RESEARCH BRIEF

Predictors of Rapid Deceleration Events among Older Drivers: AAA LongROAD Study

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Research over the past two decades has focused on developing effective countermeasures to reduce the frequency and severity of crashes involving older drivers.

Recent studies in which vehicle acceleration data were recorded have explored the relationship between hard braking events (known as rapid deceleration events (RDEs)) and safety-related outcome measures such as near crashes and declining functional abilities. This relationship has found that RDEs may be related to driving safety. To this end, the relationship between crash risk and RDEs among older drivers has been examined as a surrogate measure of unsafe driving.

Two previous studies recently examined factors related to RDEs in naturalistic driving among cohorts of older adults. They yielded different results, although they also used different thresholds for rapid deceleration. The lower threshold RDEs of .35 g (RDE35) may be more indicative of risky driving by drivers who have high functional abilities (as found by Keay et al., 2013). In contrast, the high threshold RDEs (.75 g, RDE75) may be indicative of driving errors or lapses that are more common among those with fewer functional abilities (as found by Chevalier et al., 2017).

This new examination continued the research by examining the relationship among RDE rates, demographics, visual abilities, cognitive abilities and perceived driving comfort. Findings indicate that RDE rates may have value as a surrogate safety measure, in conjunction with other factors, including sex and the driving environment. Further research is needed to better understand and define an appropriate threshold for determining a RDE and its value as a surrogate measure of crash risk. However, even with the limited information available at this juncture, RDE75 or greater may be a better surrogate measure of driving safety. In the following years, with more time for these drivers to mature, the LongROAD cohort will prove instrumental in supporting this research area.

METHODS

The study utilized data from 2,774 participants from the multi-site AAA Longitudinal Research on Aging Drivers (LongROAD) study. Objective visual and cognitive data were collected at baseline and global positioning system (GPS) data were collected over one year of driving after baseline.

Three aspects of objective visual ability were analyzed: (1) acuity; (2) contrast sensitivity; and (3) overall visuospatial perception ability. Several tests of cognitive ability were also analyzed: (1) verbal fluency (retrieval fluency test); (2) executive function (trail making A and B); (3) visuospatial ability (clock drawing test); (4) episodic/working memory (immediate and delayed word recall); and (5) attention and psychomotor speed (digit symbol substitution test). Simple and choice reaction times (Deary-Liewald reaction time task) were also analyzed in the cognitive test.

A datalogger device was installed in participant's vehicles, which recorded GPS information whenever the vehicle ignition was turned on. Based on previous studies with older drivers (Chevalier et al. 2017; Keay et al. 2013) RDEs were calculated from longitudinal acceleration derived from vehicle speed from the GPS data. Counts of all RDEs with a peak value of either .35 g (RDE35) or more, or .75 g or more (RDE75), and a starting speed greater than

4.47 m/s (10 mph) were recorded for each month and each participant.

Driving comfort was collected from items assessing self-reported level of comfort on a 7-point scale (1 not being at all comfortable and 7 being completely comfortable) in 10 scenarios. Table 1 shows the number of participants (n), means, and standard deviations (SD) for the 10 driving scenario comfort measures.

Analyses

Each participant's first 12 months of full driving data were identified and monthly averages of the number of RDEs and the number of miles driven were calculated. An RDE rate for each threshold was calculated per 1,000 miles driven using both of these monthly averages. Negative binomial regression models with backward elimination were developed to examine study outcome variables and RDE35s and zero-inflated Poisson regression models were developed for RDE75 rates. The models controlled for study site and five objective driving measures (# of trip chains, % of trips during AM peak, % of trips during PM peak, % of trips less than 15 miles and # of speeding events).

Table 1: The number of participants (n), means and standard deviations (SD) for the driving scenario comfort measures

Driving Comfort Measure	n	Mean ± SD
Driving alone	2772	6.7 ± 0.6
Driving on the freeway	2765	6.3 ± 1.2
Backing up	2772	6.2 ± 1.2
Making unprotected left turns	2768	6.1 ± 1.3
Driving on busy roads	2773	6.0 ± 1.2
Driving in rush hour	2767	5.7 ± 1.3
Driving in unfamiliar areas	2766	5.7 ± 1.2
Driving at night	2771	5.5 ± 1.4
Driving in bad weather	2767	5.1 ± 1.5
Driving at night in bad weather	2769	4.8 ± 1.6
Composite (all scores combined)	2774	5.8 ± 0.9

RESULTS

Over the 12-month period, participants drove a total of 26,169,650 miles, with an average of 9,434 ± 5,308 miles per participant. During this period, a total of 124,738 RDE35s (range per participant = 0-678) and 124 RDE75s (range per participant = 0-25) were recorded. Nearly all participants (99.6%) had at least one RDE35 but only 2% of participants had an RDE75. The average RDE rates per 1,000 miles were: RDE35, 5.3 ± 6.2 (range = 0-91); and RDE75, .005 ± .06, (range = 0-2.7).

RDE35 and RDE75 rates by demographics are shown in Table 2. Table 3 shows the means and other data for the cognitive assessment measures.

Analyses showed that the number of trip chains, the percent of trips during the morning peak, the percent of trips during afternoon peak, the percent of trips less than 15 miles and the number of speeding events were significantly associated with RDE35 rates (Table 4). As shown in this table, the rate decreased 5% for every unit increase in the number of trip chains. The rate decreased 2% for every unit increase in the percent of trips during AM peak, increased 1% for every unit increase in the % of trips during PM peak and increased 3% for every unit increase in the % of trips less than 15 miles. For every unit increase in the number of speeding events, the rate increased 0.3%.

Participant sex and site were also significantly associated with RDE35 rates. As shown in Table 4, the RDE35 rate for women was 1.13 times the rate for men. RDE35 rates varied by site. With the exception of the comparison between MI and MD, all site comparisons had significantly different RDE35 rates, with CA having higher RDE35 rates than every site followed by CO.

Three functional outcome variables were significantly associated with RDE35 rates: clock drawing score, choice reaction time and delayed word recall. As shown in Table 4, the corresponding incident rate ratios showed that the RDE35 rate: decreased 8% for every unit increase in the clock drawing score, increased 0.04% for every

Table 2: Number of participants (n), average monthly RDE rates per 1,000 miles driven, standard deviations (SD) and ranges by demographics

Demographic	n	RDE35		RDE75	
		Mean ± SD	Range	Mean ± SD	Range
Sex					
Male	1308	5.0 ± 5.6	0 - 57.1	0.006 ± 0.09	0 - 2.7
Female	1466	5.7 ± 6.6	0 - 91.0	0.003 ± 0.03	0 - 0.6
Age					
65-69 years	1158	5. 4 ± 6.8	0 - 91.0	0.007 ± 0.09	0 - 2.7
70-74 years	953	5.2 ± 5.8	0 - 52.4	0.003 ± 0.04	0 - 0.8
75-79 years	663	5.4 ± 5.7	0 - 41.7	0.003 ± 0.03	0 - 0.6
Education					
Less than a college degree	781	5.4 ± 6.7	0 - 91.0	0.10 ± 0.1	0 - 2.7
Associate or Bachelor's degree	834	5.6 ± 6.7	0 - 58.6	0.002 ± 0.02	0 - 0.4
Master's/professional/doctoral degree	1150	5.1 ± 5.5	0 - 57.1	0.004 ± 0.04	0 - 0.8
Income					
Less than $50,000	703	5.9 ± 7.2	0 - 91.0	0.009 ± 0.1	0 - 2.7
$50,000 - $79,999	678	4.7 ± 5.9	0 - 57.1	0.002 ± 0.02	0 - 0.4
$80,000 - $99,999	398	4.9 ± 5.5	0 - 52.4	0.002 ± 0.02	0 - 0.3
$100,000 or more	898	5.5 ± 5.9	0 - 58.6	0.005 ± 0.05	0 - 0.8
Site					
CO	530	6.2 ± 6.1	0 - 52.4	0.003 ± 0.03	0 - 0.4
NY	566	2.8 ± 3.3	0 - 34.9	0.005 ± 0.04	0 - 0.6
MD	554	5.0 ± 5.0	0 - 39.9	0.01 ± 0.1	0 - 2.7
MI	569	5.0 ± 4.7	0.1 - 35.4	0.001 ± 0.01	0 - 0.2
CA	555	7.8 ± 9.2	0 - 91.0	0.003 ± 0.02	0 - 0.3

unit increase in choice reaction time, and decreased 3% for every unit increase in delayed word recall score. Comfort in rush hour traffic and driving on freeways were significantly associated with RDE35 rates (Table 4). The incident rate ratios in Table 4 showed that the RDE35 rates decreased 6% for every unit increase in comfort driving in rush hour traffic and increased 7% for every unit increase in comfort driving on freeways.

The RDE75 rate multivariate regression modeling showed that all predictor variables were non-significant except for percent of trips at night (estimate=0.1019; SE=0.0206; Wald Chi-Square=24.54; p<.0001). The RDE75 incident rate ratio was 0.11 ± 0.04, indicating that the RDE75 rate increased 11% for every unit increase in the percentage of trips at night.

DISCUSSION

This paper investigated factors related to RDE rates among a large cohort of older drivers using two empirically-based thresholds for an RDE—.35 g and .75 g. Unlike Chevalier et al. (2017), the present study found very few RDEs when the threshold was defined as .75 g or greater deceleration. While the reason for this difference in the rates of RDE75 is unknown, it is possible that participants in the study by Chevalier et al. had lower functional abilities that were more likely to adversely affect driving behaviors. The Chevalier sample was considerably older and drove significantly fewer miles than AAA LongROAD participants.

Table 3: The Overall number of participants (n), means, standard deviations (SD) and ranges for cognitive measures

Cognitive Measure	n	Mean ± SD	Range
Retrieval fluency (#)	2774	22.6 ± 6.3	0 - 47
Trail making A (sec)	2772	35.2 ± 12.8	4.1 - 142.9
Trail making B (sec)	2744	93.3 ± 45.5	27.6 - 300.0
Simple reaction time (sec)	2622	349.0 ± 68.7	20.0 - 858.8
Choice reaction time (sec)	2621	639.6 ± 122.8	19.0-1273.5
Immediate word recall (score)	2676	6.0 ± 1.6	-2 - 10
Delayed word recall (score)	2719	4.0 ± 2.0	-7 - 10
Digit symbol substitution test (score)	2680	43.5 ± 10.1	-25 - 82

Unlike both Chevalier et al. (2017) and Keay et al. (2013), none of the visual ability measures and few of the cognitive measures were significantly related to RDE rates. One possible explanation for this difference is that the LongROAD participants at baseline were very healthy and high functioning compared to the older driver groups used in the other studies. In the Keay et al. (2013) study, for example, the sample's average contrast sensitivity (1.50) and Trail Making B time (130 sec) reflected reduced abilities than the LongROAD participants' average scores (1.79 and 93 sec, respectively). It is expected that as LongROAD participants continue in the study, they will start to experience declines in functional abilities as they age, and future analyses will be better able to address the relationship among RDE rates and functional abilities.

In conclusion, RDE rates as defined by a longitudinal deceleration of .35 g or greater may have value as a surrogate safety measure, especially in conjunction with many other factors including driver sex and the driving environment. Other ability-related covariates may also be significantly related to RDE35s. However, the lack of variance in these measures in the current study due to relatively healthy and high functioning sample did not allow us to find these effects. Further, RDE defined as longitudinal decelerations of .75 or greater may be a better surrogate measure of driving safety but could not be investigated adequately in the current study because of low number of events. The driving behaviors of the LongROAD participants will be tracked five years, which should yield sufficient time to explore this further.

Results of this study suggest that the selection of a specific threshold for RDEs has important implications for which factors may be associated with this driving behavior, and what the safety outcomes might be. Future research is needed that examines the full range of RDE thresholds to better understand the implications of rapid deceleration as a safety surrogate. AAA LongROAD data will be instrumental in supporting this research area as it is one of the largest cohorts of older drivers. A key takeaway note for future researchers and practitioners is recognizing that this new generation of aging drivers, largely the baby boomers, are healthy and maintaining their driving. The Federal Highway Administration reported that in 2016 one in five drivers were 65 years or older. This age group is the fastest growing. Thus, it is important to allow sufficient time for these drivers to mature to allow researchers to observe functional declines and their effects on safe driving.

Table 4: RDE35 incident rate ratios for the final model

Predictor Measure	Incident Rate Ratio ± 95% CI	*p*-value
# of trip chains[a]	-0.5 ± 0.01	<.0001
% of trips during AM peak[a]	-0.2 ± 0.01	<.0001
% of trips during PM peak[a]	0.1 ± 0.01	0.01
% of trips less than 15 miles[a]	0.3 ± 0.00	<.0001
# of speeding events[a]	-0.03 ± 0.00	0.002
Female vs Male	1.3 ± 0.09	<.0001
CO vs NY	6.9 ± 0.22	<.0001
CO vs MD	2.5 ± 0.14	0.0001
CO vs MI	1.2 ± 0.15	0.02
CO vs CA	-1.9 ± 0.09	<.0001
NY vs MD	-2.6 ± 0.09	<.0001
NY vs MI	-2.9 ± 0.09	<.0001
NY vs CA	-5.2 ± 0.06	<.0001
MD vs MI	-0.3 ± 0.11	0.10
MD vs CA	-3.5 ± 0.07	<.0001
MI vs CA	-3.3 ± 0.08	<.0001
Clock Drawing[a]	-0.8 ± 0.04	<.0001
Choice reaction time[a]	-0.0 ± 0.00	0.01
Delayed word recall[a]	-0.3 ± 0.02	0.01
Comfort in rush hour traffic	-0.6 ± 0.02	<.0001
Comfort on freeways	0.7 ± 0.05	0.01

[a]Reference is per unit increase

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