Leveraging the SHRP2 NDS – Examining Driver Behavior Entering Rural High Speed Intersections

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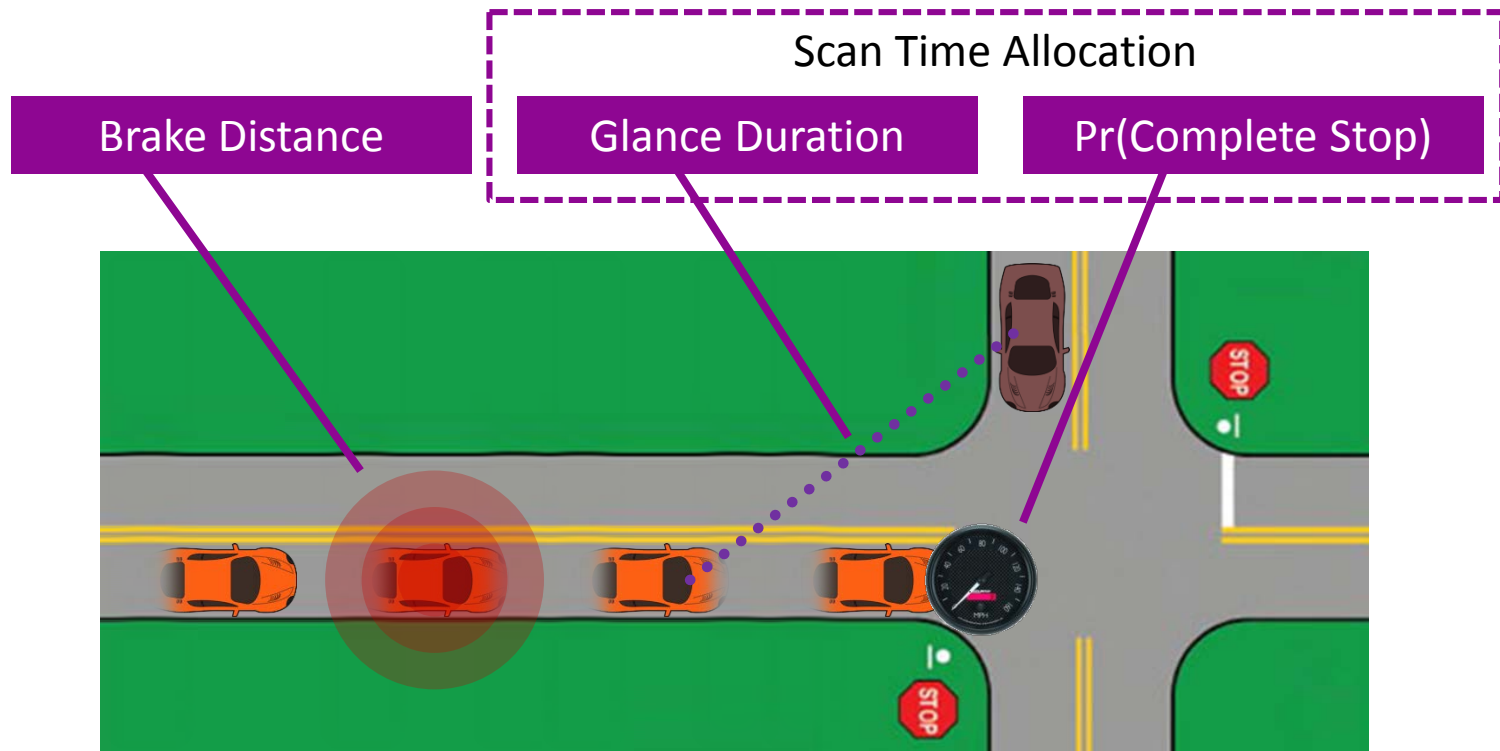
Objective

Leverage the SHRP2 NDS…

to quantify drivers' stopping and scanning behaviors…

as they approach and enter rural, high-speed intersections.

Introduction

What kind of stopping and scanning behaviors?

Scan Time Allocation

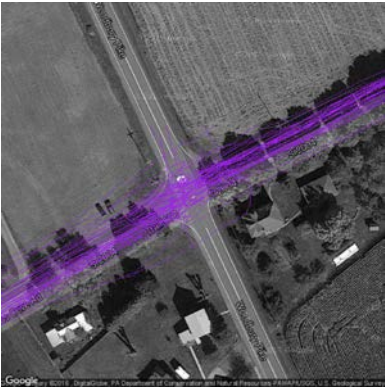Brake Distance   Glance Duration   Pr(Complete Stop)

Introduction

Why these intersections?

- Roughly 14,000 fatalities per year at rural stop-controlled intersections

- Factors believed to contribute to these incidents include:
  - Inadequate surveillance,
  - Failure to obey/yield,
  - Driver inattention,
  - Speed

- Insight into stopping and scanning behaviors may inform intersection collision warning systems, signage, speed calming mechanisms, etc.

Intersection Selection

Rural intersections in Pennsylvania with four approaches, all having one thru lane in each direction and no turn lanes, with a posted speed limit $\geq$ 50 mph on the major route and stop-controlled minor routes:

Intersection: 1	2	3	4
Crossings: 71	130	56	154
Participants: 3	8	14	7

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Data Extraction and Reduction

- Extracted static (demographics, driving history, etc.) and time series (GPS, kinematics) data

- Collaborated with VTTI to customize a reduction protocol:

| Eyeglance Directions | Traffic Presence |
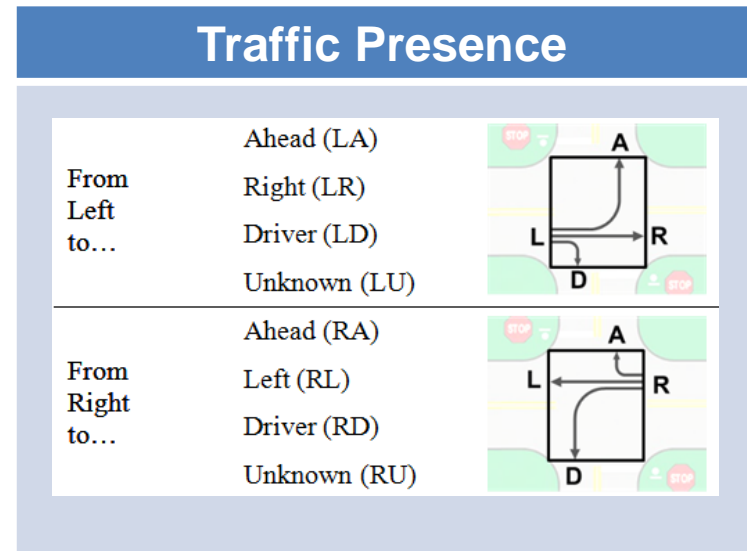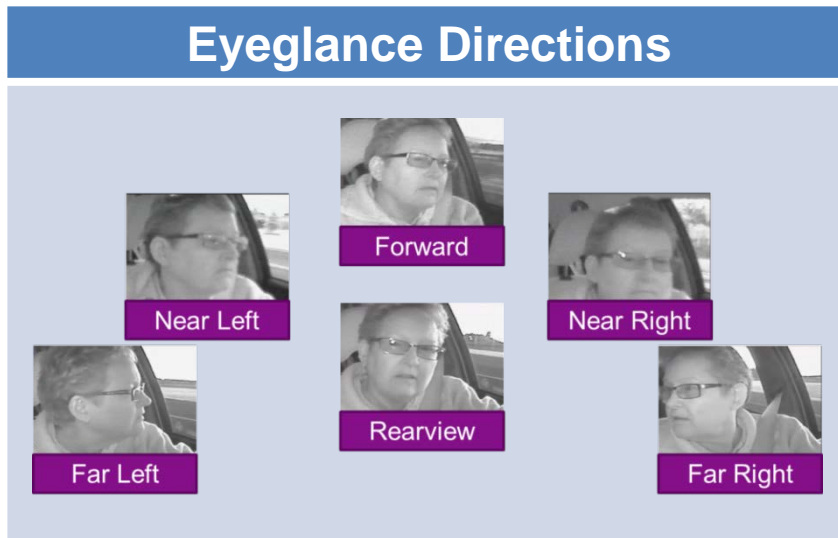
- Also requested: maneuver, surface road conditions, weather, construction

Model Estimation

Cross traffic (CT) and vehicle queues affect minimum speed:
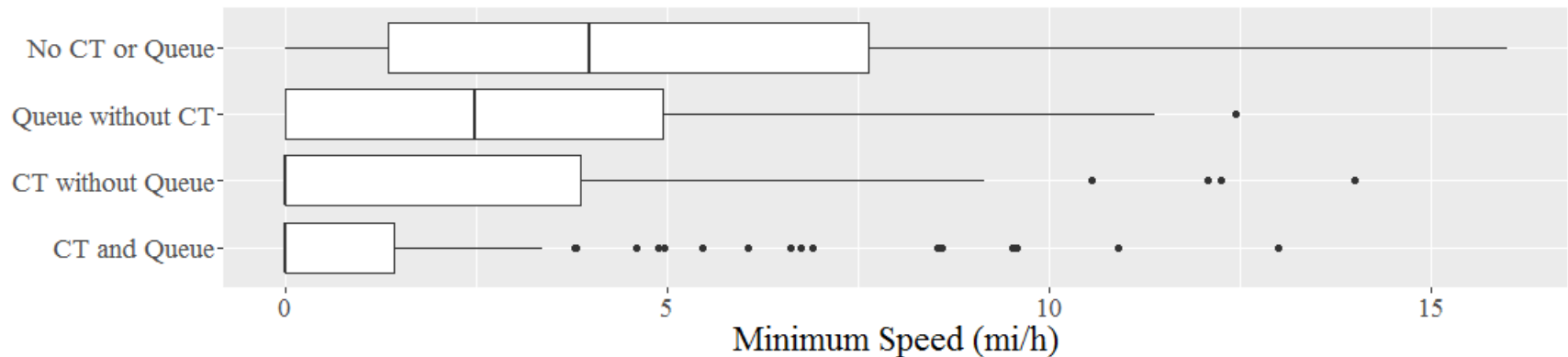
We therefore exclude some data depending on the analysis:
- Brake distance: only crossings without queues ($N = 279$)
- Pr(Complete Stop):   only unimpeded crossings ($N = 79$)
- Glance duration: all ($N = 411$)
- Scan time allocation: all ($N = 411$)

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Brake Distance

Non-queued crossings only.

N = 279
Mean = 100.4
Std. Dev. = 35.3
Median = 91.7
IQR = 59.3

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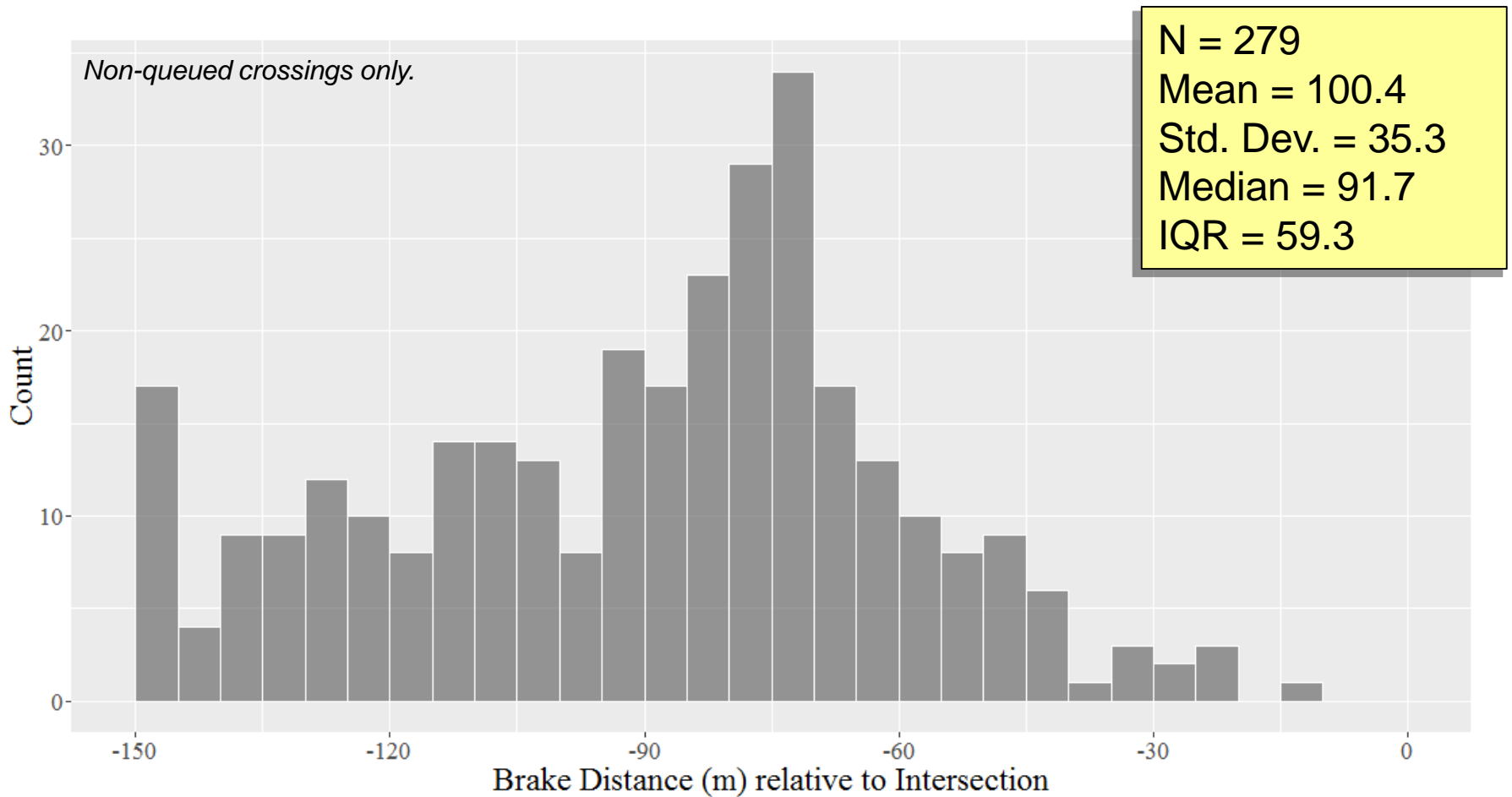
Brake Distance

- Highly dependent on speed at brake application

- Higher speed associated with greater brake distance

Brake Distance
$= 2.3 \times$ Brake Speed $- 43.4$
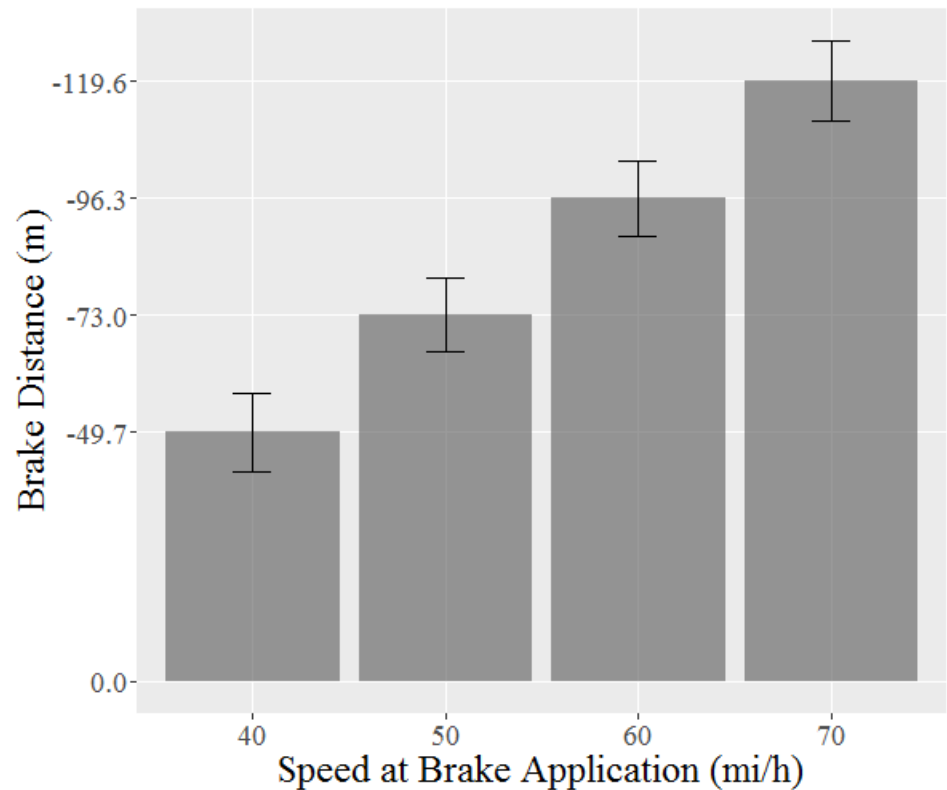
Brake Distance

- Age group was the only variable that significantly improved model fit.

- Older drivers apply the brakes earlier, especially at higher speeds.

Brake Distance
$= 1.3 \times$ Brake Speed $- 41.1$
$\times$ Older $+ 1.0 \times$ BS
$\times$ Older $- 0.6$
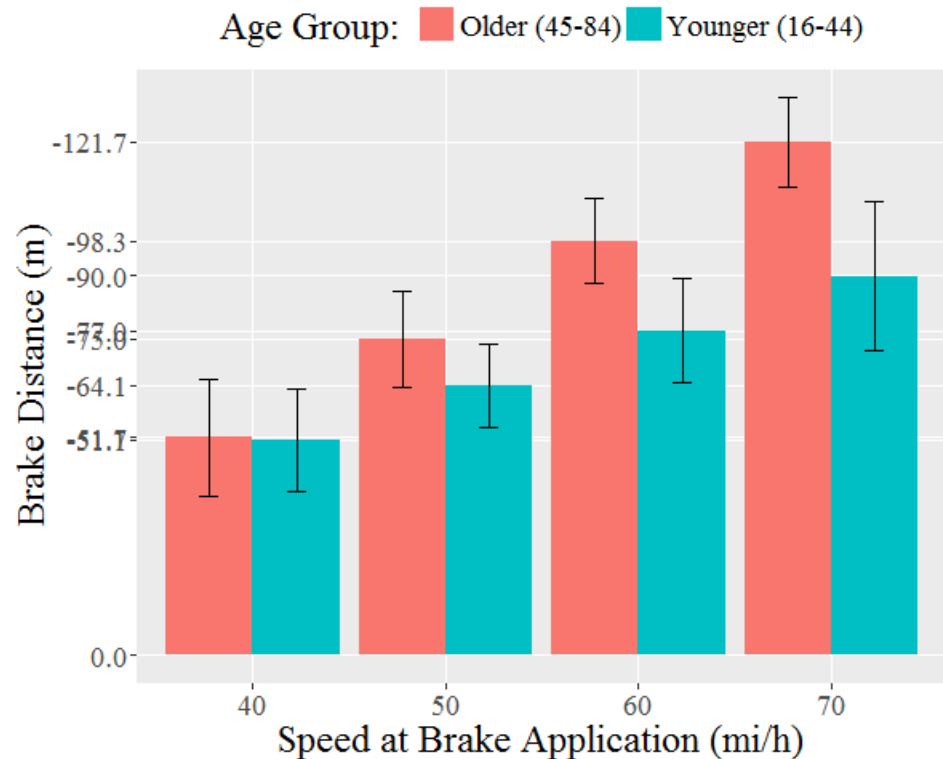
Pr(Complete Stop)

- Based on the minimum speed observed during the crossing

All 411 crossings

50% > 0 mi/h

34% > 3 mi/h

18% > 6 mi/h
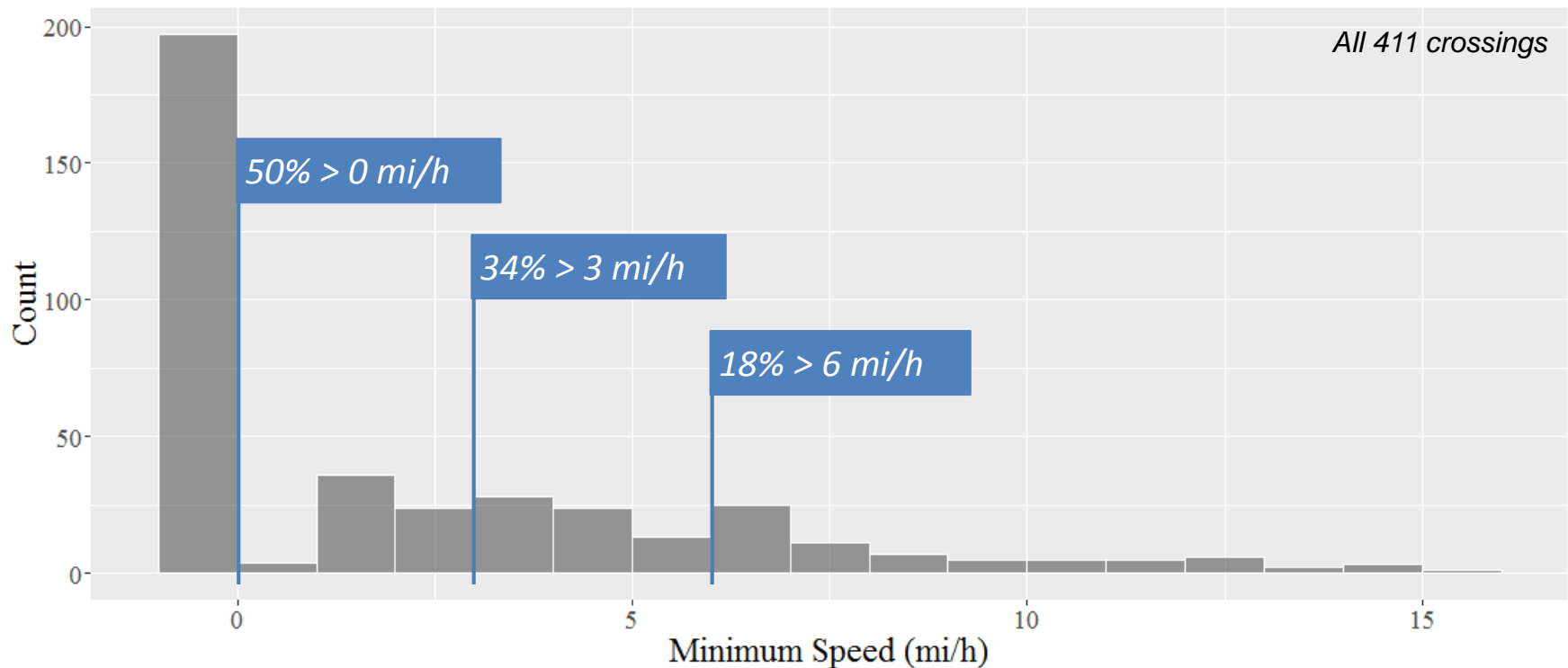
- Three thresholds were used to classify a complete stop

Pr(Complete Stop)

We're interested in the *choice* to stop

N = 79
Mean = 4.9
Std. Dev. = 4.4
Median = 4.0
IQR = 6.3

No CT or Queue
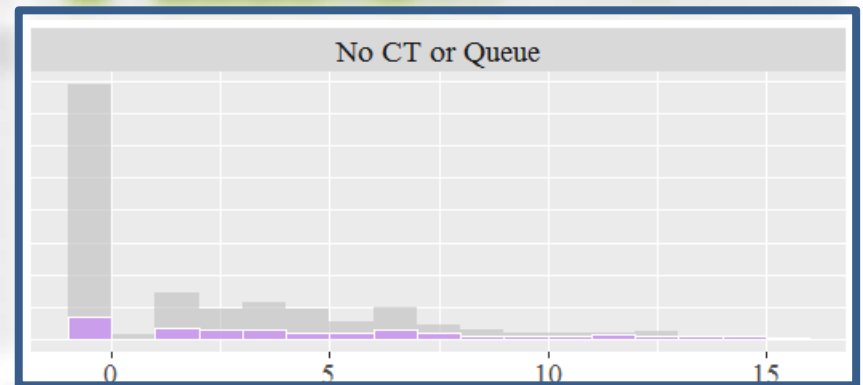
Minimum Speed (mi/h)

Pr(Complete Stop)

- More experienced drivers were 9.1x more likely to make a complete (0 mi/h) stop
  - 0.71 vs 0.08

- No significant difference in 3 mi/h stops; not enough variation in 6 mi/h stops
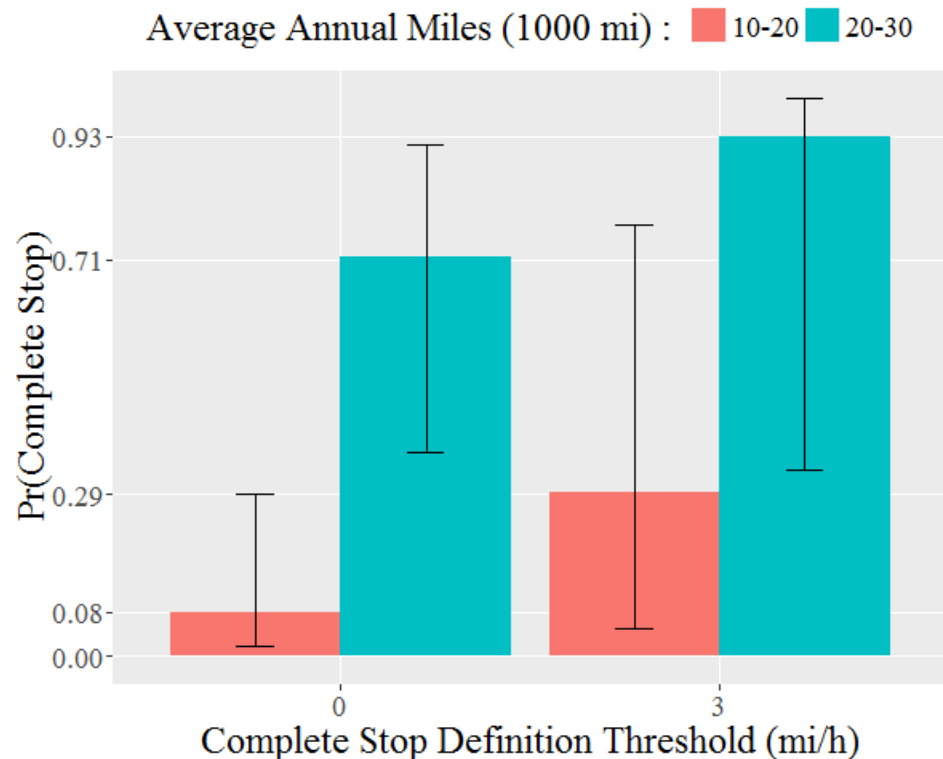
Pr(Complete Stop)

- "If you were to not make a full stop at a stop sign, how do you think it would affect your risk of a crash?"

- Drivers who consider rolling stops a high risk were actually *more* likely to make them
  - o 3 mi/h: 6.8x
  - o 6 mi/h: 14.0x
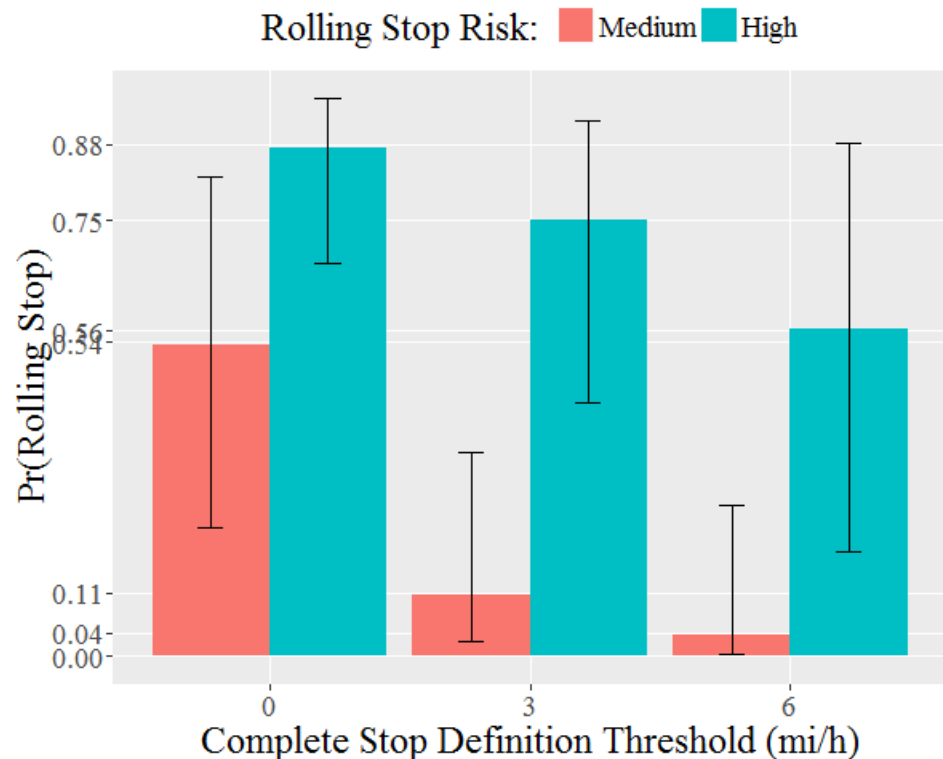
Pr(Complete Stop)

- "In the past 12 months while driving, how often did you not make a full stop at stop sign?"

- Drivers who claim to never/rarely commit rolling stops were no less likely to do so than those admitting often/sometimes

Eyeglances

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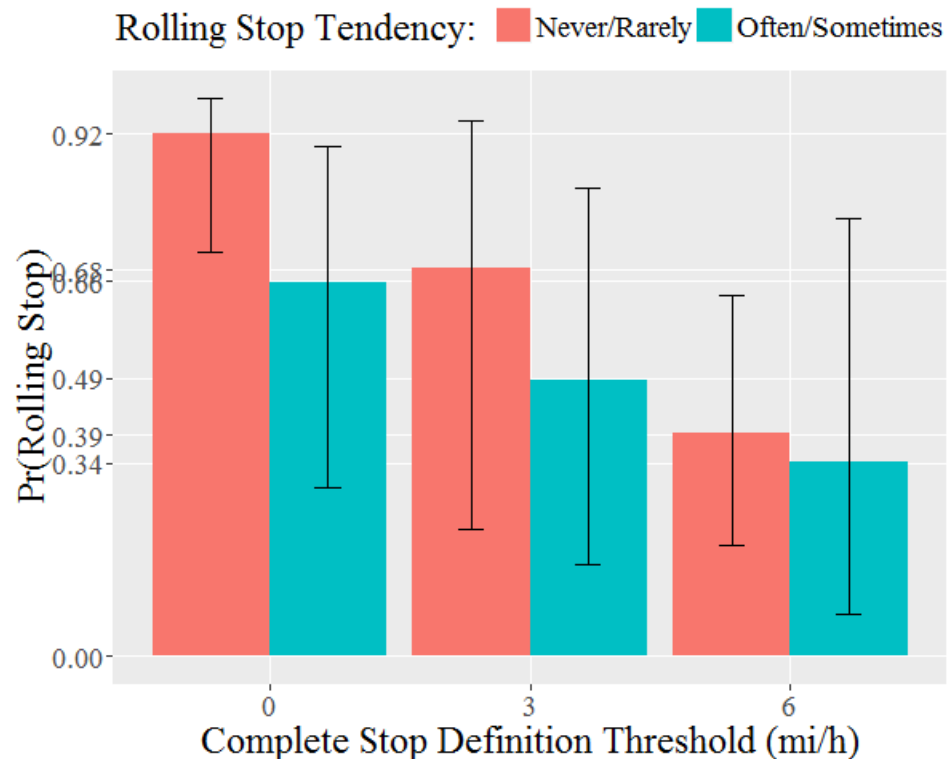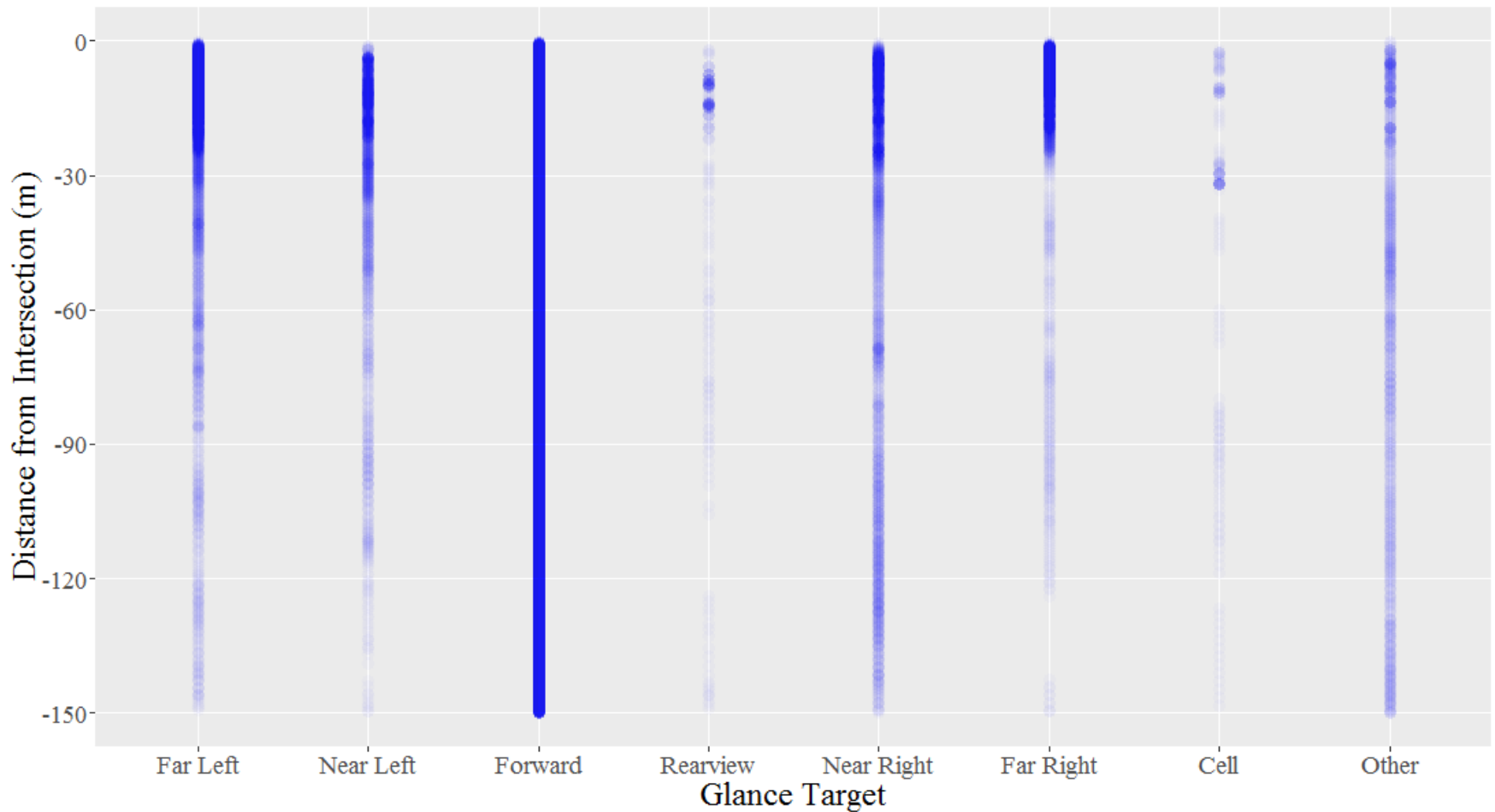
Eyeglances → Glance Duration

- Many prior studies focus on single-glance duration: 2 s off roadway significantly increases crash risk

- Our goal was to describe glance patterns at different points along the approach

- To compare the time that drivers spent glancing at each ROI along the approach, approaches were divided into five 30-meter segments:
    - Segment 1: 0 – 30 m
    - Segment 2: 30 – 60 m
    - Etc.

- *Total* Glance Duration *within segment and ROI*

Glance Duration

- Within 30 m of the intersection (segment 1), drivers devoted much more time to scanning ROIs (near and far, left and right)

- Among these ROIs, the majority of glance duration (at least 61.5%) occurred within 30 m of the intersection

Mean Total Glance Duration (s): 1 2 3 4

Segment	FarLeft	NearLeft	Forward	Rearview	NearRight	FarRight	Cell	Other
1	2.40	0.39	4.15	0.08	0.48	1.83	0.03	0.12
2	0.12	0.10	2.14	0.01	0.08	0.03	0.04	0.07
3	0.06	0.04	1.74	0.01	0.07	0.02	0.01	0.06
4	0.03	0.04	1.42	0.00	0.08	0.03	0.01	0.04
5	0.03	0.01	1.34	0.01	0.07	0.00	0.00	0.05

All crossings
(N = 411)
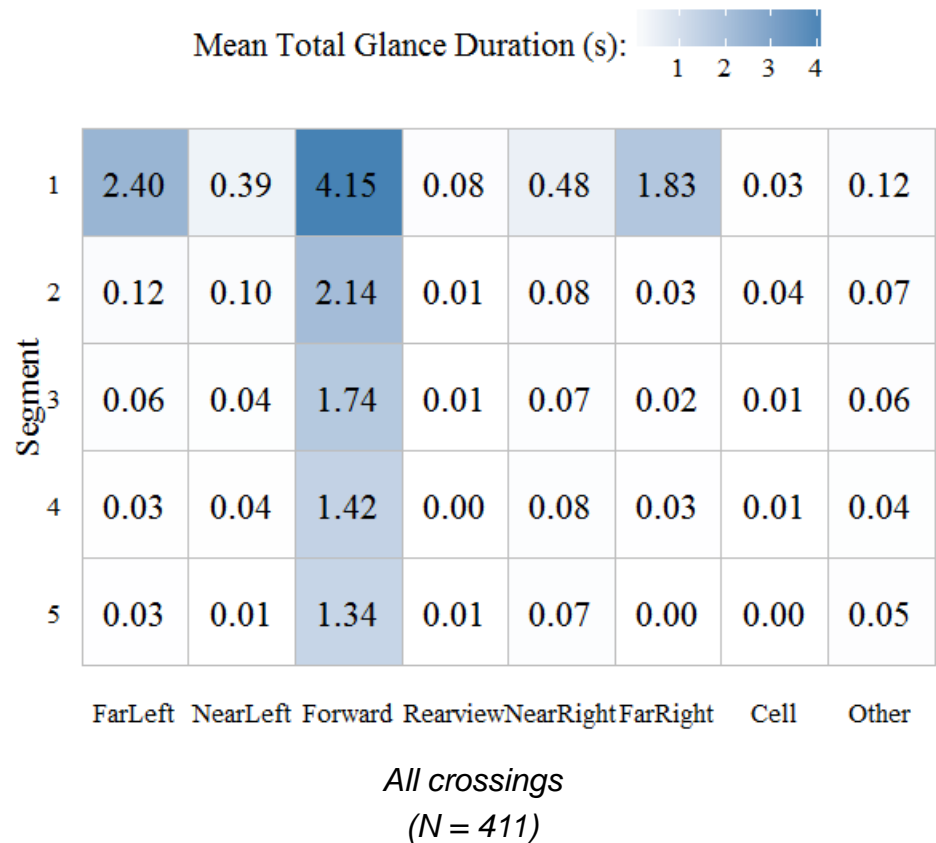
Glance Duration

This pattern is robust to traffic conditions:

Mean Total Glance Duration (s): 1 2 3 4

Segment	FarLeft	NearLeft	Forward	Rearview	NearRight	FarRight	Cell	Other
1	2.40	0.39	4.15	0.08	0.48	1.83	0.03	0.12
2	0.12	0.10	2.14	0.01	0.08	0.03	0.04	0.07
3	0.06	0.04	1.74	0.01	0.07	0.02	0.01	0.06
4	0.03	0.04	1.42	0.00	0.08	0.03	0.01	0.04
5	0.03	0.01	1.34	0.01	0.07	0.00	0.00	0.05

All crossings
(N = 411)

Mean Total Glance Duration (s): 0.5 1.0 1.5 2.0

Segment	FarLeft	NearLeft	Forward	Rearview	NearRight	FarRight	Cell	Other
1	1.30	0.21	2.40		0.22	0.95		0.03
2	0.13	0.14	1.79		0.06	0.06		0.04
3	0.06	0.03	1.55		0.09	0.04		0.07
4	0.05	0.07	1.30		0.12	0.03		0.04
5	0.05	0.00	1.28		0.13	0.00		0.03

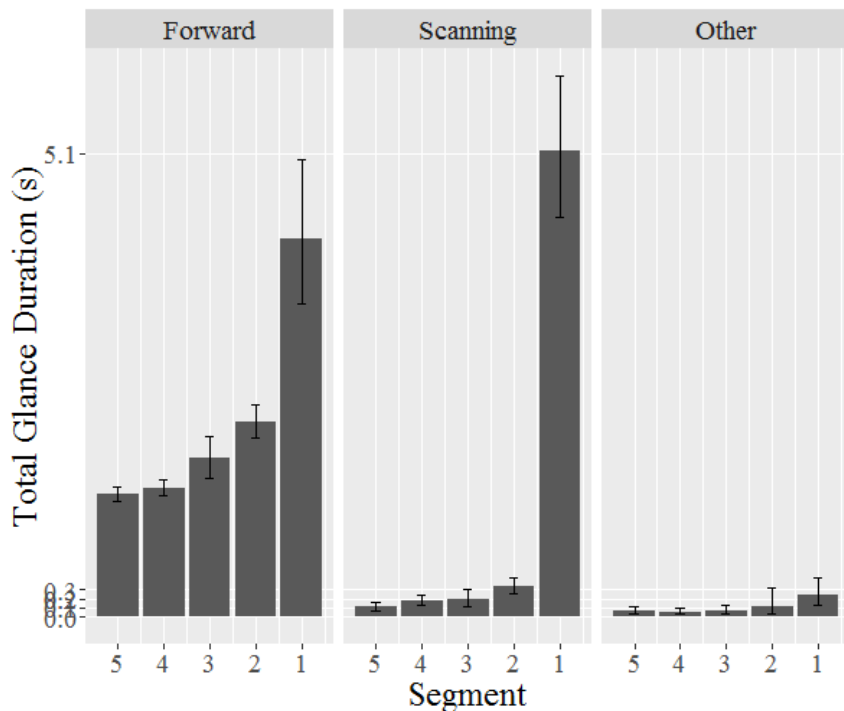*No Queue or Cross Traffic*
(N = 79)

Glance Duration

- We can aggregate the scanning ROIs into one for a clearer picture

- Total scanning duration in segment 1 averaged 5.1 s, a statistically significant 4.8 s increase over segment 2.

- Drivers performed 86.6% of their scanning within 30 meters of the intersection.
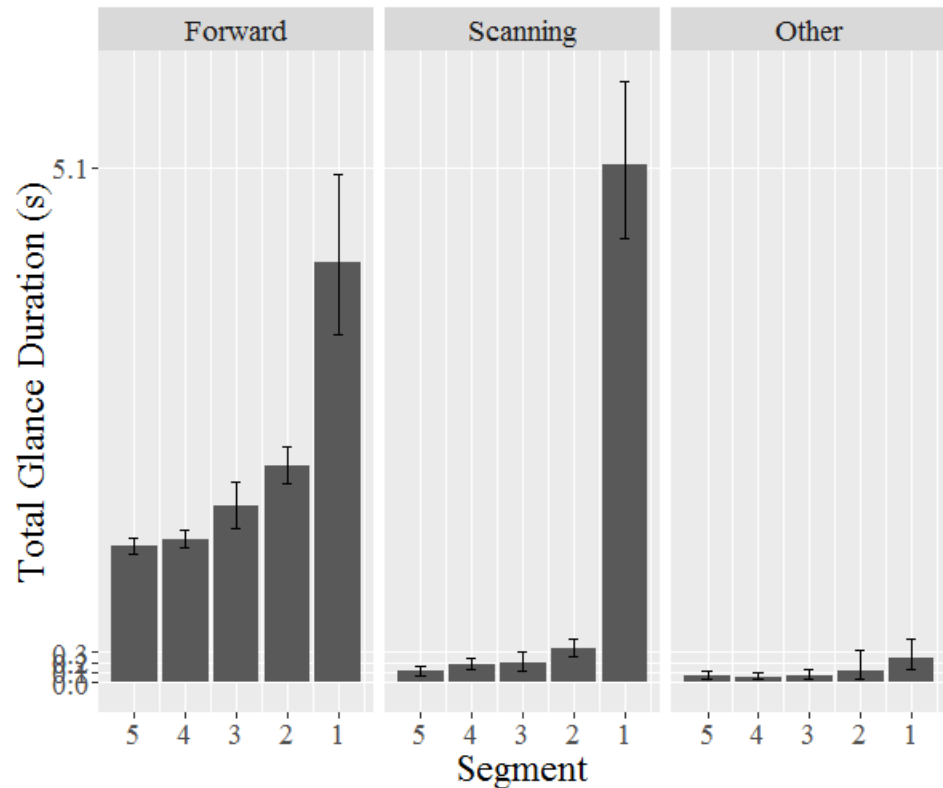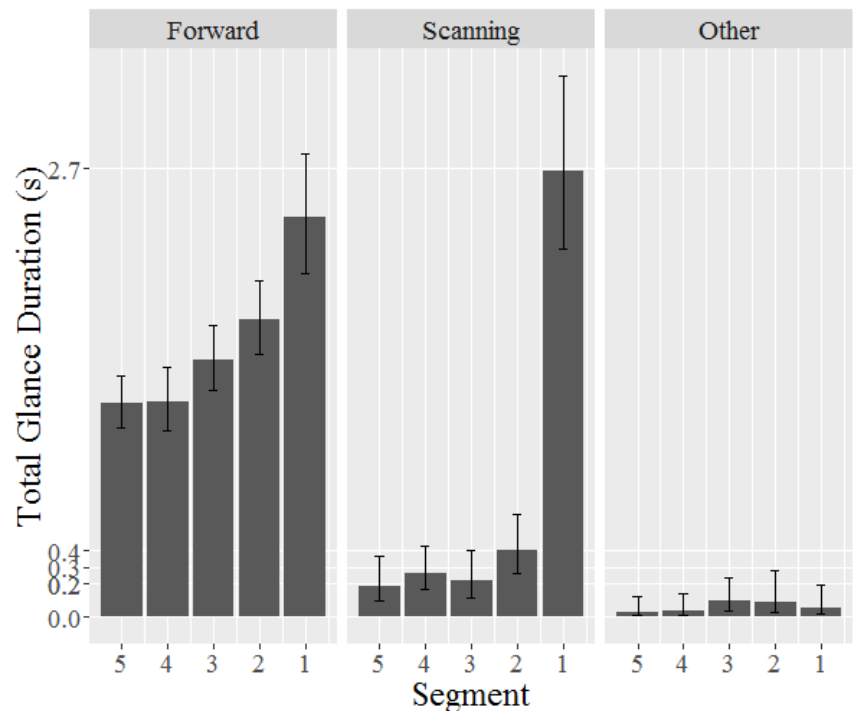

All crossings
(N = 411)

Glance Duration

This pattern is also robust to traffic conditions:

*All crossings*
(N = 411)

No Queue or Cross Traffic
(N = 79)

Scan Time Allocation

- How are stopping and scanning behaviors related?

- Definitions:
  - Proportion of pre-stop glance duration devoted to scanning the intersection
  - Calculated as the sum of glance durations to ROIs {Far Left, Near Left, Near Right, Far Right}, expressed as a percentage of total glance time before and after stopping
 - Pre-stop scan percentage + post-stop scan percentage = 100%, so only pre-stop time analyzed

- Example…

Scan Time Allocation
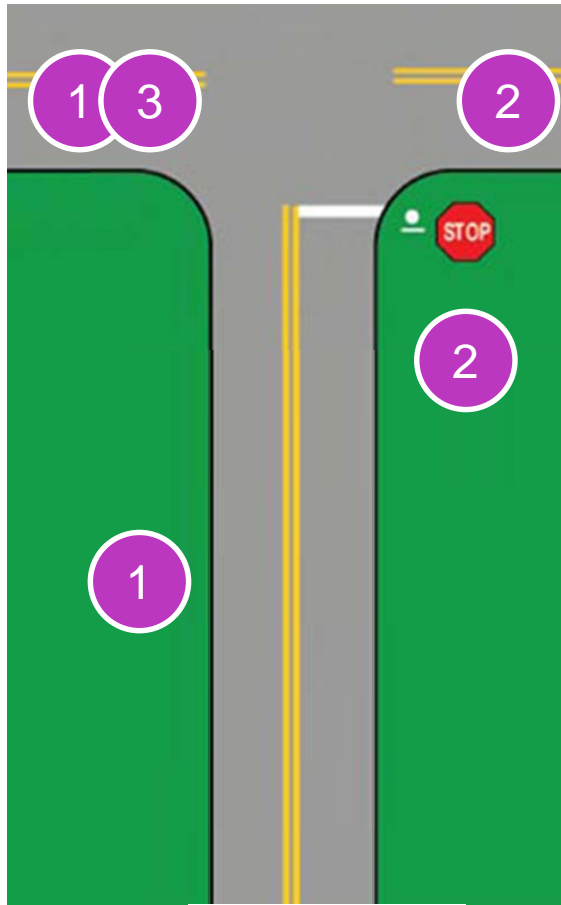
- Let 1 s glances be represented by: ⬤

- Observe the glances before and after stopping…

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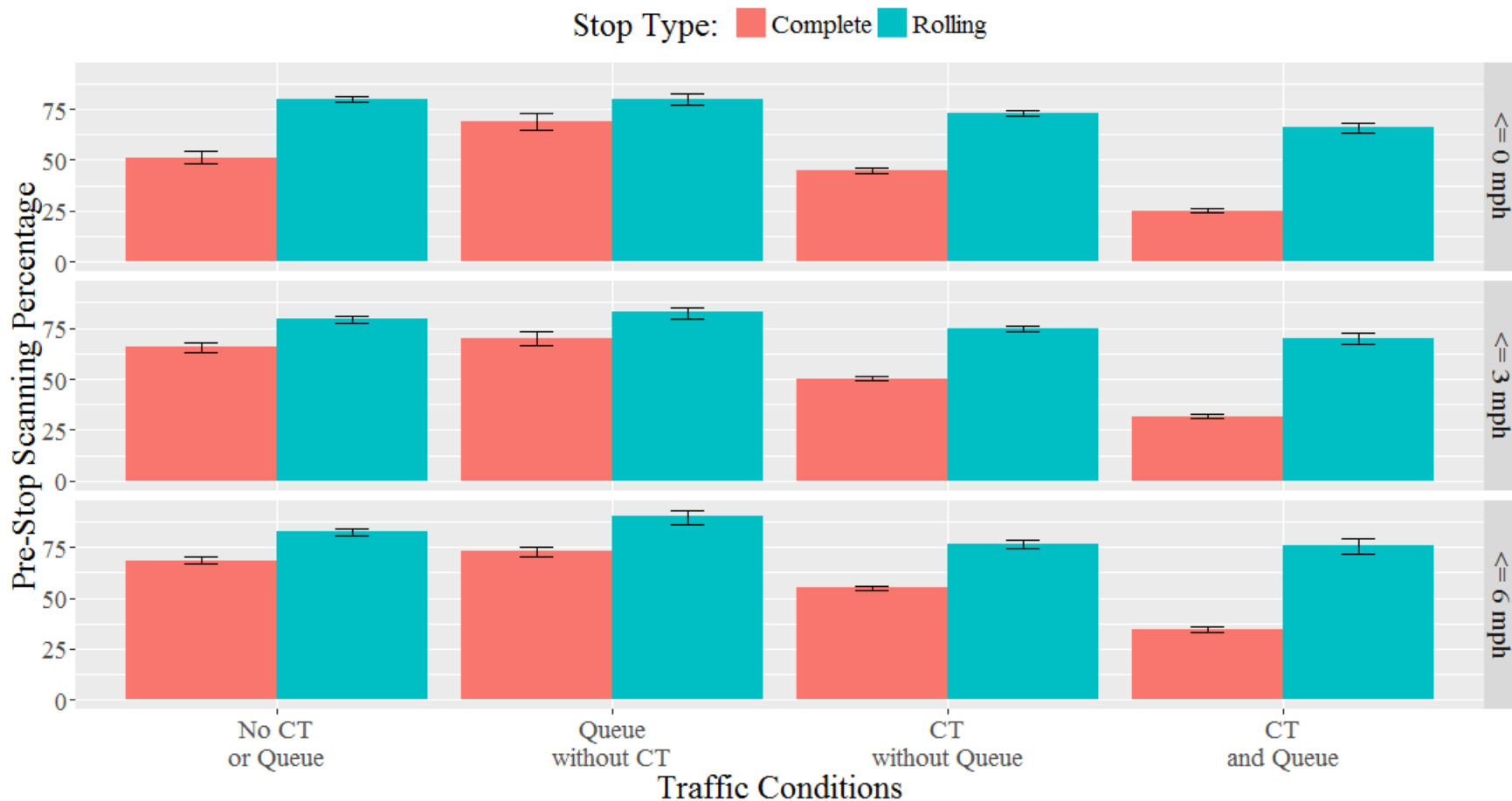Federal Highway Administration

Scan Time Allocation

- Complete-stoppers spend less time scanning the intersection prior to stopping
  - 0 mi/h   0.53:1
  - 3 mi/h   0.61:1
  - 6 mi/h   0.65:1

- Suggests two distinct intersection-scanning protocols:
  1. Approach intersection, stop (completely), scan, proceed
  2. Scan intersection during approach, slow (to a rolling stop), proceed

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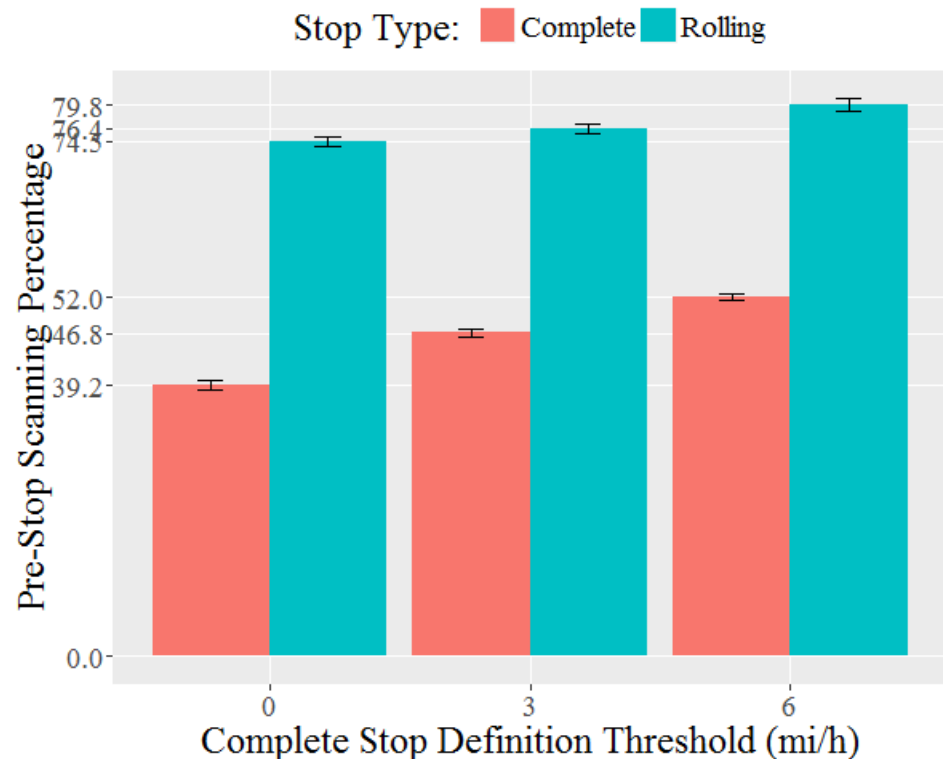
Scan Time Allocation

This pattern is also robust to all traffic conditions

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Summary

Brake Distance	– Overall average 100.4 m – Greater speed at brake application = greater brake distance – Older drivers brake farther, especially at higher speeds
Pr(Complete Stop)	– Average minimum speed (no CT or queue) 4.9 mi/h – More experienced (higher mileage) drivers more likely to make complete stop – "Rolling stops are highly risky" drivers less likely to make complete stops – No difference in actual rate of complete stops between drivers who "never/rarely" and "often/sometimes" commit rolling stops
Glance Duration	– Nearly all scanning occurs within 30 m of intersection
Scan Time Allocation	– Complete-stoppers do most scanning after stopping – Rolling-stoppers scan while approaching