Safety Concerns with Older Drivers: Mining Data from SHRP2 Naturalistic Driving Study

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NETC Webinar

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PRESENTATION OUTLINE

- Research Motivation
- Project Methodology
- Obtaining SHRP2 NDS Data
- Data Review and Analysis
- Study Results
- Limitations and Discussion

RESEARCH MOTIVATION

- Older people are at greater risk of crashes while driving. Older drivers are especially at risk while making left turns at signalized intersections.
- Learn more about older driver behaviors and factors behind these using data from the SHRP2 Naturalistic Driving Study (NDS)
- Explore how useful NDS data is for examining such research questions

PROJECT METHODOLOGY

OBTAINING OF NDS DATA

- Queries on InSight to inform & refine data request to VTTI
- Data Use License (DUL) with VTTI
- UMass IRB approval

OBTAINING NDS DATA

Driver Characteristics	Trip & Event Details	Vehicle Characteristics
Age	Time of Day	Year
Gender	Trip Duration	Classification
Driving History	Speed	Mileage
Driving Knowledge	Acceleration	
Driving Behavior	Braking	
Medical Conditions	Steering	
Sleep Habits	Event Data	
Visual Abilities	Video	
Cognitive Abilities		

OBTAINING NDS DATA

Drivers: Ages 65+, & ages 30-49 for comparison

Focus: Left turns at signalized intersections

Also received: other trips with signalized intersections

All crashes & near crashes for age 65+

Sample of baseline trips (non-eventful)

	Drivers Age 30-49	Drivers 65 & over	Total
Crash	26	55	81
Near Crash	140	156	296
Baseline	200	299	499
Non-Subject Conflict	4	4	8
Total	370	514	884

NDS DEFINITION OF CRASH

- Contact of subject vehicle with an object, at any speed in which kinetic energy is measurably transferred or dissipated.
- Also includes non-premeditated departures of the roadway where at least one tire leaves the travel surface of the road (includes hitting a curb)
- Crashes are classified by crash severity as follows:

  I - Most Severe (injury, towing, airbag deployment)

  II - Police Reportable (but not most severe)

  III - Minor Crash (little damage; curb/tire strikes with potential risk)

  IV - Tire strike, low risk

NDS DEFINITION OF NEAR CRASH

Any circumstance that requires a rapid evasive maneuver by the subject vehicle or any other vehicle, pedestrian, cyclist, or animal to avoid a crash. Near Crashes must meet the following 4 criteria:

- 1. Not a crash. The vehicle must not make contact with any object, moving or fixed, and the maneuver must not result in a road departure.
- 2. Not pre-meditated.
- 3. Evasion required. An evasive maneuver is defined as steering, braking, accelerating, or combination of control inputs that is performed to avoid a potential crash.
- 4. Rapidity required. Rapidity refers to the swiftness of the response before potential impact.

DATA SCORING AND REVIEW

- Developed & fine-tuned video scoring methodology
- Scored all received videos (n=868)
- Requested additional video footage where videos were cut off before completion of left turn
- Reviewed data to learn more about crashes & at-risk drivers

VIDEO SCORING RUBRIC

	A	B
1	For the videos, the main focus is on scoring left turns at signalized intersection	
6	**Key**	**Value**
7	Initials_of_Scorer	Initials
8	File_id	Event Id
9	Day_night	1- Day time travelling
10		0 - Night
11	Weather	0 - clear
12		1 - not clear
13	Intersection Type	1 - T intersection
14	(Note: if all of video only shows driver	2 - 4 way
15	driving straight through intersections,	3 - other
16	then select the intersection closest to	
17	the end of the drive & complete the	
18	scoring sheet for it)	
19	Dedicated Turn Lane(s) at Intersection	1 - yes
20	(for vehicles turning left)	0 - no
21	Wait at Intersection	1 - wait
22	(due to queue or signal)	0 - no wait
23	Signalized Intersection	1 if signalized intersection
24		0- if not signalized intersection
25	Opposing Lanes	1 - yes
26		0 - no
27	Vehicle Movement	1 - left turn
28		2 right turn
29		0 - through the intersection
30	Signal Obscured	1 - if obscured
31		0 - not obscured
32	Signal State	0 - no signal
33	at time of turn/going through intersection	1 - Green
34		2 - Yellow
35		3 - Red
36	Turn Signal indication	0 - no signal
37		1 - circular signal
38		2 - flashing signal
39		3 - arrow
40	Turn phasing (for direction of turn)	2 - if protected (have right of way)
41		1 - if permissive (should yield)
42		0 - not applicable (or no turn)

<u>Driving Conditions</u>

Daytime/nighttime

Weather

<u>Intersection Conditions</u>

4-way/T-intersection/other

Permissive/protected turn

Opposing traffic

Wait to turn

<u>Driving Behaviors</u>

Following leading vehicle

Gap decision needed

VIDEO SCORING

T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE
Time_day	weather_(	intersection_	Dedicated	Wait_at_i	signalized_intersec	opposing_lanes	vehicle_movemer	Signal_obscured	signal_state	turn_signal	turn_phas
1	1	2	2	1	2	2	1	1	2	2	
2	1	2	2	2	2	1	3	1	2	2	
2	2	2	1	2	2	2	1	1	2	2	
2	1	2	2	2	2	2	1	1		2	
2	1	1	2	1	2	2	3	1	2	2	
1	1	2	2	2	2	2	1	1	4	2	
2	1	2	2	2	2	2	2	1	2	2	
2	1	2	2	1	2	2	1	1	2	4	
2	1	2	2	2	2	2	2	1			
2	1	2	1	2	2	2	1	1	2	2	
2	1	2	1	1	2	2	2	1	2	2	
2	1	1	1	1	2	2	1	1	2	2	
1	1	1	1	2	2	2	3	1	2	2	
2	1	2	2	2	2	2		1			
2	1	2		2	2	2	3	1	4	2	
1	1	1	1	1	2	1	3	1	4	2	
2	2	2	1	1	2	2	1	1	2	2	
2	1	1	2	2	2	2	1	1	2	4	
2	1	2	2	2	2	2	2	1	2	2	
2	1	2	2	1	2	2	2	1	2	2	
2	1	2	2	1	2	2	3	1	2	2	
2	1	1	1	1	2	2	1	1	2		
2	1	1	2	2	2	1	2	1	2	2	
2	2	2	1	1	2	2	2	1	2	2	
2	1	2	2	1	2	2	2	1	2	2	

REVIEWING AND ANALYZING DATA

Video data combined with:

- Event Data (crash, near crash, baseline; event severity)
- Trip and Vehicle Data (speed, acceleration/ deceleration)
- Data from pre-study questionnaires & screenings

REVIEWING AND ANALYZING DATA

Left Turns at Signalized Intersections

- 285 left-turn drives with video data
- From Event data:
  39 crashes (67% age 65+); 118 near-crashes (61% age 65+)

	Drivers Age 30-49	Drivers Age 65 & over	Total
Crash	13	26	39
Near Crash	46	72	118
Baseline	75	102	177

EVENT DATA

Crash Severity for Left Turns at Signalized Intersections

- 4 crashes considered “most severe”, all involved drivers age 65+
- 4 crashes, 75% with drivers age 65+, “Police Reportable”
- 14 minor crashes, 71% with drivers age 65+
- For drivers age 65+, 73% of crashes were minor or tire strikes

Crash Severity	Drivers Age 30-49	Drivers Age 65 & over	Total
I – Most Severe	0	4	4
II–Police Reportable	1	3	4
III – Minor	4	10	14
IV – Tire strike, low risk	8	9	17
Total	13	26	39

EVENT DATA AND VIDEOS

Crash Details for Left Turns at Signalized Intersections, Age 65+

	Crash Severity	Driver Age & Gender	Intersection Type	Description
1	Most Severe	75-79, Male	T-intersection	Not driver's fault. Hit by another driver running a red light.
2	Most Severe	70-74, Female	4-way	Not driver's fault. Driver was rear-ended while in queue at traffic light waiting to turn.
3	Most Severe	70-74, Female	4-way	Permissive turn, driver turned when the light was red & hit oncoming car.
4	Most Severe	65-69, Female	Other	Driver ran a red light & hit pickup truck turning in front of them. Crash occurred at the nearby intersection after the left turn.
5	Police Reportable	65-69, Female	T-intersection	Not driver's fault. Was rear-ended by another driver. Crash occurred at an intersection after the left turn.
6	Police Reportable	75-79, Female	4-way	Not driver's fault. Driver got rear-ended while waiting in queue to turn left. Rainy conditions. (couldn't tell if turn was permissive or protected due to weather).
7	Police Reportable	75-79, Male	4-way	This driver rear-ended the car ahead of them in the queue. Permissive turn. Car ahead started to go, but had to wait for a gap.

EVENT DATA AND VIDEOS

Video Clips of Left Turn Crashes at Signalized Intersections

Drivers age 65+

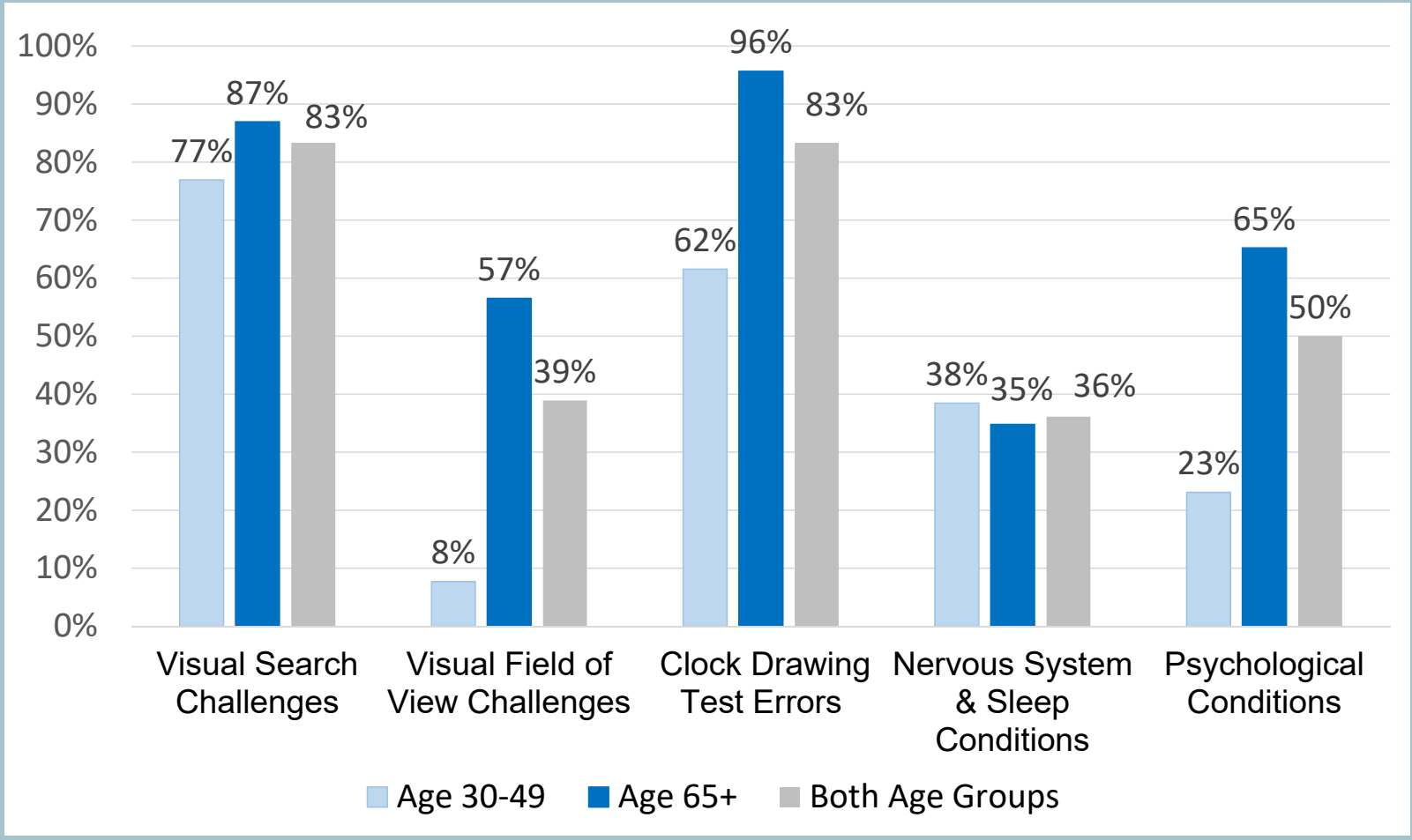
- Small number of occurrences of running red lights or not yielding when turning

With more minor crashes

- Some drivers hit outside curb at the end of the turn
- Some drivers hit inside curb if there is a median on the road being turned onto
- With multiple left turn lanes, drivers sometimes leave the lane

SCREENING AND QUESTIONNAIRE DATA

Challenges Impacting Participant Drivers with Left-Turn Crashes at Signalized Intersections (% with Impairment by Age Group)



DATA MODELING

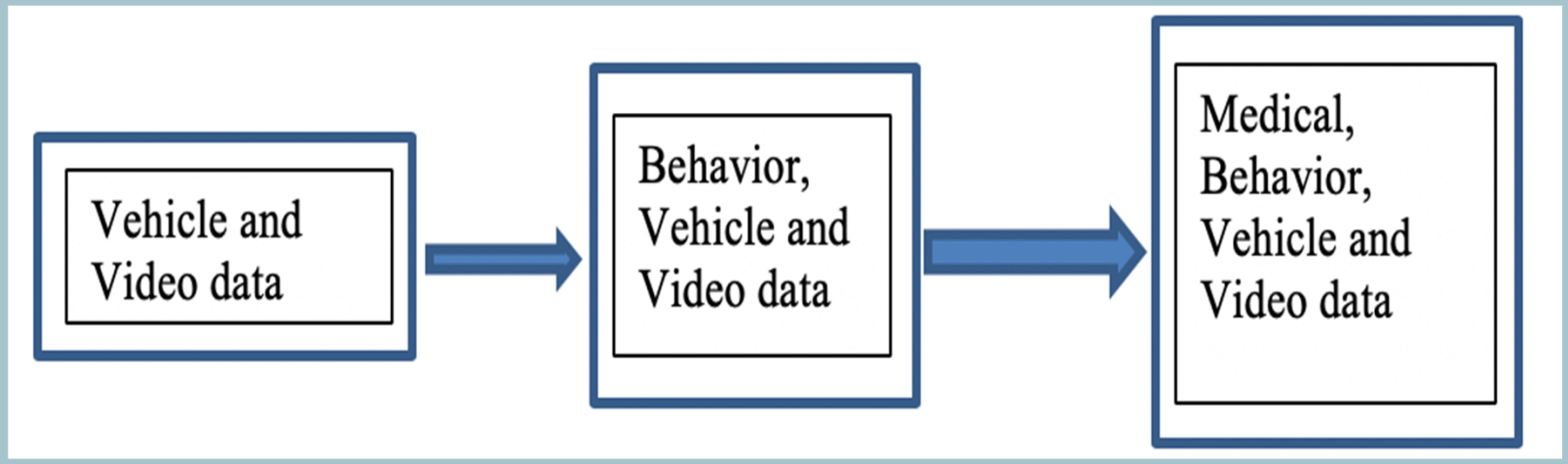
Modeling

Using video, event, trip, & questionnaire & screening data to develop predictive models for:

- Drivers having crashes vs. no crashes
- Drivers age 65+ Compared to age 30-49
- Drivers Age 65+ at risk of crashing

DATA MODELING

Input Data for the Different Models



- Iterative process
- Developed and tested a number of different regression & machine learning models, including with all variables gathered, & with the 5, 10, 15 variables anticipated to be most predictive

DATA MODELING

Predicting Crash or No Crash (both age groups)

Significant Variables (P-values)	R-Squared & Adj. R-Squared	Inputs	Model	Performance
Day/Night (0.003) Clear/Inclement Weather (0.011) Opposing Lane Present (0.019) SD of Acceleration (0.001)	0.494/ 0.411	Vehicle and Video Data (All Variables)	Logistic Regression	Training Accuracy: 89.8% Validation Accuracy: 82.7%
Day/Night (0.001) Clear/Inclement Weather (0.001) SD of Acceleration (0.001) Nervous System/Sleep Condition (0.011)	0.499/ 0.452	Medical, Behavior, Video and Vehicle Data (15 Variables)	Support Vector Machine	Training Accuracy: 83.7% Validation Accuracy: 94.3%

DATA MODELING

Predicting Left Turn Crash or No Crash, Age 65+

Significant Variables (P-values)	R-Squared & Adj. R-Squared	Inputs	Model	Performance
Nervous System & Sleep Conditions (0.001) Severe Arthritis (0.049) Impaired Field of View (0.038)	0.730/ 0.669	Medical, Behavior, Video and Vehicle Data (10 Variables)	Logistic Regression	Training Accuracy: 83.8% Validation Accuracy: **76.5%**
Gap Decision (0.037) Nervous System/Sleep Conditions (0.003) Severe Arthritis (0.052)	0.803/ 0.728	Medical, Behavior, Video and Vehicle Data (15 Variables)	Random Forest	Training Accuracy: 100.0% Validation Accuracy: **83.0%**

RESULTS

Overall Crash Risk for Drivers Age 65+ when turning left at a signalized intersections related to:

- Type of intersection; number of lanes
- Opposing lanes of traffic; is gap decision needed

With drivers age 65+, visual, cognitive, and medical factors can be significant, including:

- Field of view and visual search skills
- Medical conditions that impact fitness to drive
- Cognitive skills, & gap decision making

LIMITATIONS

- Small number of crashes/near crashes in final data set
  - Start with large NDS data set (2,300+ participants; 1-2 years)
  - From Insight:
  - # of trips for age 65+ drivers: 1.4 million
  - # of trips for age 65+ with signalized intersections: 746
  - # of crashes/near crashes, 65+ with signal. intersections: 211
- Some of the modeling results may have limited generalizability due to the small n
- Dashboard camera video, especially at night/with inclement weather, not clear enough to always see intersection details
- Additional types of data could be helpful, including eye movement data & road (Road Information Database) data

DISCUSSION

- Worthwhile project for exploring the use of NDS data
- NDS data is a rich data set regarding driver behaviors & factors that can impact driver performance
- NDS data sets get quite small when trying to examine specific crash & intersection type questions
- Potential areas for future exploration:
  - Training for drivers age 65+ to help them navigate signalized intersections & left turns & adjust to aging-related physical & cognitive limitations
  - Can improved signage, lane markings, or curb striping help with navigating left turns at signalized intersections
  - Improving safety with Advanced Driving Assist Systems (ADAS)

THANK YOU!

- <u>Fellow Researchers on this Project</u>
  Dr. Siby Samuel
  Dr. Song Gao
  Graduate Student Ravi Agrawal
  Graduate and Undergraduate Student Video Scorers

- New England Transportation Consortium

- NETC Study Technical Advisory Committee
  Chairs: Dale Peabody & Duane Brunell, Maine DOT

- Virginia Tech Transportation Institute

QUESTIONS

AND

COMMENTS

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