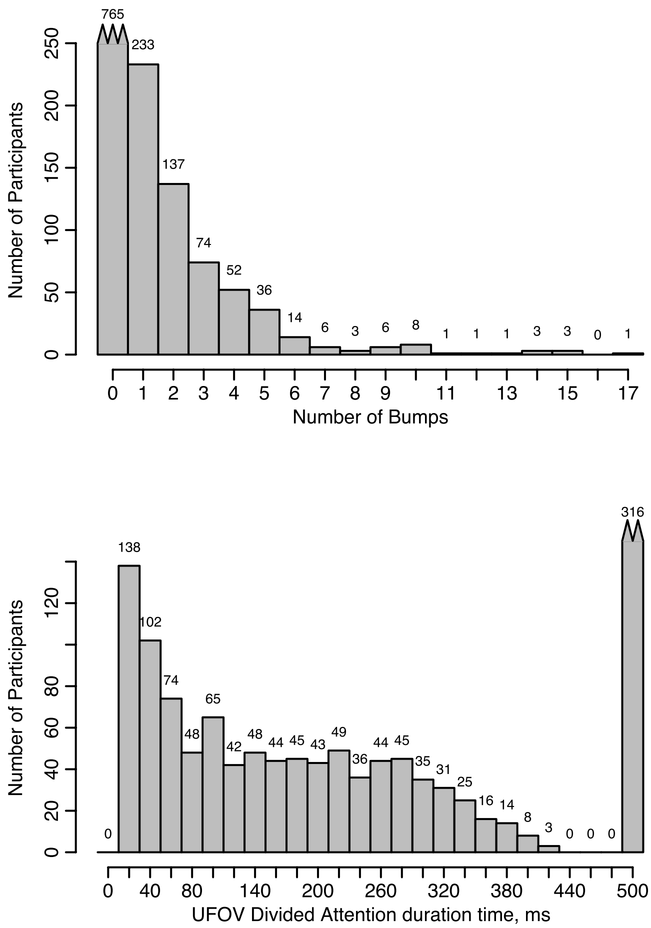

FIGURE 2. Distribution of the number of bumps and UFOV scores.

(number of bumps per course), rather than a difference in probability, or odds, of bumping. Receiver operating characteristic (ROC) curves were created to determine the ability of the UFOV divided-attention test to predict a high number of bumps.

RESULTS

Of the 1504 participants in the third round, 153 did not participate in the mobility test, because they could not walk or felt unsafe. These participants are described in detail elsewhere.[17] Briefly, those who did not attempt the mobility course were more likely to be older and frailer (as measured by grip strength) and have lower scores on the MMSE. In addition, 7 participants began, but did not complete, the mobility test and were excluded from the analyses.

Overall, 765 (57%) participants did not experience a bump while navigating the course (Fig. 2), and the average number of bumps was 1.15. Divided attention was distributed bimodally, with 383 (28.5%) participants having "normal" divided-attention ability (below 100 ms), and 290 (21.6%) participants having severe difficulty (500 ms). Average score on the divided-attention test was 235 over the entire population, and 108 among those scoring less than 500.

Those who had at least one bump while navigating the mobility course were older and more likely to be male and African American (Table 1). Of the variables evaluated, only grip strength was not related to bumping, after adjustment for age. Bumping was associated with lower cognitive function: Those with lower MMSE scores, depression, lower scores in the BTA, and divided visual attention were more likely to bump. Physical factors were also associated with one or more bumps: being taller, greater BMI, worse balance, and having more comorbid conditions. Those with worse visual acuity or visual fields were also more likely to have had at least one bump.

In a generalized linear model adjusting for age, gender, race, BMI, height, balance, number of comorbid conditions, depres-

TABLE 1. Participant Characteristics of 1344 Participants Completing the Mobility Test

Characteristic	*n**	≥1 bump (%)	*P*†
Age (y)			
70–74	439	37.4	0.0002
75–79	503	41.8	
80–84	278	48.2	
85+	124	57.3	
Gender			
Men	572	48.4	0.0003
Women	772	39.1	
Race			
White	1031	41.3	0.008
African-American	313	48.9	
BMI			
14–24	422	41.0	0.009
25–29	521	40.7	
30–59	386	47.9	
Number of comorbidities			
0–2	560	36.2	<0.0001
3–5	624	45.7	
6+	150	57.3	
Height			
Women 4′7″–5′4″	663	38.8	0.0001
Men 5′5″–6′4″	672	46.9	
Balance score‡			
1–2	179	61.4	<0.0001
3–4	263	50.2	
5–6	887	37.1	
Grip strength (score)			
3–19	298	45.0	0.37
20–24	322	41.9	
25–32	338	42.6	
33+	362	43.4	
Depression			
No	1244	42.0	0.004
Yes	86	58.1	
MMSE score			
0–18	40	72.5	<0.0001
19–23	178	63.5	
24–30	1124	38.9	
Divided attention (ms of target exposure)			
16–99	383	30.6	<0.0001
100–199	234	37.6	
200–499	318	45.6	
500	290	59.0	
Brief Test of Attention score			
0–5	629	50.1	<0.0001
6–10	638	35.4	
Presenting acuity			
Better than 20/40	1245	42.4	0.002
Between 20/40 and 20/100	68	45.6	
20/100 or worse	30	66.7	
Visual field (points missed)			
0–14	303	28.7	<0.0001
15–22	343	37.0	
23–32	321	48.3	
33–96	300	54.0	

* *n* sometimes does not equal the total sample, due to missing values.

† Adjusted for age. χ^2 test.

‡ Higher score is better balance.

Table 2. Association of Divided Visual Attention, Demographic, Cognitive, and Physical Factors with Number of Bumps, in a Multivariate Model

	Rate Ratio	LCL	UCL	*P*
Age (Per 1 year increase)	1.02	1.00	1.04	0.10
Gender (Female)	0.98	0.73	1.31	0.90
Race (African American)	0.86	0.68	1.10	0.24
BMI				
Low	0.89	0.71	1.12	0.32
Mid	1.00	—	—	—
High	1.40	1.12	1.76	0.003
Height (Per 5-cm increase)	1.14	1.05	1.23	0.001
Balance				
Low	1.33	0.97	1.82	0.07
Mid	1.00	—	—	—
High	0.81	0.63	1.03	0.08
Comorbidities (Per 1-count increase)	1.04	0.99	1.09	0.15
Depressed	1.23	0.84	1.77	0.28
MMSE result (Per 1-point increase)	0.93	0.89	0.96	<0.0001
Divided visual attention (Per 50-point decrease)	1.08	1.04	1.11	<0.0001

LCL, lower confidence limit; UCL, upper confidence limit.

sion, and cognitive status, an increase of 50 ms in divided attention was associated with a 7.6% increase in number of bumps (rate ratio [RR] = 1.076, $P = 0.00001$; Table 2). The model appeared to fit well, with no trends in the working residuals. Among the adjustment factors, those with high BMI, worse balance, lower MMSE and who were taller had higher rates of bumping.

Since the test of divided attention contains both visual and more general attention elements, we sought to determine whether the UFOV test added information on bumping beyond these factors. We added a nonvisual test of divided attention (BTA), visual field, and visual acuity measures to the model. After adjustment for visual field value and presenting acuity, an increase of 50 ms in divided attention was associated with a 6.1% increase in bumps ($P = 0.0007$). With adjustment for BTA, an increase of 50 ms was associated with a 6.4% increase in bumps ($P = 0.0003$). After adjustment for vision and attention measures, UFOV divided attention remained independently associated with number of bumps, with an increase of 50 ms associated with a 4.9% increase ($P = 0.009$; Table 3). In other words, the UFOV divided-attention score appeared to be a predictor of bumping, beyond that explained by acuity, visual field, and nonvisual attention tests. Among the vision and attention measures used for adjustment, visual field was highly associated with bumping, with a 17.0% increase in bumps per 10 field points missed ($P < 0.0001$). A point decrease in BTA was weakly associated with a 4.6% increase in number of bumps ($P = 0.04$). Although loss in visual acuity appeared to be associated with fewer bumps in the multivariate model, this association was not significant ($P = 0.3$) and was most likely due to some colinearity between the vision measures. When acuity was entered into the model as the sole vision measure, loss of 3 lines of acuity was associated with a 3.47% increase in number of bumps ($P = 0.05$).

The distribution of the divided-attention score was somewhat U-shaped, with 316 observations at the extreme value of 500 (Fig. 2). Excluding these observations weakened the association of bumping with divided attention slightly, but not by much. A 50-ms increase in the divided attention score was associated with a 4.0% increase in bumps ($P = 0.24$), compared with a 4.9% increase when all observations were included, in the presence of attention, vision, and other adjustment factors shown in Table 3. However, individuals with scores of 500 ms were those who could not complete the test within the allowed processing time and represent the most impaired participants. We kept these individuals in the final models to avoid biasing the results.

ROC curves were created to look at the screening ability of the divided-attention test to accurately detect those who would have more bumps along the course (Fig. 3). Curves were plotted for persons having more than four, five, and six bumps along the course. These represented 10%, 6%, and 3.5% of the cohort, respectively (Fig. 2). Values for test cut points are shown next to their sensitivity and specificity in the plots. ROC curves were also plotted for visual field, which was also highly predictive of bumps. Although the visual field test had a slightly higher area under the curve (i.e., better diagnostic ability) than the divided-attention test, both tests performed well in screening for those with a high number of bumps. In screening for those with more than six bumps, area under the ROC curve was 0.81 for the UFOV test, and 0.83 for the visual field test. However, because of the small number of participants with more than six bumps, the predictive value of a positive test (proportion of actual cases among those who tested positive) was low: 5.5% for 426 ms on the UFOV test, and 6.6% for 29 points missed on the visual field test.

Discussion

Although there have been studies that looked at the relationship between divided attention and falling, or between divided attention and vehicle crashes in older adults, ours is the first study to find a relationship of divided visual attention and bumping while walking. This is also the first study to look at predictive properties of divided visual attention, as measured by processing speed, rather than visual field extent.

In this sample of older adults, worse divided visual attention was independently associated with a higher number of bumps while walking. Moreover, a person's visual field and nonvisual attention level did not completely explain this relationship, indicating additional predictive information contained in the UFOV test. However, visual field was also an important independent predictor of bumping. This finding may be due in part to a small overlap between measurements of visual field and divided attention, when divided attention is assessed with processing speed rather than size. Presenting acuity was not associated with bumping, when visual field was included in the model. This lack of association between visual acuity and mobility has been reported in other small, clinically based studies.[23–25]

Other risk factors also affected the number of bumps: high BMI, which also has been associated with slower walking speed,[17] was associated with a higher number of bumps. This

Table 3. Association of Divided Visual Attention, Visual, and Attention Measures with Number of Bumps

	Rate Ratio	LCL	UCL	*P*
Divided visual attention (Per 50-point decrease)	1.05	1.01	1.09	0.009
Visual field (Per 10 points missed)	1.17	1.09	1.25	<0.0001
Visual acuity (Per 3 lines loss)	0.36	0.05	2.50	0.30
Brief Test of Attention (Per point increase)	0.95	0.91	1.00	0.04

Data are adjusted for age, gender, race, BMI, height, balance, number of comorbidities, depression, and MMSE score in a multivariate model. Abbreviations as in Table 1.

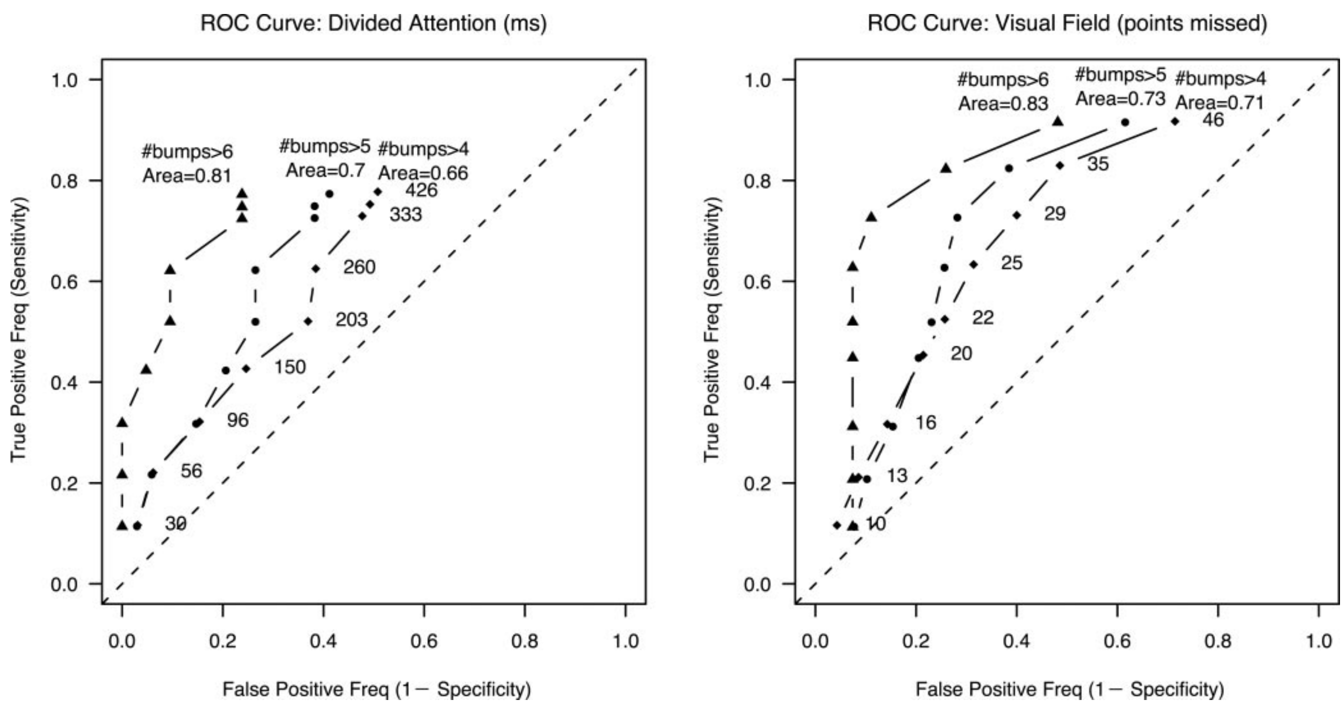

FIGURE 3. ROC curves predicting more than 4, 5, and 6 bumps. Area indicates area under the ROC curve; numbers indicate the test cutpoints used.

was expected, as the course was encased in walls with protruding objects, and larger persons would have had less clearance than leaner persons. Better balance, which has been associated with better gait stability and lower risk of falls,[26] was associated with fewer bumps. Taller people had more bumps over the course, but this was most likely due to four hanging plants that were part of the course. Height was not associated when bumps due to plants were removed from the bump count. Better cognition was associated with fewer bumps: a point decrease in MMSE score was associated with a 7.4% increase in the number of bumps. The BTA result had a borderline association with the number of bumps, even in the presence of divided visual attention. This finding may be due to the differences between the UFOV and BTA tests, beyond the use of vision. Whereas the UFOV requires quick processing speed, the BTA requires sustained attention or concentration, which may also be useful for avoiding obstacles and following a directed path.

The ROC analysis suggested that the UFOV test of divided attention was slightly less predictive of bumping than was the visual field test. This finding is different from the findings of Owsley[8] and Owsley et al.,[9] who showed that the risk of motor vehicle crashes were predicted better by the field extent of the UFOV than by visual field.[8,9] This difference is not surprising, given the differences in the outcome being measured. Bumping while walking is fairly common, usually with no serious consequences, whereas vehicle crashes occur less frequently and are potentially fatal. With regard to visual processing, the slower traveling speed of a walker results in an overall slower rate of change in visual information compared with that of the driver, for whom objects move quickly in and out of the field of view. However, neither the UFOV nor visual field test result had good positive predictive properties when used in this cohort.

There are some limitations of this study. First, those who did not complete the mobility course were different in important ways from those who did complete the course. Those who had worse vision (measured by acuity), worse cognition (MMSE), or were frailer (grip strength) were less likely to take part in the mobility test. Among the 153 who did not take the mobility test, 73% also did not take the UFOV test, due to vision or cognition impairments. It is likely that this group would have experienced even more bumps, and including them in the models would have strengthened the relationship between the vision and cognition measures and bumping. Second, the number of bumps observed in the mobility course may be a conservative estimate, since we assessed performance in a static environment. People with poor UFOV measures would likely bump more in environments with moving people or objects.

In summary, the UFOV test of divided attention, as measured by processing speed, independently predicted bumping while walking. Personal safety while navigating is an important component of independent mobility, and our data suggest that poor visual attention lowers a person's ability to avoid obstacles while walking, creating unsafe situations. Improvements in visual attention may assist in decreasing the risk of bumping while walking.

Acknowledgments

The authors thank Jennifer Istre-Walker, Christina Alston, David Alston, Jackie Townsend, Josh McIntosh, Caroline Porter-Long, Millie Hernandez, and Patricia Eaglen for their skill and support in collecting the data for this study and Donna Gilbert and Christine Humphries for data management and quality assurance.

References

1. Black BS, Rabins PV, German PS. Predictors of nursing home placement among elderly public housing residents. *Gerontologist.* 1999;39:559–568.
2. Fried LP, Kronmal RA, Newman AB, et al. Risk factors for 5-year mortality in older adults: the Cardiovascular Health Study. *JAMA.* 1998;279:585–592.
3. Guralnik JM, Simonsick EM, Ferrucci L, et al. A short physical performance battery assessing lower extremity function: associa-

tion with self-reported disability and prediction of mortality and nursing home admission. *J Gerontol*. 1994;49:M85–M94.
4. Melzer D, Lan TY, Guralnik JM. The predictive validity for mortality of the index of mobility-related limitation: results from the EPESE study. *Age and Ageing*. 2003;32:619–625.
5. Tinetti ME, Williams CS. Falls, injuries due to falls, and the risk of admission to a nursing home. *N Engl J Med*. 1997;337:1279–1284.
6. Ball K, Owsley C, Sloane ME, Roenker DL, Bruni JR. Visual attention problems as a predictor of vehicle crashes in older drivers. *Invest Ophthalmol Vis Sci*. 1993;34:3110–3123.
7. Myers RS, Ball KK, Kalina TD, Roth DL, Goode KT. Relation of useful field of view and other screening tests to on-road driving performance. *Percept Motor Skills*. 2000;91:279–290.
8. Owsley C. Vision and driving in the elderly. *Optom Vis Sci*. 1994; 71:727–735.
9. Owsley C, Ball K, McGwin G Jr, et al. Visual processing impairment and risk of motor vehicle crash among older adults. *JAMA* 1998; 279:1083–1088.
10. Ball KK, Beard BL, Roenker DL, Miller RL, Griggs DS. Age and visual search: expanding the useful field of view. *J Opt Soc Am A*. 1988;5:2210–2219.
11. Rubin GS, West SK, Munoz B, et al. A comprehensive assessment of visual impairment in a population of older Americans. The SEE Study. Salisbury Eye Evaluation Project. *Invest Ophthalmol Vis Sci*. 1997;38:557–568.
12. Wetherill GB, Levitt H. Sequential estimation of points on a psychometric function. *Br J Math Stat Psychol*. 1965;18:1–10.
13. Bailey IL, Bullimore MA, Raasch TW, Taylor HR. Clinical grading and the effects of scaling. *Invest Ophthalmol Vis Sci*. 1991;32: 422–432.
14. Esterman B. Functional scoring of the binocular field. *Ophthalmology*. 1982;89:1226–1234.
15. Nelson-Quigg JM, Cello K, Johnson CA. Predicting binocular visual field sensitivity from monocular visual field results. *Invest Ophthalmol Vis Sci*. 2000;41:2212–2221.
16. Schretlen D, Bobholz JH, Brandt J. Development and psychometric properties of the Brief Test of Attention. *Clin Neuropsychol.* 1996; 10:80–89.
17. Turano KA, Broman AT, Bandeen-Roche K, Munoz B, Rubin GS, West SK. Association of visual field loss and mobility performance in older adults: Salisbury Eye Evaluation Study. *Optom Vis Sci.* 2004;81:298–307.
18. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state": a practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res*. 1975;12:189–198.
19. Goldberg DP. *The Detection of Psychiatric Illness by Questionnaire.* Maudsley Monograph No. 21. Oxford, UK: Oxford University Press; 1972.
20. Goldberg DP, Hillier VF. A scaled version of the General Health Questionnaire. *Psychol Med*. 1979;9:139–145.
21. Caulfield LE, West SK, Barron Y, Cid-Ruzafa J. Anthropometric status and cataract: the Salisbury Eye Evaluation project. *Am J Clin Nutr*. 1999;69:237–242.
22. Buchner DM, Hornbrook MC, Kutner NG, et al. Development of the common data base for the FICSIT trials. *J Am Geriatr Soc*. 1993;41:297–308.
23. Lovie-Kitchin J, Mainstone J, Robinson J, Brown B. What areas of the visual field are important for mobility in low vision patients? *Clin Vision Sci*. 1990;5:249–263.
24. Geruschat DR, Turano KA, Stahl JW. Traditional measures of mobility performance and retinitis pigmentosa. *Optom Vis Sci*. 1998; 75:525–537.
25. Brown B, Brabyn L, Welch L, Haegerstrom-Portnoy G, Colenbrander A. Contribution of vision variables to mobility in age-related maculopathy patients. *Am J Optom Physiol Opt*. 1986;63: 733–739.
26. Cromwell RL, Newton RA. Relationship between balance and gait stability in healthy older adults. *J Aging Phys Act*. 2004;12: 90–100.