RESEARCH BRIEF

The Relationship Between Visual Abilities and Driving Habits Among Older Drivers: A LongROAD Study

This study examines the relationship between measures of visual function at baseline and objective measures of driving habits averaged over a one-year follow-up period in a sample of older drivers. Results showed that participants had relatively good visual function at the time of their enrollment in the study. Analyses found that lower visual acuity and visual-spatial abilities were related to the driving behavior categories of staying closer to home, less driving overall and greater driving avoidance, although not for every measure. Poorer contrast sensitivity, which is related to one's ability to see in low-light conditions, was associated with avoidance of both nighttime driving and driving on high-speed roads but was not related to driving closer to home or overall driving.

METHODS

Vision is important for safe driving, yet studies have found mixed results about the effects of visual function declines on driving habits. Some studies (e.g., Szlyk, Pizzimenti, & Fishman, 1995) have shown that crash risk is lower for some people with vision-related conditions due to changes in driving habits. Studies using self-reported driving measures have confirmed this. Recent work, however, has found that when self-reported estimates of driving over one week were compared with actual driving measured by a GPS device, older drivers were found to inaccurately estimate their amount of driving and the number of trips they had taken (Blanchard, Myers, & Porter, 2010). Thus, there is a need to assess driving habits related to visual function using objective measures of driving. This study examines the relationship between measures of visual function at baseline and objective measures of driving habits (staying close to home, exposure and avoidance) averaged over a one-year follow-up period in a sample of older drivers.

Study data were obtained from measurements of visual function and objective driving data averaged over 12 months following baseline assessment of active drivers ages 65-79 enrolled in the LongROAD multisite prospective cohort study (Li et al., 2017). The driving data were filtered to identify participants with at least 12 full months of data at the time of analysis (n=2,131) and the remaining participants were excluded. For participants with more than one year of data, only the first 12 months were analyzed. The objective driving habit measures were based on previous work (Molnar et al., 2013) and were conceptualized based on three components of the Driving Habits Questionnaire (DHQ, Owsley et al., 1999): driving closer to home (called driving space), driving exposure and driving avoidance. The objective driving habit measures used were similar to the self-reported topics addressed in the DHQ but derived from data recorded from a small GPS device installed in each participant's vehicle. This system automatically recorded all driving when the vehicle was turned on and could determine whether or not it was the participant who was driving.

The driving habit measures used in this study included two measures each of driving closer to home (percentage of trips within 15 miles of home and percentage of trips within 25 miles of home), driving exposure (average miles

driven per month and average days driven per month) and driving avoidance (average percentage of trips at night and average percentage of trips on high-speed roads). Definitions of these measures are shown in Table 1. The monthly driving habit measures were averaged for each participant's year of data to obtain a mean and standard deviation for each measure.

Three measures of visual function were extracted from the baseline assessments of the participants. Visual function was measured with glasses or contacts being worn if they were used for driving. The measures of visual function were: visual acuity, contrast sensitivity and visual-spatial perception ability. The visual acuity and visual-spatial analyses used measures for both eyes. The analyses of contrast sensitivity used results from only the better eye.

Table 1. Means, standard deviations, definitions and categories for each driving habit measure

Driving Habits Measure	Mean (SD)	Definition for the Monthly Variable (Trip is defined as ignition-on to ignition-off)	Category
Average monthly % trips within 15 miles of home	64.1 (22.4)	Percentage of trips traveled in month within 15 miles of home.	Driving Closer to Home (Driving Space)
Average monthly % trips within 25 miles of home	75.8 (18.9)	Percentage of trips traveled in month within 25 miles of home.	Driving Closer to Home (Driving Space)
Average miles driven per month	791.4 (444.2)	Total number of miles driven in month.	Driving Exposure
Average days driving per month	22.5 (5.0)	Total number of days in month with at least one trip.	Driving Exposure
Average monthly % of trips at night	6.7 (5.1)	Percentage of trips in month during which at least 80% of trip was during nighttime (defined as civil twilight or a solar angle greater than 96 degrees).	Driving Avoidance
Average monthly % of trips on high speed roads	12.9 (10.9)	Percentage of trips in month where 20% of distance traveled was at a speed of 60 mph or greater.	Driving Avoidance

RESULTS

Of 2,131 participants included in these analyses, 48.6% were male and 85.7% were white non-Hispanic (6.8% were black non-Hispanic, 2.6% Hispanic and 2.3% Asian). Participants were a mean age of 71.2 years and were well educated: 13.3% had a high school/trade degree or less, 21.2% had some college or an associate degree, 23.8% had a bachelor's degree and 41.7% had an advanced college degree. Annual household incomes were relatively high: 4.3% reported less than $20,000; 21.0% reported $20,000-$49,999; 24.8% reported $50,000-$79,999; 15.0% reported $80,000-$99,999 and 31.4% reported $100,000 or more. The scores for the three visual functions measures are shown in Figures 1-3.

Table 2 shows results of the correlation analysis (coefficient and p-value) across each driving habit and visual function comparison. The study found that both measures of driving close to home were significantly associated with visual acuity and visual-spatial scores, with scores indicating poorer visual function being associated with a higher percentage of trips close to home. Contrast sensitivity was not associated with measures of driving close to home. Analysis of the two driving exposure measures showed that average miles driven per month were significantly lower in the group with impaired acuity. Contrast sensitivity and visual-spatial scores were not statistically associated with this measure but lower visual-spatial scores were associated

with a greater average number of days driving per month. To explore this finding further, we divided the average monthly days of driving scores into quartiles and determined the average visual-spatial score for each quartile. We found no evident trend that explains the significant but very small correlation. Both driving avoidance measures were associated with all three visual function measures, except that percentage of trips on high-speed roads was not associated with visual acuity. In all significant cases, better visual function scores were associated with increasing average percentages of trips at night and on high-speed roads.

Table 2. Spearman correlations and p-values across each driving habit/visual function comparison, with significant differences shown in bold

Driving Habit Measure	Visual Acuity (n=1,673)	Contrast Sensitivity (n=2,117)	Visual-Spatial (n=2,127)
Average monthly % trips within 15 miles of home	**0.09138 p=.0002**	0.01242 p=.5679	**-0.05029 p=.0204**
Average monthly % trips within 25 miles of home	**0.08536 p<.0005**	0.00232 p=.9149	**-0.08076 p=.0002**
Average miles driven per month	**-0.09121 p=.0002**	-0.00684 p=0.7532	0.02556 p=.2397
Average days driving per month	-0.01305 p=.5937	-0.00159 p=.9416	**-0.04550 p=.0360**
Average monthly % of trips at night	**-0.07812 p=.0014**	**.07880 p=.0003**	**0.08199 p=.0002**
Average monthly % of trips on high speed roads	-0.04368 p=.0741	**0.12199 p<.0001**	**0.14885 p<.0001**

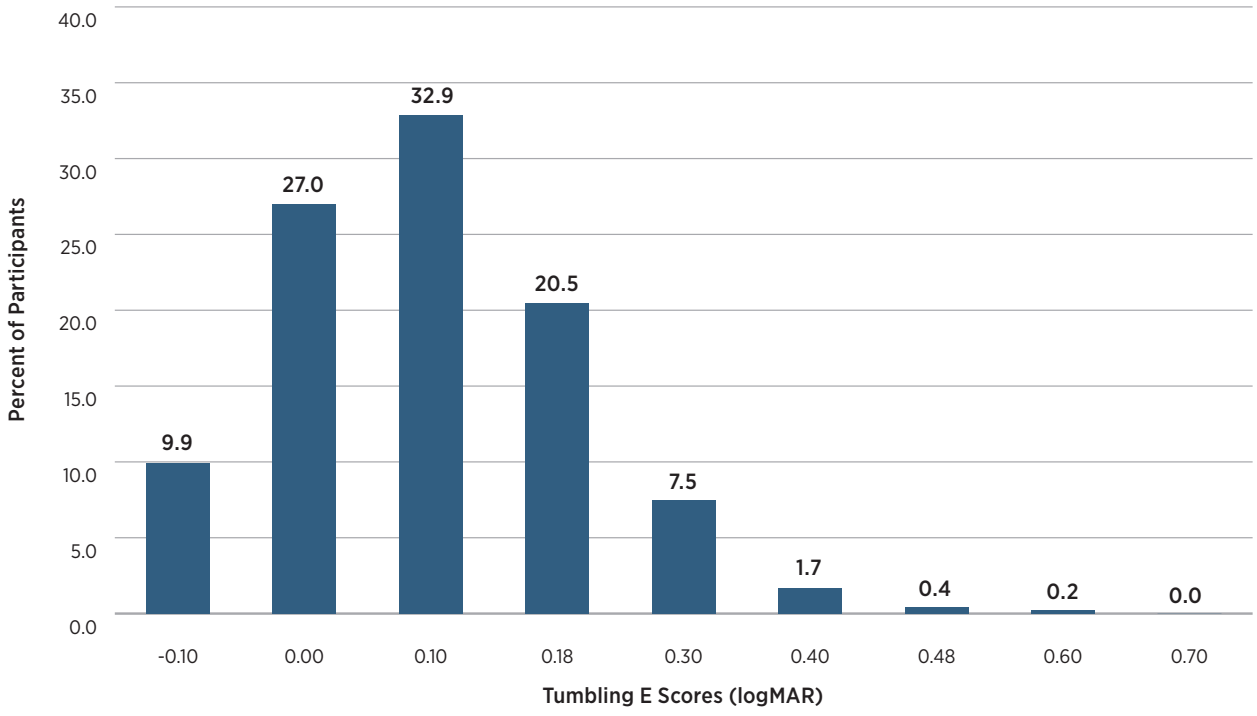

Figure 1. Distribution of scores for the Tumbling E test of visual acuity (zero is average acuity)

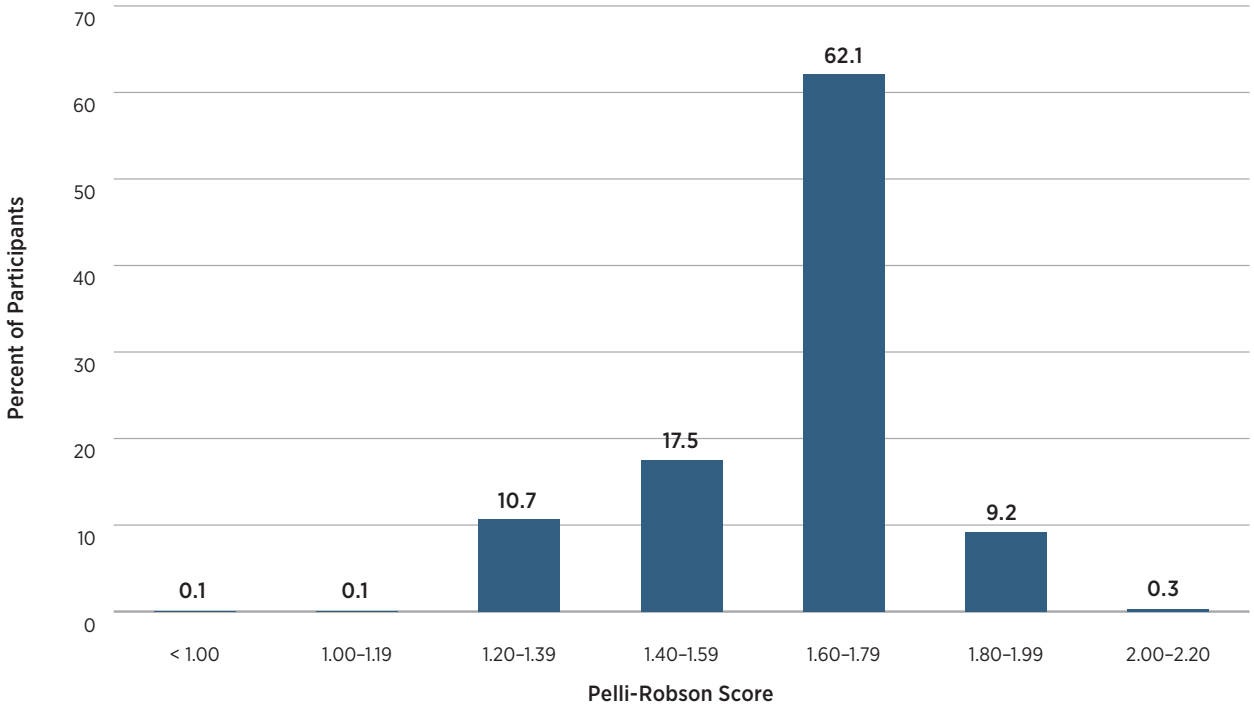

Figure 2. Distribution of scores for contrast sensitivity on best eye.

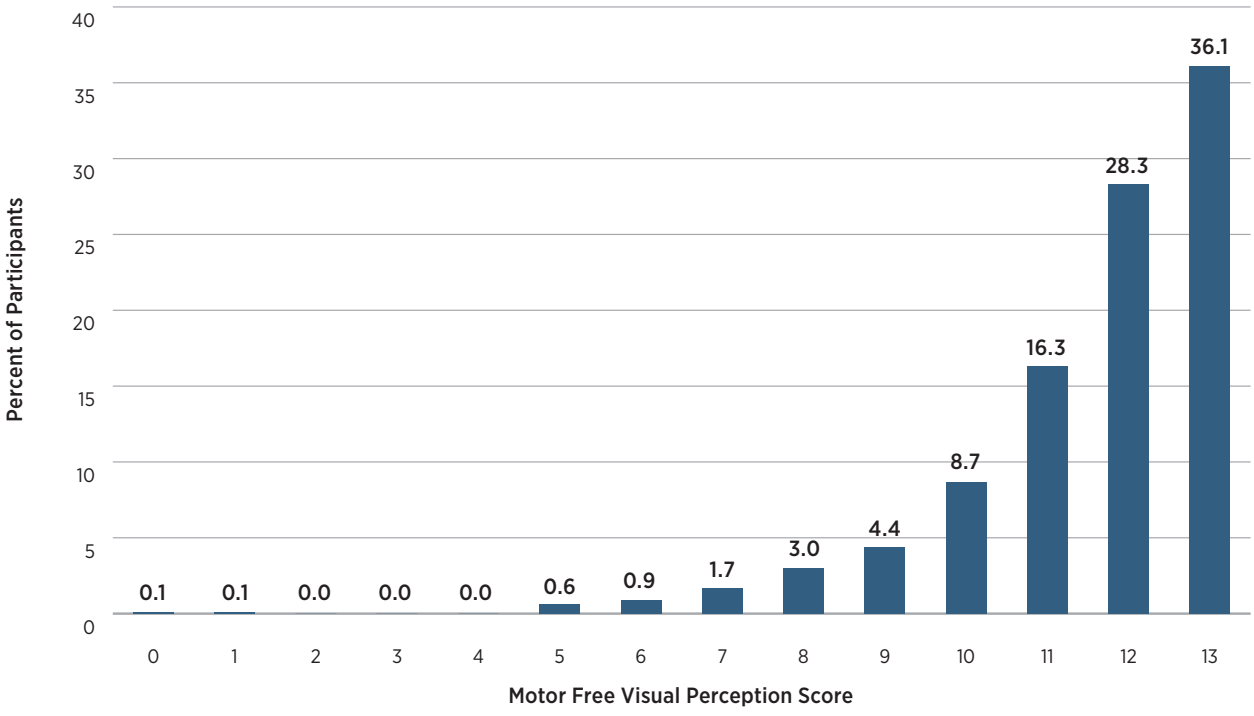

Figure 3. Distribution of scores for visual-spatial perception.

DISCUSSION

The study sought to answer the question of whether or not there was a significant relationship between baseline measures of visual function and objective measures of driving habits averaged over a one-year follow-up period after visual function measurement. The study found that lower visual acuity and visual-spatial abilities among this cohort of older drivers were related to the categories of driving closer to home, lower driving exposure and greater driving avoidance, although not for every measure. Poorer contrast sensitivity was associated with avoidance of nighttime driving and driving on high-speed roads but was not related to measures of driving closer to home or exposure. Thus, at least among the LongROAD cohort of older drivers, poorer visual function was generally related to the three categories of driving habits investigated in the study, as measured over a full year after visual function measurement.

Study results showed that the LongROAD participants included in these analyses had relatively good visual function at the time of their enrollment in the study. We anticipate that visual function measures will show overall declines compared with the present results in the second in-person assessment, which started taking place in late 2017.

Using objective measures of driving, rather than self-reported driving, this study provides further evidence about how poor visual abilities can impact driving in the year following assessment. Scores on the visual-spatial test, in particular, were related to restricted driving for all but one of the driving habit measures. These results also provide further evidence that the lower-than-expected crash involvement of people with declining visual function may be related to the fact that these drivers self-regulate their driving by driving closer to home, staying in areas that are more likely to be familiar; driving less overall and avoiding challenging driving situations, which can, in turn, lower their risk of a crash.

The strengths of this study include the use of a large sample of older drivers who were recruited at five distinct geographic locations in the United States and the use of objective driving data collected over an entire year. The limitations of the study include the fact that all significant correlations were relatively small, suggesting that other variables in addition to the ones analyzed also relate to driving habits and visual function scores. Finally, the LongROAD cohort is relatively well educated with high household incomes and therefore, not necessarily representative of all older adult drivers. As such, these results may not generalize to all older driver populations.

REFERENCES

Blanchard, R.A., Myers, A.M., & Porter, M.M. (2010). Correspondence between self-reported and objective measures of driving exposure and patterns in older drivers. Accident Analysis & Prevention, 42(2), 523-529.

Li, G., Eby, D.W., Santos, R., Mielenz, T.J., Molnar, L.J., Strogatz, D., Betz, M., DiGuiseppi, C., Ryan, L.H., Jones, V., Pitts, S.I., Hill, L.L., DiMaggio, C., LeBlanc, D., & Andrews, H.F. for the LongROAD Research Team. (2017). Longitudinal Research on Aging Drivers (LongROAD): Study design and methods. Injury Epidemiology, 4, 22.

Molnar, L.J., Charlton, J.L., Eby, D.W., Bogard, S.E., Langford, J., Koppel, S., Kolenic, G., Marshall, S., Man-Son-Hing, M. (2013). Self-regulation of driving by older adults: Comparison of self-report and objective driving data. Transportation Research Part F, 20, 29-38.

Owsley, C., Stalvey, B., Wells, J., & Sloane, M.E. (1999). Older drivers and cataract: Driving habits and crash risk. Journal of Gerontology: Medical Sciences, 54A(4), M203-M211.

Szlyk, J.P., Pizzimenti, C.E., & Fishman, G.A. (1995). A comparison of driving in older subjects with and without age-related macular degeneration. Archives of Ophthalmology, 113, 1033-1040.

ACKNOWLEDGEMENTS

The research described in this research brief was performed at the University of Michigan Transportation Research Institute, with support from the AAA Foundation for Traffic Safety.

ABOUT THE AAA FOUNDATION FOR TRAFFIC SAFETY

The AAA Foundation for Traffic Safety is a 501(c)(3) not-for-profit, publicly supported charitable research and education organization. It was founded in 1947 by the American Automobile Association to conduct research to address growing highway safety issues. The organization's mission is to identify traffic safety problems, foster research that seeks solutions and disseminate information and educational materials. AAA Foundation funding comes from voluntary, tax-deductible contributions from motor clubs associated with the American Automobile Association and the Canadian Automobile Association, individual AAA club members, insurance companies and other individuals or groups.

SUGGESTED CITATION

Eby, D.W., Molnar, L.J., Kostyniuk, L.P., Zakrajsek, J.S., Ryan, L.H., Zanier, N., St. Louis, R.M., Stanciu, S.C., DiGuiseppi, C., Li, G., Mielenz, T.J., Strogatz, D., LeBlanc, D., Bogard, S.E., Smith, J., Yung, R. and Nyquist, L. on behalf of the LongROAD Research Team. (2018, March). The Relationship Between Visual Abilities and Driving Habits Among Older Drivers: A LongROAD Study. (Research Brief.) Washington, D.C.: AAA Foundation for Traffic Safety.